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SOCIAL SCIENCES

Conflicts

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White caps above and below – it goes without saying that these are part of our image of the blue planet. But for how much longer? In the case of the North Pole, at least, whose cover consists entirely of sea ice, it is an essential question. After all, nowhere in the world is climate change as visible as it is in the Arctic. Never before, since reliable records have been available, was the September minimum – the expansion of the Arctic Sea ice at the end of the summer – as low as it was in 2012. The Arctic ice is not only an indicator of climate change, but also an important factor in the climate system: the smaller the ice areas become in the Arctic summer, the less sunlight is reflected and the more is absorbed by the ice-free ocean. In winter, the ice insulates the relatively warm water from the much colder air; without this “cap,” the ocean would release gigantic volumes of heat into the atmosphere. The ice cover is therefore extremely important for the temperatures at the North Pole.

Dirk Notz from the Max Planck Institute for Meteorology in Hamburg would like to explain the role of the sea ice, its complex internal structure, and thus also the conditions necessary for its formation and stability. To this end, he and his team measure, among other things, the thickness of the ice on the ice floes and its composition of pockets of freshwater ice, brine and gas. All of the data is included in complex numerical simulations. The most important discovery to date: Contrary to what was originally feared, there doesn’t appear to be any tipping point in the climate system, after which it would be impossible to prevent the complete loss of the Arctic ice cap. According to the model calculations, the state of the sea ice is closely related to the prevailing climate conditions at all times. This also means that if greenhouse gas emissions continue to increase at the current rate, then by the end of the century, the Arctic will be completely free of ice in September at the latest.
Conflicts

18 The Difficult Birth of a State
States don’t emerge from a void, but are always the result of political decision-making processes among not only the people who live in them, but also a complex array of external players. These processes are seldom free of conflict, as the example of South Sudan, the newest member of the international community of sovereign states, shows. Researchers from the Max Planck Institute for Social Anthropology are studying the emergence and development of this African country.

24 God’s Law on the Path to Modernity
Dynamic family law reform, recognition of adoption and consideration of a child’s best interests: researchers at the Max Planck Institute for Comparative and International Private Law demonstrate in their studies how complex and mutable law in Muslim countries is. And that it absolutely does allow for different interpretations.

32 The Anatomy of the Shooting Spree
Shooting sprees shock us and spark bewilderment and fear. At the Max Planck Institute for Human Development, a Minerva project is examining the link between possession of firearms, violence and emotions, based on the example of shooting sprees. The controversial topic “youth and weapons” has already been studied previously at the institute from a historical perspective.

ON THE COVER Conflicts divide and cause injury. They are omnipresent, in our personal environment and in society alike, at the national level no less than in the international context. At the same time, conflicts are a fertile field of study for researchers from various disciplines, such as social anthropologists or researchers of law or human development. They consider the issue in all of its facets and from different perspectives.
PHYSICS & ASTRONOMY

46 Neither Star nor Planet
The name isn’t exactly sensational: brown dwarfs. But researchers at the Max Planck Institute for Astronomy have gained fascinating insights.

BIOLOGY & MEDICINE

52 A Repairable Heart
Newts possess the almost magical ability to regenerate damaged tissue. Scientists from the Max Planck Institute for Heart and Lung Research want to learn from these amphibians how an organism can regrow entire organs.

MATERIAL & TECHNOLOGY

58 Quantum Mechanically Engineered Steel
Car bodies, aircraft wings or turbine blades – alloys today are customized for any purpose. Experts at the Max-Planck-Institut für Eisenforschung are also developing new varieties, and in their search for innovative materials, they even apply the laws of the quantum world.
New President Takes Office

Martin Stratmann takes over the leadership of the Max Planck Society from Peter Gruss

The first speakers at the Plenary Assembly in Munich’s Prinzregententheater were Bavaria’s Minister President Horst Seehofer and Federal Chancellery Minister Peter Altmaier. Before an audience of around 800 guests including leading representatives of the political, business and scientific communities, Professor Martin Stratmann thanked his predecessor who had guided the fortunes of the Max Planck Society over a period of 12 years. Among the most visible changes were the 9 new institutes founded during this time, along with the reorientation of 15 existing institutes and the 14 Max Planck Centers established jointly with leading international research institutions: “I set myself the goal of developing the Max Planck Society in such a way as to enhance its international profile,” said the departing President.

His successor, Martin Stratmann, was previously Section Chairperson and Vice President of the Chemistry, Physics and Technology Section of the Max Planck Society. “Never before has this office been held by a scientist so experienced in the dealings of the Max Planck Society,” emphasized Peter Gruss, as he handed over the chain of office. Describing the aspects that he intends to focus on in the future, the new Max Planck President called on the Society to be ready “to dare more Harnack.”

An abbreviated version of his inaugural address is included under the “Viewpoint” column in this issue of MAXPLANCKRESEARCH.

40 Years of Close Relations with China

The Max Planck Society and the Chinese Academy of Sciences celebrate their cooperation

The Max Planck Society is a pioneer in scientific cooperation with China. As far back as the 1970s, the Society began to develop relationships and networks, and established a program of mutual collaboration in which the Chinese Academy of Sciences (CAS), China’s leading research organization, played a central role. Today, the Max Planck Society is one of the most important partners of CAS worldwide. Internationally, their cooperation serves as a model of dynamic and successful partnership based on mutual interest, and extends far beyond the exchange of scientists and cooperation on individual projects.

Highlights of the anniversary celebrations in Beijing included a scientific forum of brief presentations and the opening of the Science Tunnel at the China Science and Technology Museum. These events were followed in Shanghai by a conference jointly organized by the Max Planck Society and CAS on the subject of “Personalized Medicine.”

The exhibition scouts at the opening of the Science Tunnel at the China Science and Technology Museum in Beijing.
“The pressure on patients could increase”

Individualized medicine poses challenges for health policy and the law/
Interview with Max Planck Director Ulrich Becker

The concept of improving our understanding and treatment of diseases by taking the patient’s genetic disposition into account is becoming steadily more important in medical research. Particularly in the field of cancer therapy, individualized medicine is already part of day to day clinical practice. New methods allow patients to receive more specifically targeted treatments and avoid those that are ineffective. Ulrich Becker, Director at the Max Planck Institute for Social Law and Social Policy, is working with scientists at Ludwig-Maximilians-Universität Munich and the Helmholtz Center Munich to study the legal, ethical and economic consequences of this development for the German healthcare system.

People often speak about individualized medicine as if it were a matter of customized pills. Just what form does such treatment take?

Ulrich Becker: Individualized medicine doesn’t mean that it is customized for each individual person. It refers to certain biological features that may be displayed by various persons. As for the medical products already on the market, typically a genetic test will be performed when a certain type of cancer is first diagnosed. The object is to investigate the patient’s genetic make-up and discover how cells have already been altered by the cancer in order to select a treatment that is as specific as possible. But it must be understood that the term individualized medicine doesn’t refer to a tightly enclosed concept. There is a very broad spectrum of tests and medical applications.

What legal challenges does this entail?

Apart from the issue of approving new treatments and diagnostics, there is the question of how individualized medicine fits into the catalog of services covered by statutory health insurance, and above all there is the matter of data protection. If individualized medicine is to be practiced on a large scale, a great deal of personal data must be collected. Scientists must know which biological features permit which interpretations. However, the laws as they apply make only limited provision for the use of such data. These bio-databases need a basis of their own in law so that researchers can use the data safely and securely. And there must also be adequate legal protection for patients.

The thought of going to the doctor and first having to undergo a genetic test is something a lot of people aren’t comfortable with. Will my doctor then tell me which diseases I am likely to suffer from in the years ahead?

This can indeed lead to difficulties. Assuming that the tests were to reveal information pointing to some other health problem – a so-called chance discovery: Should, or must the doctor inform you? Is the doctor even allowed to do so? Up to now, you have had a right to not knowing. In fact, the protection afforded by the existing laws is relatively strong. You, as the patient, give your consent for the doctor to investigate your genetic data for one specific purpose only, and in doing so, you are able to restrict the scope of the investigation. The doctor may inform the patient of nothing more than the test results within that envelope. However, the situation becomes particularly problematic when the genetic information that is discovered is hereditary and poses a health risk for close relatives. Without the consent of the patient, it isn’t permissible for his or her relatives to be informed.

Patients covered by the state health insurance scheme can already enjoy certain individualized medical benefits. Could these increase significantly in the future. How might this change the state health insurance scheme?

New drugs and methods of treatment first have to be included in the list of those eligible for funding under the state scheme. As a matter of principle, new treatments have to meet high standards of effectiveness. These standards are satisfied particularly when there is statistical evidence available based on as high a number of cases as possible. However, it is difficult to provide statistical evidence of the effectiveness of individualized medicine given that, up to now, any uniform disease patterns have, as it were, been fragmented by focusing on different genetic manifestations. As a result, one disease pattern can become two, or five, or more. The question must be asked whether the requirements for evidence of the effectiveness of any given method need to be modified.

Will health insurers soon be able to order a patient to take a genetic test?

The state insurance scheme must abide by the existing regulations, and these currently protect patients quite comprehensively. But it’s conceivable that our attitude toward genetic data may change in the future. If, as a result of individualized medicine, we start collecting this data far more often, it may occur to us to take a different view of the need to protect such data. On the other hand, if the health insurance funds could, in the future, save on costs as a result of individualized medicine, the pressure could increase on patients to allow access to their data.

And will health insurers be able to save money as a result of individualized medicine?

As part of our project, the economists considered the application of individualized medicine in certain cases. We’re fairly certain that individualized medicine per se won’t lead to a reduction in costs. It isn’t possible to generalize with any serious intent. It’s a matter of taking a close look at each individual case.

Interview: Michael Schlegelmilch
Spotlight on Genes and Signal Molecules

Bayer CropScience backs fresh ideas from Max Planck start-up targenomix

Lothar Willmitzer and his team at the Max Planck Institute of Molecular Plant Physiology in Golm are world leaders in the study of signal paths and metabolic processes in plant cells. These investigations are essential not just in the interests of basic research and in understanding biological systems. They are also of great economic importance, in that they have the potential to contribute to the development of new, higher-yielding and more resistant plant varieties. It was for this reason that Willmitzer founded the company targenomix in fall 2013. And targenomix has now found a powerful partner in Bayer CropScience. Through the partnership, Bayer CropScience has access to the research results achieved by targenomix. The company is thus also following a trend toward outsourcing research in the pharmaceutical and agrichemicals industry. “Smaller companies are generally more dynamic and more innovative than large conglomerates. And it also allows the big groups to minimize their own risk,” says Lothar Willmitzer. For targenomix this is likely to be a profitable cooperation in all respects.

Cellular Light Switches

Axxam is developing new technology to accelerate drug screening

In recent years, a dream has come true for neurobiologists: With the aid of optogenetics, they are now able to integrate light-sensitive ion channels – known as channelrhodopsins – derived from the alga Chlamydomonas reinhardtii into nerve cells and switch these on and off using light. This in turn allows them to study cell communication within a neuronal network. The light-gated channel opens and the influx of ions depolarizes the cell, which means that the voltage across the membrane changes and an action potential is triggered. The company Axxam has now employed this principle for the first time in a screening platform that can test a large number of different voltage-dependent ion channels in parallel.

Such channels are interesting targets in the search for new medical agents. The process involves altering the cells genetically in such a way that they form different variants of channelrhodopsin and of the ion channel under investigation. The voltage in the cells is altered via the light-activated channelrhodopsin, enabling scientists to investigate whether a candidate agent modifies the behavior of the target channel at different voltages as desired. The new platform replaces expensive and time-consuming methods that rely on electrodes or unnaturally high concentrations of potassium.

Cellular Light Switches

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Bridging the Gap between History and the Sciences

Max Planck Institute in Jena now reoriented

The Max Planck Institute of Economics has been reoriented and re-named the Max Planck Institute for History and the Sciences. Geneticist Johannes Krause (Tübingen) and evolution research specialist Russell Gray (Auckland, New Zealand) have been appointed as Founding Directors. The new institute bridges the gap between history and the sciences. Biologists, linguists and social scientists will jointly make use of innovative scientific methods from, say, the field of genetic sequencing in order to exploit a new spectrum of information derived, for instance, from existing anthropological and archaeological collections.

“We have succeeded in appointing two internationally outstanding researchers to the new institute, Russell Gray and Johannes Krause, whose previous work impressively demonstrates the potential of this thoroughly interdisciplinary approach,” says Max Planck President Martin Stratmann. With the reorientation of the institute, two decades of economic research at the former Max Planck Institute of Economics will come to an end at the close of 2014.

The two new Directors Johannes Krause (left) and Russell Gray.

On the Net

Max Planck Has over 50,000 Fans
In early July, the number of fans of the Max Planck Society’s English-language Facebook page broke the 50,000 mark. With daily posts focusing on careers, research and scientific events, we are reaching a very young audience aged between 18 and 24. And the community is international, with the bulk of users coming from India (9,000), Germany (5,500), the US (4,900), Brazil (2,700) and Mexico (2,600). A month or so ago, the English and German-language sites were joined by a Spanish version managed by the Latin America office in Buenos Aires.

www.facebook.com/maxplansociety
www.facebook.com/maxplanckgesellschaft
www.facebook.com/sociedadmaxplanck

Monitoring System for the Planet
Researchers at the Max Planck Institute for Ornithology in Radolfzell are working on a highly innovative project: ICARUS. Using the latest satellite technology, they not only intend to track a wide variety of species on their migrations, but they also hope to develop an entirely new type of monitoring system for our planet. It is possible that the migration routes may provide clues to predict epidemics or other natural disasters:

www.orn.mpg.de/animal_tracker

A Trio of Science Videos
Don’t miss the three educational science videos by Jon Parnell from the Max Planck Institute for Solid State Research: “Graphene: Sketches of our Future” is an insightful investigation of an everyday object: pencils. “The Other Infinity” explores the challenges of the nanoscale world and how they are tackled. The third video in the series, “A Universal Language,” explains the phenomenon of fundamental constants and the quantum Hall effect, and also features a compelling interview with Max Planck scientist and Nobel Prize laureate Klaus von Klitzing.

https://www.youtube.com/maxplanck-stuttgart

National Awards Presented in the “Jugend forscht” Competition

Imagine the pendulum of an old grandfather clock. When another is hung on the end of the pendulum, it becomes a double pendulum. Once in motion, this arrangement can perform some crazy movements: initially, the pendulum swings smoothly back and forth; but then suddenly it begins to dance around chaotically and unpredictably. Vincent Stimper decided to take a closer look at this phenomenon. He created a computer simulation that takes Earth’s gravity into account, enabling him to precisely imitate the pendulum’s swing. His results show that, even in cases in which the movement of the double pendulum appears regular, on closer examination, it may already be in chaos. The jury praised the young researcher for the astonishing depth to which he had familiarized himself with these highly sophisticated methods of theoretical physics and declared him the national winner of the competition.

The Max Planck Society not only donates the 1,500 euro award for the national winner of ”Jugend forscht,” but also funds all of the other awards in the physics category – at the regional, state and national level.
Are We Ready to Dare More Harnack?

Adolf von Harnack, the founding father of the Kaiser Wilhelm Society, was a courageous pioneer of new and future-oriented structures in science. Interestingly, his concepts have lost little or none of their topicality. Even today, the words he put down on paper must give us food for thought.

TEXT MARTIN STRATMANN

Does Germany need the Max Planck Society? Would the country be missing something if there were no Max Planck institutes? These are questions that absorbed my attention before taking office, and caused me once again to revisit the origins of the Max Planck Society. Where better to begin than with Adolf von Harnack, a theologian and member of the Prussian Academy of Sciences. After all, it was his memorandum penned in 1910 on the “Necessity for a new organization to promote the sciences in Germany” that ultimately led to the foundation of our predecessor organization, the Kaiser Wilhelm Society.

In his considerations, Harnack initially harks back to the ideal, developed a hundred years earlier by Humboldt, of the university as an institution that combines research and teaching as one inseparable unit, and that to this day constitutes the basic formula for most universities. Based on this successful underlying university structure, he analyzed the development in research up to the early 20th century and came to the conclusion that scientific research had developed an incredible dynamic that far exceeded anything that might have been imagined in Humboldt’s day. “There are entire disciplines that no longer fit within the framework of the university, partly because they demand such extensive equipment and instrumentation that no university institute can afford them, but partly also because they address problems that are beyond the grasp of students.”

Examples at that time included nuclear physics, organic chemistry and breakthroughs in biology, particularly infection biology. Harnack concluded – long before the age of mass-market universities – that “the laboratories and capabilities of the universities are proving less and less adequate, as ever greater requirements are rightly imposed on them to allow students to engage in the practical work that should become the focal point of their education, to the point where these needs threaten to monopolize all resources.”

His proposal to the then Kaiser foresaw the creation of professional non-university research institutes in the most modern fields of science of the time: institutes that Harnack wished to amalgamate within a uniform organization. He concluded “that in the organization of these research institutions, it is most important not to define their objectives in advance, but to allow them every freedom for future development. The direction of research should be a product of the personalities of the academics that lead them.”

No new alternative university model

Still relevant in the present day: Adolf von Harnack, shown in a new light in the permanent exhibition at the Harnack House in Berlin. Starting in September 2014, a series of installations will document the history of the conference venue founded in 1929.
and of the development in science itself. Were the institu-
tutes to be dedicated, from the beginning, to spe-
cific purposes, it would be all too easy to be led down
blind alleys, for science often exhausts itself with sur-
prising speed."

Harnack didn’t intend his proposal to lead to the
complete separation of research and education. On
the contrary, he wanted to make a distinction be-
tween a university, whose primary task in Humboldt’s
sense is to provide a close combination of research
and teaching, and a research organization that is ded-
icated first and foremost to research, but that charac-
teristically also encompasses elements of education,

The education market
has become more global

albeit highly specialized and tailored directly to the
needs of research. His memorandum was thus not a
draft for a new alternative university model – quite
the contrary: it foresaw the continuous fruitful ex-
change of scientists.

There are two aspects of Harnack’s comments that
are particularly striking: he makes no mention of any
division between basic and applied research. His
words are at all times colored by the understanding
that the findings of basic research have a direct con-
sequence for applications, and thus also for the wel-
fare of society. Nor does Harnack ever speak of ex-
cellence. Universities and the new non-university
institutes may differ in terms of a division of labor
based on partnership, but not in terms of their qual-
ity. To think otherwise would have been inappro-
priate, for at the start of the 20th century, German uni-
versities were setting international standards, and
with just about 55,000 students, they were outstanding
institutions.

And today? If anything has changed, it is that the
number of students in Germany now stands at over
2.5 million! Over half of each annual cohort now
goes on to study at a university, and rightly and pri-
marily desires a good academic education as a means
of successfully embarking on a career. Only very few
of them are genuinely interested in the advancement
of science. German universities are thus forced to per-
form a balancing act. They must guarantee that half
of each cohort receives an outstanding education,
and at the same time, they must provide a high qual-
ity research infrastructure for what is likely to be a
very small proportion of their students. A research in-
frastucture that is becoming steadily more complex
and expensive!

If one compares Harnack’s comments with the
present day, one is bound to agree that his analysis is
more relevant than it ever was, with universities that
are almost at the point of collapse under their educa-
tional burden, the exploding costs of infrastructures
that can be operated only by skilled professionals,
and international competitiveness that must be safe-
guarded also in economic terms. And in the midst of
all this are highly motivated and capable scientists,
the best of which are coveted internationally, who
must be courted and who are quickly lost if the gen-
eral conditions aren’t right.

Moreover, the education market has become more
global, and students more mobile. Many of them are
guided primarily by the reputations of universities or
research institutions. Reputations are a credible indi-
cator of outstanding performance in research and
teaching – and thus a promise of an optimum educa-
tion and an ideal start to a career. A glance at the
Shanghai ranking shows that the US research univer-
sity model is particularly successful, with just three
non-US universities among the top twenty in the cur-
rent ranking: Cambridge, Oxford and the ETH – none
of which are in Germany.

Harvard, Stanford, Yale – these are the highly suc-
cessful scientific international gold standard. With a
generous budget (Harvard has over three billion eu-
ros per year at its disposal), they attract the world’s
best professors, they have developed professional
management structures, and they provide a small
number of students with a hands-on scientific edu-
cation. Josef Joffe, editor of the German weekly Die
Zeit, recently published a commentary entitled “Der
Olymp macht zu” (Mount Olympus slams the door)
in which he remarked on current figures indicating
that Stanford University will accept only 2,100 appli-
cants this year, out of a total of 42,000. That’s a mere
5 percent, compared with 20 percent 30 years ago!
The Anglo-American system is optimizing itself at the cutting edge: universities are becoming a primary filter in the selection of a social elite that more or less inevitably will go on to occupy leading positions in politics, industry and science. This is the only way to justify the enormous tuition fees, and the only explanation for the huge endowments. In 2012/2013, Stanford University alone pocketed over 900 million dollars in donations, or four times the budget of the University of Heidelberg.

In Germany, unlike the US or England, there are no marked differences in quality between the universities – despite the Excellence Initiative. Our universities are funded almost entirely out of the public purse – funds that must be democratically justified – and open to all those with the relevant abilities. Germany puts its faith in very high quality, and in internationally recognized, broadly available education, and takes a skeptical view of the formation of social elites at isolated educational institutions.

Nevertheless, Germany has succeeded in creating a climate for research at the very highest level; a climate that is attractive to the leading international scientific elite and that bears comparison with the leading American universities. The Max Planck Society, in close cooperation with the broad-based universities, has an important role to play: the Society is a scientific beacon with the ability to fill young people with enthusiasm for research, to help prevent the best among them from migrating, but also to attract outstanding minds from abroad.

With our particular combination of breadth, depth and permeability, we in Germany can hold our own at the cutting edge – scientifically as well as economically, and with no little interdependence between the two! By contrast, many countries in Asia, America and Europe. Now, as then, economic and scientific aspects are tightly interwoven. How will Europe – how will Germany – position itself in the course of this (not only) scientific contest? What goals must we achieve to ensure that the continent we all value so highly performs well?

Let me summarize goals and means in four propositions:

1. Development in the European Research Area must serve our overall interests.

If we consider the total numbers of Nobel Prizes for science that have gone to Europe and the US, the figures aren’t very far apart. However, if we look exclusively at the trend since World War II, we must concede that the US is now much better off than Europe.

We need European career structures
Of the ten institutions hosting the most Nobel laureates, only two are European: the University of Cambridge and the Max Planck Society. So there is much to do – and all the more so given the yawning gaps between research areas within Europe. It is simply not acceptable in the long term that entire countries should have no chance in the contest for outstanding scientists. And if we are to offer good prospects for advancement for young scientists throughout Europe, we need European career structures similar to those in the US. After all, in Europe as a whole, there are 183 universities that feature among the top 500 in the Shanghai Ranking (by comparison, there are 149 in the US), albeit very few of them in Eastern Europe. The Max Planck Society already has institutes in three European countries (Italy, Luxembourg and the Netherlands). This European commitment could be expanded. And it is to the benefit of Germany that this should happen, given that we must necessarily have a major interest in the continuing economic and scientific development of Eastern Europe in particular. Europe must make itself more attractive to students of outstanding caliber, and alter the ratio of “brain drain” to “brain gain” in its favor, and do so with sustained effect. Universities and research organizations will be of fundamental importance in this process.

2. Expenditures for education and research will increase. The scale of the necessary investment, however, will be determined by our competitors rather than by us.

We can’t rest on the laurels earned in past years. The lead the German economy holds will last, not for decades, but for just a few years, at best. And as the past has shown us, economic monocultures are in themselves a danger. We therefore need to see an ever-expanding diversification of our economic base, founded on scientific innovations. Consequently, we must strengthen the universities, and we must do so through structural diversification and not by way of general, uniform budget increases. An increase in basic funding should be a matter of primary consideration, since universities, too, need both scientific and financial scope to define and determine the foci of their research for themselves. What sets the German university landscape apart on an international level is its high and homogeneous performance capacity and its availability to all – an advantage that must under no circumstances be forfeited. Therefore, we need educational opportunities for all, and we should attach no small value to the diversity and high quality of Germany’s educational institutions, from technical colleges to internationally renowned universities!

3. We must create genuine added value through cooperation, particularly with an eye to the formation of a scientific elite.

Broad-based universities and highly specialized Max Planck institutes can form a sound foundation for science in Germany only if both sides cooperate with one another intelligently and efficiently. The key question is: How can one commit to networking without losing one’s own specific identity? How can one create genuine added value through cooperation between organizations that are otherwise pitted against one another in competition for resources and personnel – cooperation that is sincerely desired, that is beneficial and that isn’t imposed by compulsion? Local campus structures have a major role to play, as these structures – in addition to scientific training – can also cater to the social needs of individuals and families. I also see great opportunities in the development of supra-regional science-driven clusters in future-oriented scientific fields. In this context, we can concentrate on the most internationally visible areas of concentration, and in so doing, substantially strengthen the attraction of graduate training for students with an enthusiasm for science, and play a part in the development of internationally visible career paths. Our goal must always be to bring together intelligent minds with an interest in research.
4. The Max Planck Society must not only focus more on young people and women, it must also be more courageous in the future orientation of its institutes.

Albert Einstein was 36 years old when he first published his general theory of relativity in 1915. Two years had passed since Max Planck had brought him to Berlin, and at the age of 38 he became Director of the newly established Kaiser Wilhelm Institute for Physics. Einstein was certainly an exceptional talent, and yet experience shows that it is at this age that many scientists make their decisive breakthroughs – which they should make with us! However, the Max Planck Society must not only focus more on young people, but also on women. Now that we have a large number of women among our doctoral students and post-docs, we must once and for all ensure that they are willing and able to carry on working in science. We find ourselves here in competition with numerous business undertakings, and it is a contest that we can win only by offering convincing alternatives.

Of course, science doesn’t stand still; it goes merrily on its way, paying no heed to any increases that may or may not be granted to us: Entirely new branches of science are developing in the space between the natural sciences and the humanities, the field of computer sciences has staged an unprecedented triumphal progress, while the boundaries between chemistry and biology are disappearing and intelligent materials are revolutionizing the materials sciences. We shall address many of these topics – and in the future, we will probably find ourselves more than ever consistently questioning and, where necessary, readjusting the orientation of existing institutes. Only by so doing will the Max Planck Society remain in a position to dare to venture into new areas of research, thereby redefining the boundaries of knowledge.

THE AUTHOR

Prof. Dr. Martin Stratmann, born in 1954, studied chemistry at the Ruhr University Bochum and received his doctorate at the Max Planck Institute für Eisenforschung (iron research) in Düsseldorf. After spending two years as a post-doc at Case Western Reserve University in Cleveland, USA, he returned to the MPI für Eisenforschung as a staff member, and subsequently as Leader of the Corrosion Research Group. From 1994 to 1999, Prof. Stratmann worked at Friedrich Alexander University in Erlangen, where he held the Chair for Corrosion and Surface Technology. In 2000, the Max Planck Society appointed him a Director at the MPI für Eisenforschung. In June 2014, Martin Stratmann took up the post of President of the Max Planck Society.

This article is an abbreviated extract from the inaugural address delivered by Martin Stratmann at the Annual Meeting on June 5, 2014.
The last harvest of passion fruit has been brought in. In our private jungle, which we’ve planted on the grounds of our property and in which bananas and coconuts also grow, around 20 kilograms ripen every two months. Alida and I have again made jam and juice from this crop. Not that this is really necessary here in Manaus, the Brazilian city in the Amazon with a population of two million, where all sorts of exotic fruit and delicious juices made from them are available.

Nevertheless, a degree of self-sufficiency can be useful. Manaus is, after all, very remote – there is only one highway that doesn’t even head toward Brazil, but instead north, to Venezuela. Sure, you can get anywhere from the airport, but otherwise, there are only the waterways that connect the urban jungle in the rainforest with the outside world. And since this is the case, there’s sometimes a glut of certain foods. On the other hand, you can spend weeks searching for them in vain in the supermarket should the supply ship be delayed.

I’ve now been here for four years and will feel somewhat like a Brazilian in exile when I return to Jena in the summer. There are many things that I’ll miss, including one aspect of everyday life that is wonderfully aggravating: the heat. At seven in the morning, the outside temperature already stands at 30 degrees Celsius. Inside, you have to rely on air conditioning, which provides a noticeably cooler environment – at least until noontime. People then take a siesta that lasts several hours, and often travel home to eat. In this midday rush hour, the journey home from the institute, the Instituto Nacional de Pesquisas da Amazônia, takes at least
20 minutes by car, despite the fact that we live only a kilometer away. This is part of the endearing madness here in this concrete jungle in the heart of the world's largest rainforest.

The climate also has its plus points: You don't usually need to dry off after showering .... And the location at the equator ensures there are moist forests. This is the reason why I've spent the last four years here carrying out research. When I travel out into the jungle, the humidity is almost 100 percent. There is an odor of turf and humus, similar to the one found in garden nurseries in Germany. Not like in the big home improvement stores, but in the small garden nurseries, as I remember them from my childhood.

I find the rainforest fascinating because of the vast array of plants and animals, which you usually only discover at second glance, or when you take the time to pay attention to detail. This is best done when I stay overnight in the jungle during a field trip, taking just a tarp, a mosquito net and a hammock. Sometimes this results in extraordinary encounters: once, in a single day, I got to see all three varieties of anteaters. That may sound cute, but the chances are almost as remote as your numbers coming up in the lottery.

A colleague told me that the institute used to be located outside the city in the 1970s and 1980s, practically in the jungle. But Manaus is a growing city, and the roads quickly become congested. As the soccer World Cup made things even worse, the government decreed four days of public holiday – whenever tournament matches took place. The working hours had to be made up on other days, and school kids even had to attend special classes on Saturdays.

We are now a tri-national family. Alida is Mexican, and our daughter Camila was born in Brazil. When we travel, we take a blue, a green and a red passport along with us. And during the World Cup, we of course cheered on all three teams. My heart went out to the Brazilians after their hammering by Germany. But this was outweighed by the joy of seeing Germany win the World Cup for the fourth time – naturally! Brazil will definitely remain with us. And it isn't just my research that will bring me back: after all, Manaus is the city where our daughter was born.

Report: Jens Eschert
The Difficult Birth of a State

States don't emerge from a void, but are always the result of political decision-making processes among not only the people who live in them, but also a complex array of external players. The case of South Sudan, the newest member of the international community of sovereign states, is one more example of such a process taking a violent turn, since the divergent interests are far from being balanced, and institutional methods of dealing with conflicts are weak or not generally accepted. Many of the complex patterns of emergence and models involved here strike Katrin Seidel and Timm Sureau from the Max Planck Institute for Social Anthropology as being extremely familiar.

After almost half a century of civil war, South Sudan seceded from Sudan about three years ago. Together, they once formed Africa's largest country. After a conflict that is estimated to have cost around two million people their lives, it appeared that peace had finally arrived once the constitution of statehood was achieved. However, a major new conflict flared up toward the end of last year. This time, it wasn't the rebel armies of the South who lined up against the soldiers and allied militia of the Sudanese central government, but the South Sudanese fighting among themselves. It began as a political incident that set in motion a conflict spiral in which the South Sudanese President Salva Kiir Mayardit and Riek Machar, who Salva Kiir Mayardit had removed from his position as Vice President, became the main political opponents. Around five months later, in June 2014, under pressure from international players, President Salva Kiir Mayardit and his former deputy Riek Machar signed a ceasefire agreement that includes the formation of a new “Transitional Government of National Unity.”

ALTERNATING PHASES OF WAR AND PEACE

In the opinion of researchers from the Max Planck Institute for Social Anthropology, the prospects that this new attempt at brokering peace will last are far from certain. “With regard to state emergence processes in the Horn of Africa region, we've been observing situations involving alternating phases of violent and non-violent dynamics,” explains lawyer and Africa specialist Katrin Seidel. The staff member of the “Law & Anthropology” department headed by Director Marie-Claire Foblets
Beef is a staple food in South Sudan. Because of this, the protection of cattle – as practiced here by a member of the Dinka people in 2013 – is an important task. Now the country is threatened with a disastrous famine, as fields couldn’t be tilled in some regions due to the fighting in the country.
the researchers’ view, from today’s perspective, one of the most momentous moves was the removal of Vice President Riek Machar from office. After the latter began to publicly show ambitions to stand for the office of President in 2015, President Salva Kiir Mayardit finally dismissed his deputy, together with the entire cabinet, in July 2013, citing the need to form a leaner and more effective government as his reason for its dissolution.

POWER: ALWAYS A MOTIVE FOR CONFLICT

“Surprisingly, it took several months for the expelled political actors to react publicly,” reports Seidel. In a press release issued in December of the same year, members of different political factions associated with the former Vice President and the ministers who had been removed from office along with him reproached the President for abuse of power. In addition, they criticized his autocratic style of leadership and accused him of excessive patronage. As Seidel explains, the President didn’t take these accusations lying down: “He presented them as futile attempts by resentful political losers to discredit him.” The conflict didn’t remain limited to verbal jousting for long. On the contrary, the political situation quickly escalated into a violent conflict that once again claimed countless lives, filled the ad hoc refugee camps far beyond the limits of their current capacity, and was now expected to come to an end with the aforementioned ceasefire agreement.

This to and fro between phases of violence and peace is like a wrecking ball dangling over the emerging state structure. Even though South Sudan formally became the newest member of the international community of sovereign states in July 2011, “the process of state formation is far from complete,” says Seidel. Together with Timm Sureau, she has studied the implementation of governmental infrastructure in theory and practice.

South Sudan’s polity is far from solid in its standing or condition, or from forming the clearly delineated, stable entity suggested by the Latin term status, from which the English word “state” derives. “You have to imagine it like a cloud that accumulates water molecules and then loses them again,”
says Seidel, suggesting a more appropriate concept. The lowest common denominator in such assemblages, which are subject to spatiotemporal change, isn’t the word, idea or concept, but the structure itself. “In this accumulation, boundaries are constantly redrawn between those on the inside and those on the outside,” she says.

Based on the observations of the two researchers from Halle, such processes of inclusion and exclusion are pervasive in South Sudan. Although the Transitional Constitution of 2011 stipulates that all South Sudanese have equal rights, the reality is quite different. As the researchers have discovered in many places, far from all of the country’s residents have access to citizenship and the associated rights and privileges. In anthropological field studies, which led him to the region around the provincial capital of Torit, Timm Sureau observed how the current system for the regulation of land rights also incorporates new forms of discrimination. As he discovered, “in this case, it affects urban migrants.”

In most cases, these are people who fled their original villages in an attempt to evade murder and assassination in the chaos of the war, or left them as combatants in the civil war against the central government, and now sought to establish a new existence in the surroundings of the small but rapidly growing capital city of Eastern Equatoria. Lucy – a Lokoya woman who had sown a field of millet not far from the capital and whose progress Sureau followed for nine months as part of his research – presents an exemplary case of current practices in relation to legal rights and the treatment of citizenship.

According to the Transitional Constitution, the land belongs to all people in South Sudan. Locally around Torit, it is usually accepted that anyone who makes a parcel of wilderness agriculturally productive is also entitled to farm it. Accordingly, Lucy merely asserted her right as a citizen when she ploughed an area of fallow land and cultivated millet on it. And she was allowed to do this until the United Nations Mission in South Sudan (UNMISS) needed space for the extension of its local office and was allocated a piece of development land by the representatives of the National Land Commission – the land on which Lucy’s field was located. Suddenly she found herself standing in front of a barbed-wire fence.

LAND RIGHTS YES, BUT NOT FOR EVERYONE

In reality, as Timm Sureau discovered in the interviews he conducted with representatives of the ministries responsible for land allocation, the local authorities involved in the process, and the Monyomiji, a kind of council who wield the highest authority at the local level, the fair and equitable access to land for all South Sudanese citizens enshrined in the constitution is subject to very loose interpretation and reinterpretation. The researcher encountered remarkable contradictions in the statements made by those he spoke with about these issues. On the one hand, they accepted the legally established land rights of all South Sudanese. On the other hand, they denied this right in Lucy’s case, for example, based on the argument that she didn’t come from Torit originally and is therefore not “local,” having been born in a village 40 kilometers away.

As a result of the authorities’ practice of applying two criteria in the assessment of citizen’s rights, according to Sureau, a new generation of “second class citizens” is being produced. The researcher considers this trend to be highly volatile. As the recent past has shown, such distinctions can carry social dynamite with them. “With the resistance to the central government of Khartoum, from which the civil war between the North and South and, ultimately, the division of the country developed, the residents of the South were initially only concerned with fighting against their perceived marginalization,” says Sureau’s colleague Seidel. What was essentially at stake here was the right to participate in political decisions and in the profits gained from oil deposits so that they could improve their living conditions.

However, even at that stage, the political elites of the South brought the very vague category of “indigenous” into play in legitimizing their claims and mobilizing resistance within the multicultural state. As the example of land rights shows, this is now being reinterpreted in a very different...
way and is giving rise to further divisions. “The much vaunted ‘unity in diversity’ that derives from the Declaration of Independence and that was supposed to provide the pillar on which South Sudan rests as a sovereign state, even to the point of being enshrined in the Transitional Constitution, still appears to be a matter for negotiation,” says Seidel.

In any event, it would be difficult to establish a functioning South Sudan polity on the basis of existing normative frameworks, such as the Transitional Constitution, says the expert in legal matters. “The Transitional Constitution is a very hastily produced amalgam that was compiled under enormous international political pressure and time constraints.” For Seidel, the constitution presents itself as a pre-fabricated legal framework that has little to do with political will formation of the South Sudanese people. It reflects neither the diversity, needs and demands of the local communities united under the umbrella of the new state nor their respective legal concepts, let alone constituting an expression of sovereignty. “The idea of a territory of Southern Sudan can be traced back, in part, to colonial concepts of the 1920s when the Anglo-Egyptian government regulated the migratory flows applying a so-called ‘district policy’,” say Sureau and Seidel.

Today, some of the political actors involved in the first period of governance appear to have been aware that this fiction of a territorial constituency from the colonial period goes beyond the legal and social realities. In this context, a comment made by the former undersecretary of South Sudan’s Ministry of Culture and Heritage, Jok Madut Jok, who the researcher met in April 2013, is telling. “He sees South Sudan in its current constitution as little more than a geographical fact, the unity of which emerged solely from the common rejection of Sudan’s central government,” she says.

THE ETHNIC CONFLICT IS MERELY A PRETEXT

As the two Halle-based researchers have observed, the processes of division continue to operate in South Sudan even after the secession, after the North stopped serving as a unifying enemy. For Max Planck Director Günther Schlee, who has already studied the mechanisms of collective identity formation in numerous African countries once torn by civil war, the question of social identification also plays a crucial role in the emergence of the conflicts in South Sudan. “It is always about who belongs to whom, and why. Membership in a group or alliance also regulates access to resources, support and other advantages that aren’t enjoyed by those outside these constructed social boundaries.”

In Schlee’s opinion, “ethnicity” and “indigenousness” are the categories with which inclusion and exclusion are practiced in South Sudan. They constitute arguments for political actors and local elites alike – for example when dealing with the question of citizenship and the associated rights that someone either has or – as in the case of the expropriated farmer Lucy – doesn’t appear to have.”

Such examples, as the social anthropologists see it, illustrate the flexibility of sociopolitical categories. “These political arrangements can be altered as needed without any loss in terms of their plausibility, for example, by shifting the focus to ethnic criteria in one case, or religious or regional criteria in others. All of these arrangements can also be defined more narrowly or broadly,” says Schlee. Moreover, the processes in South Sudan clearly show how sovereignty claims of political actors go hand in hand with the actors’ attempts to ob-
tain privileged positions and room for political maneuvering for themselves. Group formation and exclusion thus play a role in this process; in this instance, however, through the very clear deployment of ethnicity merely as an instrument. President Kiir belongs to the Dinka ethnic group; his former Vice President and political opponent Riek Machar is one of the Nuer people. They are both currently exploiting their membership in these ethnic groups to mobilize their followers against their opponents. Interestingly, the two most similar ethnic groups in South Sudan are once again being set against each other. “The Dinka and Nuer are closely related culturally,” says Schlee. For this reason, conflicts regarding pasture land and waterholes repeatedly arose between these two pastoral groups in the past. “The potential for conflict increases with similarity,” he says, describing the mechanisms well known from conflict research, which completely contradict the popular theory of the clash of civilizations.

Katrin Seidel and her colleague Timm Sureau succeeded in unearthing some reliable information about how the population perceived the spreading political and military confrontations across the entire country, starting from the escalations in the capital city of Juba on December 15, 2013. However, one public opinion survey that was carried out by a non-governmental organization in Juba enabled them to draw some illuminating conclusions about the true nature of this supposedly ethnic conflict. “In the survey, many people wondered why the government failed to resolve its differences in a non-violent manner,” Seidel reports. Obviously, it is clear to even large sections of the civil population that what is involved here are turf wars between representatives of political elites who are now using their ethnicity to gain the support they require. The researchers in Halle also see things in a similar light. “It is the typical wrangling among victors for the resources, offices and powers that, as examples from history show, often accompanies the early decades of the state formation process,” explains Katrin Seidel.

State formation processes in themselves are difficult to compare because they don’t follow particular patterns. Despite this, states are measured with respect to their risk of disintegration on the basis of certain criteria. According to the current “Fragile States Index 2014,” which was published by the Fund for Peace and Foreign Policy, South Sudan leads the list of “failed” states. “Paradoxically, an emerging state is simply dismissed in this way,” says Seidel. This categorization doesn’t get to the core of the matter because it’s based on certain European ideas of statehood. In Günther Schlee’s view, this assessment is based on false premises. “It presupposes a collective identity, meaning a fictitious entity comprising the entire ‘constitutive people’ for whom the state has failed,” he states. “But in the case of South Sudan, this constitutive people hasn’t yet been formed.”

“Processes of state formation frequently go hand in hand with alternating violent and peaceful phases,” says Seidel. In Schlee’s view as a conflict researcher, one can set orientation marks to let people find the path to peace. There are three of them: “First, ethnicization and religious polarization must not be encouraged, and ethnic stereotypes and differentiation should always be challenged. Second, the idea of equality shouldn’t be abandoned in favor of group rights. And third, one should hold on to the idea of ‘universal citizenship’, that is, the same legal status and the same opportunities in life for all citizens.”
Dynamic family law reform, recognition of adoption and consideration of a child’s best interests: Nadjma Yassari from the Max Planck Institute for Comparative and International Private Law in Hamburg and her “Changes in God’s Law – An Inner-Islamic Comparison of Family and Succession Law” research group illustrate how complex and mutable law in Muslim countries is.

TEXT MICHAELA HUTTERER
Forward into the stone age,” read a headline in the German newspaper Frankfurter Allgemeine Zeitung in early May in a report on the introduction of sharia in the Sultanate of Brunei: ultimately even with the threat of death by stoning.

“Islamic law really doesn’t have a good image,” bemoans Nadjma Yassari. “It is generally reduced to Islamic criminal law and its corporal punishments. Many people underestimate how diverse and open to reform Islamic law is, and consequently also jurisprudence in Muslim countries,” remarks the head of the research group “Changes in God’s Law” at the Max Planck Institute for Comparative and International Law in Hamburg.

Together with her team of eight, she is providing significant insights and information. “Emotions and generalizations prevent objective, scientific analysis of legal systems that are often fraught with controversy,” emphasizes Yassari. Disputes often arise between law and religion, between state legislation and religious norms. Family law is a minefield of conflicting interests, for instance between the sexes and between the individual and society.

The research team is examining common traits and differences, as well as areas of conflict in the family law of countries governed by Islamic law – which, after all, number 33. Only Turkey has completely rejected Islamic family law, instead adopting Swiss family law.

In most Islamic countries, family law nevertheless continues to be based on Islamic law in the respective regional form of the predominant Islamic school of jurisprudence. Islamic law’s claim to validity differs in these countries. The research group sees its task as exploring and conducting research into this field.

“I am delighted to be part of a team of outstanding academics who share my passion and desire for research into the law of Muslim countries. Our field
The research group has been analyzing the bases and forms of family and succession law in Muslim countries since 2009. “The full complexity of the law needs to be understood to make its effects transparent and to identify reforms and reform potentials,” explains Yassari, outlining the adopted research approach.

The research group has been analyzing the bases and forms of family and succession law in Muslim countries since 2009. “The full complexity of the law needs to be understood to make its effects transparent and to identify reforms and reform potentials,” explains Yassari, outlining the adopted research approach.

The influence of procedural law is highly significant. It often contains provisions that affect substantive law. Under Islamic law, marriage can be entered into without formalities. Nevertheless, marriages must be registered in most countries. This is due, on one hand, to the desire for the administration to acquire legal certainty, while on the other, legislators are also seeking to curb the estimated number of unknown cases of marriages between minors and so-called informal marriages. “Substantive law is reformed through the introduction of mandatory registration into a neutral branch of law, such as procedural law, thus avoiding directly addressing the discrepancy between what is permitted by religion and the state,” Yassari points out.

This has far-reaching consequences that differ from country to country. Whereas a non-registered marriage has legal implications in Iran, claims from such marriages will not be heard in Egyptian courts, even if they are valid under Islamic law. In Tunisia, however, unregistered marriages are always deemed invalid. In order to conduct research into family law in Muslim countries, extensive knowledge of the sources of Islamic law and its methods of law-finding is, unfortunately, still perceived as some exotic form of science,” says the 43-year-old lawyer.

There is, however, nothing exotic about divorce, custody or a child’s best interests. When marriages break down, the same disputes arise regardless of whether it happens in the Persian Gulf or on Lake Constance: Who gets custody of the children, who has to pay maintenance and who receives the assets? “It’s ultimately about life plans unraveling, injured pride, unfulfilled expectations, revenge and money – that’s not very different from what goes on in German courtrooms,” says Yassari.

When legal scholars conduct research, they don’t develop patents, invent equipment or discover serums. Instead, they establish the foundations for objective decision-making, and provide academic insight into legal systems that are only ostensibly exotic.

Islamic law is often reduced to criminal law and its corporal punishments – its diversity and openness to reform are overlooked.
are essential. Law sources include the Koran, the traditions of the prophet Mohammed, the consensus of legal scholars and the findings of law by analogy – in other words, the transfer of existing provisions to similar new cases. Islamic law is established through the interpretation of these sources – known as *īghtiḥād* in Arabic – by Islamic scholars. They play a significant role in the formulation of legal norms.

**ISLAMIC LAW IN TRANSITION**

The research group’s first project focused primarily on marriage law. From 2009 to 2013, the group traced, by means of inner-Islamic legal comparison, the development of particular legal issues and phenomena – such as informal and interfaith marriages or the placing of Islamic family law under state control – in various countries. In doing so, they revisited the myth of the immutability of Islamic law.

As part of their work, the scientists visit the region, conduct local interviews with attorneys, authorities and judges, and observe proceedings. They evaluate judgments and specialist publications, follow legislative processes and foster an interdisciplinary international network. Research into Islamic law requires more than just legal and linguistic expertise: an understanding of people, their situation and the historical context is also a vital attribute.
The view has long prevailed that, toward the outside, a homogeneous Muslim community acts uniformly as a united group. “The Arab Spring has shown that there is no such Arab community per se, but rather individual countries whose seemingly uniform appearance ends just as abruptly as their regimes with the fall of their rulers,” reports Imen Gallala-Arndt.

UNCERTAINTY OVER MARRIAGE LAW

The native Tunisian is currently qualifying as a university lecturer with a thesis on interfaith marriages in Tunisia, Israel and Lebanon. Her specialist field is highly contentious: Difference of faith is an obstacle to marriage under religious law. When interfaith couples marry in Germany, they often don’t know whether the marriage will also be recognized in their native countries. This results in a lack of legal clarity. While the marriage is valid under German jurisdiction, it may not have any effect in the spouses’ countries of origin.

Gallala-Arndt has also been focusing intensively on the upheaval in the Arab world since 2010. “Arab society is going through a transformation and is revealing its true face with all the conflicts and contradictions, whether in law, family or faith.” Secular forces calling for detachment from Islamic law and conservative religious factions are currently going head to head. “Everything is in a state of flux. It’s unclear how events will turn out,” acknowledges the jurist.

Take Egypt, for example: Long before the first protests took place on Cairo’s Tahrir Square, Suzanne Mubarak, the wife of former president Hosni Mubarak, was fighting for women’s rights as part of a feminist organization. The progress made was swept away with the fall of the regime. Indeed, everything associated with the past is regarded as dubious and is frowned upon.

Reform didn’t begin with the Arab Spring. Family law has long been dynamic. “The law is as diverse as the countries in which it is practiced,” explains Lena-Maria Möller, who analyzed family law in the Gulf States in her recently completed doctoral thesis. “There are these ultra-modern cities and centuries-old law that is supposed to meet the needs of the modern world.”

MORE DIVORCES

Marriages are no longer lasting a lifetime in Islamic states, either. Divorce rates are rising and traditional roles are being eroded. “Almost all of the Gulf States have adopted new codes of family law over the past decade that govern divorce and its consequential matters, such as custody and alimony,” remarked Möller. All Arab countries have codified family law except for Saudi Arabia.
The United Arab Emirates have made significant headway in this respect. Emirati law firstly followed a general trend of Islamic states by establishing the principle of the child’s best interests in custody law. It has also taken an extraordinary step beyond that: if a divorced mother marries again, she now no longer automatically loses custody of her child. “This provision represents a departure from traditional teaching,” observed Möller.

Children are traditionally transferred to the custody of the father starting at a certain age – girls somewhat later and boys somewhat earlier. Irrespective of who initiated proceedings, a divorce therefore often meant a life of asceticism or informal marriage for the mother. “A new principle is now establishing itself: the child’s best interests take precedence over traditional Islamic law,” explains the scientist. Recent judgments show that this law doesn’t just exist on paper. The Court of Cassation there recently allowed the child to stay with the mother despite the fact that she had remarried.

The research team led by Nadjma Yassari isn’t yet extolling the virtues of statutory law. The researchers are aware that it takes time before new legislation is accepted and implemented in practice. Take another example from Egypt: Egyptian law grants engaged couples the right to contractually govern their personal and financial affairs upon marriage. Space is provided for special agreements in the official marriage certificates. However, when a German-Egyptian woman in Cairo wished to register a different custody arrangement, the official refused to admit the clause. “This field always remains empirical,” he told her unsympathetically. Having and exercising rights are two different things.

LIBERAL JUDGES, LIBERAL LAW

Even more significant is the administration of justice. It is the judges who interpret and breathe life into positive law. It is their duty to further the law through ijtihad, or interpretation. They can’t be accused of lacking relevant experience. Iran’s family judges, for example, have to be married themselves to sit on the bench in family matters. Although judicial office is open to women in almost all Muslim countries, there are but few women in the judiciary.

Irrespective of how judges reach their decisions, one thing is clear: in contrast to secularized countries, the interpretation of statutory law cannot contradict the principles of religious law.

However, this doesn’t restrict judges’ discretionary powers. “Islam doesn’t prohibit liberal views,” emphasizes Imen Gallala-Arndt, dispelling a stereotypical belief. “Reform is compatible with Islam.” Yassari also stresses this point. “If you search hard enough, you’ll find a relevant verse in the Koran for any perspective,” she says with a twinkle in her eye. “The essence of Islamic law is the dynamic nature of lawfinding. Since Islamic law is derived from the sources and has to be interpreted, human analysis, which is fallible and pluralistic, is combined with the divine.”

This also points to the most important finding of her research: the immutability of Islamic law doesn’t stand up to scientific analysis.

The Emirate of Abu Dhabi provides teaching material on divorce, custody and maintenance law for the training of judges.

Islam doesn’t prohibit liberal views, and reform is compatible with Islam.
The research group’s findings aren’t just of benefit to legal scholars and practitioners in the Muslim world. Whether in Saarland, Berlin or Bremen, German judges also require knowledge of the law of Muslim countries. It is also applied in Germany in the same way as Italian, Turkish or Spanish law each time private international law makes reference to foreign law. If two Italian citizens get married in Munich, for example, the marriage is subject to Italian law. If two Iranians wish to divorce in Hamburg, Iranian law applies.

The Center of Expertise for the Laws of Islamic Countries in Hamburg is one of the most important sources of knowledge for both teaching and practice. An understanding of over 30 different legal systems makes Yassari and her team leading experts on the law of Islamic countries, and German judges and officials are glad to call upon their knowledge.

In her post-doc thesis, Nadjma Yassari looked at the Islamic dower, a proprietary right of the wife against the husband, which isn’t known in German law. German judges nevertheless
must decide upon dower claims in divorce cases. In her monograph on the dower, published in summer 2014, Yassari examines this legal institution from various perspectives, including those of classical Islamic law, contemporary law in selected Islamic countries, and German law.

THE CHILD’S BEST INTERESTS IN ADOPTION CASES

In order to enable it to continue following legal developments in the region, the research group’s funding period was extended by a further two years until March 2016. The second research project focuses on legislation governing the rights of children and how the principle of the child’s best interests has found its way into the legislation and courts of Muslim countries. Yassari focuses in particular on adoptions in Muslim countries that are to be recognized in Germany.

One such case involved a married couple from Cologne with Iranian roots who flew to Teheran in 2008, rented an apartment and met “their” child for the first time at an orphanage. The initial visits turned into a six-month trial stay during which the parents completed all the paperwork. They even changed their will to benefit their future adoptive child.

A court in Teheran awarded them the “definitive parental rights” to the then six-year-old. When the mother sought to return with him to Cologne, the German authorities refused the child entry. Their argument: Islamic law doesn’t recognize adoption and, what’s more, the Koran expressly forbids it. The German father appealed, taking the case as far as the Higher Regional Court in Cologne. He demanded that the court recognize the adoption abroad.

The family was involved in a three-year court battle, and received support from Nadima Yassari. The family won the case thanks to her expertise. The Federal Office of Justice’s view was that Iranian law, as an Islamic legal system, didn’t recognize adoption. This interpretation fell short of the mark. “Iran has had its own legal structure – the sarparasti, which enables adoption – for the past 35 years, without referring to it as such,” explained Yassari. The sarparasti establishes a parentage relationship between the adoptive child and the adoptive parents, similar to the adoption of adults under German law.

Expert opinions like this help authorities such as courts to carefully address specialist issues and better put them into context in their domestic legal setting. In an ever more globalized world, various legal systems are increasingly applied alongside one another. Disputes still arise between legal traditions. Yassari’s research contributes to less-biased analysis of conflicts.
The Anatomy of the Shooting Spree

Shooting sprees shock us and spark bewilderment and fear. At the Max Planck Institute for Human Development in Berlin, a Minerva project is examining the link between possession of firearms, violence and emotions, based on the example of shooting sprees. Historian Dagmar Ellerbrock has already addressed the controversial topic of “youth and weapons” in previous studies.

TEXT ADELHEID MÜLLER-LISSNER

Whether in Erfurt, Winnenden, Dunblane (UK) or Columbine (USA): shooting sprees shock us – and cry out for explanations. After a carefully prepared, armed attack on a large group of people by a lone assailant, academics in a range of disciplines are regularly confronted by the media, hungry for explanations of such unfathomable events.

Right at the start of our discussion, Dagmar Ellerbrock is careful to curb any expectations that she will provide a quick and comprehensive answer to such questions. While she addresses the topic of shooting sprees in her new project, “Godforsaken, angry or callous? Shooting sprees from a transnational perspective” at the Berlin-based Max Planck Institute for Human Development, Ellerbrock and her research group are taking care not to search for one unifying explanation, a final answer to this long-standing question.

Rather than a why, the project poses the question of a very particular – and in truth also particularly important – how: how are violence and emotions linked in shooting sprees? “We study the topic through the lens of emotion, which no one has ever looked through before,” says Ellerbrock.

TAKING A GUN TO CLASS

A few years ago, Ellerbrock demonstrated with her research on “gun boys” and the German weapons culture of the 19th and early 20th centuries that reading historical sources through this lens is exceptionally fruitful. Her starting point was the alarming news that 8 to 25 percent of German schoolchildren sometimes go to class armed. More often than not, it’s a knife they’re carrying in their pocket. This, at least, is what inquiries following the Winnenden massacre revealed.

The media was increasingly filled with concerned discussions warning against “American conditions” taking hold in Germany’s classrooms. Would it soon be necessary also in Germany to convey the message “Don’t bring guns to school!” as did the 1991 song by the American band Little?

But was everything really better back in the day? And are the terrible weapon-carrying trends really coming to us from across the Atlantic? Dagmar Ellerbrock offers a wealth of historical documents that refute both of these positions. It’s not only the students who, in Goethe’s day, didn’t think twice about coming to class with their swords, or the young tradesmen who bought decorated knives and pistols with their first paychecks.

Younger adolescents were clearly carrying firearms in Germany as early as the start of the 19th century: in the Duchy of Coburg, in any case, a decree had to be issued in 1810 prohibiting schoolchildren from using rifles.

For a long time, however, possession of weapons wasn’t prohibited. In the mid-19th century in the state of Württemberg, a speaker for the Ministry of the Interior reassured critics of the prevailing light-touch regulations:
“As concerns young people, it’s up to their parents and guardians, and not the state, to keep watch over them.” Whether 19th-century pupils in their final school year or scholars and journeymen in the Middle Ages, according to Ellerbrock, it was always the case “that young men carrying weapons was an everyday phenomenon.” The knives, swords and pistols had high emotional significance as highly coveted personal accessories. An expression of maturing manhood and strength, their owners cherished and maintained them well. What changed at the turn to the 20th century, then, were not the emotions and customs of the young men, but rather the potential danger of the new weapons now available to them.

Now automatic pistols like the Browning 1900 were coming onto the market and drawing the covetous glances of minors. “Weapons technology developed rapidly in the last third of the 19th century,” explains Ellerbrock. In addition, the possibilities for mass production made the individual object of desire significantly less costly – and also facilitated more effective marketing. One Belgian-produced model of the Browning was, as the historian discovered, even distributed by the caseload to school graduates as a promotional gift – before their parents could intervene.

For Ellerbrock, it was an agonizing experience to hold a specimen of this popular firearm in her own hand. It was, however, a model that had long ceased to be functional, found at a flea market, completely without ammunition. What feelings did the weapons arouse in the youths at the threshold of adulthood? “For a group of young people at the time, the Browning was a fashion must-have, similar to the iPhone today.”

WEAPONS IN CHILDREN’S HANDS – PROHIBITED AFTER THE WAR

Once it had reached this point, the relaxed attitudes of politicians came to an end. There was reason enough for concern, with repeated incidents involving impulsive actions and terrible accidents resulting from inexperienced children handling weapons or inebriated young men having them to hand in the heat of the moment.

The press, too, was now criticizing the fact that every schoolboy was able to procure dangerous weapons and ammunition. Ellerbrock analyzed many newspaper articles from the 1910s. In March 1911, for instance, the Pfälzische Rundschauf asked, “What does a cobbler’s apprentice need a revolver for?” and the Münchner Neuesten Nachrichten lashed out against “Firearms in the hands of children.”

“It was the First World War that changed Germany’s relationship to firearms,” explains Ellerbrock. But it wasn’t until 1928 that the German parliament passed the law on firearms and ammunition – the first law to regulate their possession and use. After the end of the Second World War, the majority of Germans could no longer fathom how weapons could ever have been associated with positive emotions: the once notoriously trigger-happy nation had changed. Weapons were no longer such a natural symbol of manhood, honor and social distinction.

“A German story of hope,” as Dagmar Ellerbrock calls it, cautiously optimistic. “Looking back at the history of weapons in Germany can relieve the unnecessary cultural pessimism toward the current weapons problems at German schools,” she writes in a piece for Stephan Rusch’s work Waffen an Schulen [Weapons in Schools], published in 2011. From her research on the so-called “gun boys” she concludes: “We Germans were at least as armed at the end of the 19th century as the US is today. And neither was everything different nor was everything better back then.”

If we look at the problem of killing sprees, however, it’s difficult to come to such an assessment. From the German Empire, at least, no reports were passed on of major catastrophic incidents in schools on a par with those in Erfurt in 2002 or Winnenden in 2009. At most, there were the brutal deeds of the Swabian teacher’s assistant Ernst August Wagner, who, in 1913, killed his wife and their four children and then went on to set fire to several houses and shot the occupants as they fled. But the man who

“...that the carrying and the sale of weapons in Prussia may not be regulated by police decree, and that such police decrees are null and void....”
Excerpt from a letter from the Attorney General in Hamm to the Minister of Justice in Berlin, 1903
newspapers of the time called a “mass murderer” was a grown man and father of four. Today’s perpetrators are typically between 16 and 25 years old. And the term “amok,” a Malay word meaning “attack in a blind rage and kill,” was not used at the time, as it is today in the German term for shooting spree, Amoklauf.

USING VIOLENCE TO ESCAPE SHAME

If we try to read shooting sprees through the lens of emotion, as Dagmar Ellerbrock aims to do in her new project, then the unhappy family man from Swabia could still provoke an interesting analysis. Wagner reported that he had a penchant for sodomy and thus felt ridiculed by the people around him.

In her project, Dagmar Ellerbrock hopes to address shame as one possible root of shooting sprees, following the approach of sociologist Thomas Scheff from the University of California. He views shame as an important regulator of violence – shame about being different from others, about not conforming to social norms. Shame is also associated with bullying. According to Scheff, shame in particular tends to be kept secret, so that an individual must deal with their problems alone, often leading to anger and rage that spill over into violence.

Scheff advocates seeing people independently of other people’s judgments, and independently of those judgments
that we anticipate in our own thoughts, or that exist merely in our heads. Only in this way can we understand the negative feelings that, in certain cases, can lead to a person running amok. Ellerbrock, too, says that “violence is frequently used to escape such negative emotions.” Since a person’s violent actions in turn determine how others judge them, the perpetrator gets caught in a fatal spiral.

It is initiated by conflicts – with oneself and with others. “For historians, conflicts are always a highly welcome lens. They illuminate predetermined breaking points and the development potential of a society,” explains Ellerbrock. But it is important to see the conflict not only with “ex-post vision” as an unavoidable trigger of violence: “We should also bear in mind other possible outcomes.” Perhaps as the paths by which conflicts can be settled without resorting to violence. “Emotions are important modulators for this. They set the tone and the direction.”

Shooting sprees have always resulted in a great sense of helplessness. “Previously, they were construed as a consequence of godlessness,” says Ellerbrock. The religious interpretation patterns have since been replaced by psychological and psychiatric ones, but these often focus solely on the perpetrator. One aim of the Minerva research focus on “Emotions, Violence and Peace” is to also embed these hard-to-understand and self-destructive acts of violence in a social framework that has been shaped by history. “We look at the situation – the perpetrator is just one player among many,” says Ellerbrock.

WHOSE FAULT IS IT: LAX GUN LAWS? THE MEDIA?

This is the point at which Ellerbrock was able to tie in her earlier research, which is concerned with the importance of weapons to the society in which both perpetrators and shooting spree victims have grown up. It’s not without reason that calls for stricter gun control laws are heard anew after each killing spree. A comparison at the national level is particularly interesting in this context: in Germany, a tightening of the laws is certainly discussed after each massacre, so far resulting in only minor details having been changed, while in the UK, the response to the events in Dunblane was a drastic tightening of gun control laws.

In this shooting spree, which took place in a Scottish primary school in 1996, 16 children and their teacher lost their lives. At issue in the current Scottish independence movement is a further tightening of these laws. In Germany, in contrast, Ellerbrock sees a permanent influence of the rifle clubs, a strong lobby that opposes such drastic regulations. For her, however, gun control laws aren’t the key to understanding national differences. “Weapons are pervasive in Scandinavia, but still there are hardly any shooting sprees,” she says. This made it all the more sensational when, in July 2012, Norwegian Anders Breivik killed 77 people, mostly teenagers, who were attending a summer camp.

What role does the media play in this structure? Are they partially responsible for turning killing sprees into a modern form of extreme violence in a globalized world? After all, negative heroes can also become role models. “Columbine had a certain exemplary character. Such details as the perpetrators’ clothing and the time of the attack were later copied by other assailants.”

In this shooting rampage at the local high school on April 20, 1999, two students killed 13 people and themselves. This is the point at which the tricky issue of positive feelings comes into play. “Violence leaves traces behind,
even in the perpetrator’s body,” says Ellerbrock. A threshold is evident in “body-contact-oriented” sports, where the boundary between tolerable and illegal attacks is determined by rules, adherence to which is ensured by referees. The overstepping of boundaries, a regular occurrence, can probably be easily explained by the pleasure potential of violence. Hooligans, for instance, could well be characterized as “lusting after violence.”

THE WORLD OF EMOTIONS IS TERRA INCOGNITA

Particularly in Germany, the pleasure potential that resides in the “self-empowerment of violence” may be a taboo topic due to its 20th-century history. The Minerva project also examined the acts of violence in the political conflicts that were carried out in the streets during the late Weimar Republic, right before the Nazi Party came to power. One example is the street fights between communists and the motorized SS in the city center of Karlsruhe in 1933.

In analyzing police and witness reports, the Max Planck researchers noticed that the rivals’ hate-filled faces were mentioned repeatedly. “Emotions were an important part of the dynamic,” says Ellerbrock. The events can’t really be understood unless you take into account the difficult situation resulting from the conflict between aggression, excitement, fun, a sense of belonging and solidarity.

For a present-day observer, much of this is difficult to comprehend. Do people from different historical epochs even have the same feelings in the face of violence, or are their feelings shaped...
Biological aspects of emotions have been a subject of neuroscience for a few years, but emotions are also shaped and conditioned by culture. One department at the Max Planck Institute for Human Development in Berlin is addressing the "History of Emotions." In the Minerva project "Emotions, Violence and Peace," headed by historian Dagmar Ellerbrock, the researchers look at, among other things, the historically changing emotions in dealing with weapons.

In the 19th century, for instance, the possession of weapons was considered to be an expression of maturing manhood and strength. Around the turn to the 20th century, however, although the emotions and customs of young men didn’t change, the potential danger of the new weapons did. The First World War influenced Germans’ attitudes toward weapons.

One of the challenges of the new project on shooting sprees will be finding suitable sources that can provide information about the emotional state of the perpetrators. In contrast to the topic of “gun boys,” there are very few historical witnesses, says Ellerbrock regretfully. “In terms of sources, the topic of shooting sprees is a very difficult one.” Many of the perpetrators didn’t even leave a suicide note behind. “The problem is that, instead, many things are ascribed to them from outside.” This, in turn, can contribute to the stylization of the negative “hero” who, however, from a sociological and historical perspective, is just one of many players in a complex event. Some propitious finds in the historical record and enough time for research – these are the favorable conditions Dagmar Ellerbrock now hopes to have for the new sub-project.

She already demonstrates impartiality in dealing with a complex issue, many aspects of which are taboo. Another force that drives her is the certainty that findings regarding the potential desirability of physical violence and the use of weapons to cope with negative emotions can ultimately contribute to a more peaceful society: “Our research doesn’t pursue purely academic interests, but also, and primarily, social ones,” she says. Because only by considering the entire spectrum of emotions that can arise in the context of violent acts – before, during and after – will we have a chance to counteract them.

Historical sources on shooting sprees are a difficult matter. Dagmar Ellerbrock (right) and her colleagues Natalia Marcelo (left) and Charlotte Piepenbrock are hoping to find more texts than just those that focus on the perpetrators. Their interest in the topic isn’t purely academic in nature; they believe that the findings absolutely could contribute to a more peaceful society.
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Receptive to Music

Pregnant women respond to music with particularly strong changes in blood pressure

Music can be soothing or stirring, it can inspire us to dance or make us feel sad. It also triggers powerful physiological reactions in pregnant women. Scientists at the Max Planck Institute for Human Cognitive and Brain Sciences have discovered that music causes significant changes in blood pressure during pregnancy – despite being rated as similarly pleasant or unpleasant by pregnant women and their non-pregnant counterparts. The researchers’ experiments showed that dissonant music played forwards caused blood pressure to drop significantly, while dissonant music played backwards resulted in higher blood pressure after ten seconds and a lower reading after thirty seconds. Unpleasant music thus doesn’t generally increase blood pressure like other stress factors. The body’s response is just as dynamic as the music itself. Music appears to have a special status among the sensory perceptions, as women’s responses to most sensory perceptions are weaker during pregnancy. It is thus possible that the embryo may already be conditioned to music in the womb. (Psychophysiology, May 19, 2014)

Computing with a Quantum Trick

With a special gate, Max Planck physicists have developed an essential logic element for quantum computers

You can count on quantum information in the future. Physicists from the Max Planck Institute of Quantum Optics in Garching have developed an innovative quantum gate, an essential component of a quantum computer. Such a computer may be able to perform certain tasks far faster in the future than a standard computer. As a key element of their quantum gate, the Max Planck physicists use an atom trapped between two mirrors of a resonator. This allows them to switch the state of the photon by reflecting it off the resonator depending on the state of the atom. Moreover, this gate operation can entangle the atom with the photon. When quantum particles are entangled, their properties become interdependent. Entanglement opens up an array of new concepts in information processing. The quantum gate now presented by the Garching-based physicists makes it possible to design quantum networks in which information is transferred in the form of photons between several quantum processors that compute with atoms. (Nature, April 10, 2014)
At the Heart of the Antimatter Mystery

An extremely accurate measurement of the proton’s magnetic moment may help explain the surplus of matter in the universe.

Why something is something and not nothing isn’t just a philosophical question, but also a physical one. Fractions of a second after the Big Bang, matter and antimatter formed in almost equal amounts — only to largely annihilate each other again. The fact that a small surplus of matter survived is explained by a previously unknown difference between matter and antimatter. A German and Japanese team, in which researchers from the Max Planck Institute for Nuclear Physics headed by Klaus Blaum were strongly represented, has now taken steps to identify this asymmetry. The scientists measured the proton’s magnetic moment with a precision never achieved before. A similarly accurate measurement of the antiproton, which the team is now planning, may reveal a difference between matter and antimatter. The physicists hope to use the data to formulate a theory of matter and antimatter that also explains the surplus of matter. (Nature, May 29, 2014)

Outgrowing Emotional Egocentricity

Egocentricity plays a major role in many conflicts. Children are also often unable to differentiate between their own point of view and that of others. A team from the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig has now demonstrated that they project not only their ideas and desires, but also their emotions onto others. Such behavior isn’t necessarily the result of poor upbringing, but may instead have an organic explanation. According to the researchers, the supramarginal gyrus region in the right part of the brain must be sufficiently well developed in children for them to overcome their egocentric behavior. This area of the brain is closely connected with other parts that are responsible for the ability to empathize with others. The supramarginal gyrus’ primary function appears to be overcoming one’s own perspective. Only when it begins to develop as they get older can children surmount egocentric thinking. (Social Cognitive and Affective Neuroscience, May 21, 2014)

“Fetch!”

Dogs can follow human voice commands to find hidden food

Researchers at the Max Planck Institute for Evolutionary Anthropology in Leipzig have now scientifically proven what dog owners have probably always suspected: dogs can locate hidden food by using human voice direction. To this end, the researchers gave dogs and puppies the opportunity to choose between two identical boxes, only one of which contained food. Therefore, dogs don’t rely just on pointing gestures or the direction of gaze, but also on their ears to find hidden food. Other animals are unable to do this: wolves, the closest relatives of dogs, and chimpanzees are unable to make much sense of such visual or acoustic cues. When domesticating the wolf, humans may have subconsciously selected the animal that paid the closest attention to them. This awareness of human signals may have thus become part of dogs’ genetic make-up. (Proceedings of the Royal Society B, May 7, 2014)

In the behavioral experiment, the dogs know that there is something to eat in one of the boxes — but not which one. They follow only the human voice to find the food.
An Odor Lexicon

A hunter-gatherer group in Thailand has multiple words for smells

“A sweet, flowery and oriental composition of scents with jasmine and May rose absolute” – this is how a well-known cosmetics manufacturer describes one of its most successful women’s perfumes. It may sound sophisticated, but it relies on metaphors and similes because Western cultures lack abstract concepts to describe the wide range of aromas in our environment, such as those used for taste or things we see. According to linguists from the Max Planck Institute for Psycholinguistics in Nijmegen, Netherlands, some languages have a specific vocabulary for odors. The Maniq, a group of hunter-gatherers in southern Thailand, can describe smells using at least 15 different abstract expressions. In contrast to languages such as German or English, these expressions aren’t derived from one specific object. Instead, there are terms that represent a smell that can originate from various sources. Maniq has a word for the smell of an old shelter, which is also the same as the one used for the odor of mushrooms, or the skin of a dead animal. Human language is thus perfectly capable of expressing the variety of smells in our environment. This probably reflects how important the sense of smell was for survival over the course of human history, something that is greatly underestimated today. (Cognition, Vol. 131, April 2014)

Smells play a significant role in everyday life for the Maniq. Linguist Ewelina Wnuk spent several years among this ethnic group and produced an odor lexicon of these hunter-gatherers in the Thai rainforest.

Fear of the Cuckoo Mafia

Out of fear of retaliation, birds accept and raise brood parasites’ young

The mafia rarely has to extort protection money by means of violence, as the fear of the consequences alone is enough to make restaurant owners pay up. Similar mafia-like behavior can also be observed among parasitic birds, like the brown-headed cowbird (Molothrus ater) found in North America. They lay their eggs in other birds’ nests. If the host birds throw the cuckoo’s egg out, the brood parasites take their revenge by destroying the entire nest. Consequently, the hosts accept a certain degree of parasitism as long as they can raise their own offspring alongside the cuckoo chicks. Only previously seen in field observations, scientists at the Max Planck Institute for Evolutionary Biology in Plön have now modeled this behavior mathematically to confirm it as an effective behavioral strategy of the host birds. The proportion of birds that accept the cuckoo’s eggs in their nests and of parasites that respond with violence toward insubordinate behavior by the hosts fluctuate periodically – and contrastingly. (Scientific Reports, March 4, 2014)

The brown-headed cowbird of North America can place several dozen eggs in other birds’ nests to be hatched by stepparents.
Desire for Reward

Pornography is a social taboo. Few will admit to its use, yet porn sites are among the most frequently visited on the Internet. However, the intensive consumption of pornography doesn’t leave traces solely on the Internet, but also in the brain. According to a study by researchers at the Max Planck Institute for Human Development, the more pornography men consume, the smaller their striata become. This area of the brain makes up part of the reward system that is responsible for producing feelings of pleasure. The activity of the nerve cells in the striatum and their communication with other parts of the brain were much lower when viewing sexually stimulating images when men watch pornography frequently and regularly. Men with high pornography consumption require even stronger stimuli to reach the same reward level. It is unclear whether frequent pornography use leads to these changes in the brain or whether, alternatively, it could be a precondition that determines the level of pornography consumption. (JAMA Psychiatry, published online ahead of print, June 2, 2014)

Resistance under Pressure

An unconventional superconductor conducts electricity at higher temperatures loss-free when compressed or stretched

Some superconductors remain a mystery to physicists. Why they conduct electric current at very low temperatures without resistance can’t be explained with the established theory of superconductivity. If physicists could solve the puzzle of these unconventional superconductors, they would come closer to the manufacture of artificial materials that conduct electricity loss-free at room temperature, thus helping to save energy. Andrew Mackenzie and his team at the Max Planck Institute for Chemical Physics of Solids have established that strontium-ruthenate becomes a superconductor at much higher temperatures than usual when it is compressed or stretched. For their experiments, the researchers developed a measuring cell that enabled a sample to be stretched and compressed in a precisely controlled way at low temperatures. (Science, April 18, 2014)
Music under the Microscope

Droplets on a microfluidic chip can be controlled so precisely that they become a musical instrument.

Water droplets are musical. Researchers at the Max Planck Institute for Dynamics and Self-Organization in Göttingen converted the frequencies of droplets flowing through thin channels into musical notes by controlling AC voltage very precisely. In this way, they played Beethoven’s *Ode to Joy*. This is more than a mere gimmick: the fact that the droplets can be controlled so precisely means they are also of interest in medical diagnostics. Laboratories on microfluidic chips, for example, are currently being developed that would make it possible to examine minute samples of fluid, such as blood and DNA, in an extremely small space. The new procedure represents a major step forward in achieving this goal. (Science Reports, April 30, 2014)

Researchers at the Max Planck Institute in Göttingen can precisely control the frequency at which the water droplets flow through the channels of a microfluidic chip using AC voltage. The four transparent tubes transport oil and water into the fine channels of the chip. The yellow lines shown are electrodes, while the red and black cables transport the electric current.

A Recipe for Star Formation

New model enables reconstruction of the spatial structure of molecule clouds

Astronomers have found a new way to predict the rate at which cosmic molecular clouds will form new stars. They developed a technique that facilitates the modeling of the spatial structure of individual gas clouds. The required data comes from an astronomical version of the X-ray procedure: the light of distant stars shining through a cloud before reaching the Earth is dimmed by the dust in the cloud. The reconstruction of the cloud structure uses the dimming measurements for tens of thousands of stars. If the scientists know the spatial structure, then they can also calculate the densities of the various sections within the cloud. It became evident that new stars formed only in regions above a particular density. The researchers from the Max Planck Institute for Astronomy estimate the critical value at around 5,000 hydrogen molecules per cubic centimeter. (Science, April 11, 2014)

Birth in the computer: This image shows star formation in a turbulent gas cloud. The astronomers used these and similar simulations to test their method for reconstructing the three-dimensional structure of such gas clouds.
The Ringed Asteroid

The asteroid Chariklo, which circles the Sun between the orbits of Saturn and Uranus, is surrounded by two rings of ice particles. This finding was obtained by a team that included scientists from the Max Planck Institute for Solar System Research. In June 2013, seven observatories in South America focused their telescopes on the 250-kilometer-wide asteroid because it was set to conceal a star. However, the star didn’t disappear abruptly for a short time: it dimmed erratically several seconds before and after the actual occultation – an indication of a ring system. It consists of two very thin structures: a gap of just nine kilometers separates the inner ring, with a width of seven kilometers, and the outer ring, with a width of three kilometers. Previously, astronomers have observed the rings of only the planets Jupiter, Saturn, Uranus and Neptune. Such rings are less likely to be found in asteroids, as their fields of gravity are weaker.

(Nature, published online ahead of print, March 26, 2014)

An Incisive Bite

The fangs of the large wandering spider (Cupiennius salei) are incisively shaped, right to the tip. The spider uses its curved fang to grasp its prey, puncture its chitinous armor and inject venom into the victim. An Austrian-German research team headed by Yael Politi at the Max Planck Institute of Colloids and Interfaces in Potsdam-Golm established that the shape and structure of the fangs have evolved extremely well to perform their lethal task as reliably as possible over the spiders’ lifetime, and with the minimum amount of damage. For the first time, the researchers analyzed in detail the correlation between the structure and the mechanical properties of the cone-shaped fang and compared it with other potential configurations, such as a needle. The chitin fibers of which the poisonous fangs are essentially made up are arranged in various layers, helping the fang to withstand pressure particularly well when biting. The findings may help improve injection devices used in medicine and technology.

(Nature Communications, May 27, 2014)

Your Stress Is My Stress

Merely observing stressful situations can trigger a physical stress response

Stress is contagious. This is the conclusion of a study by scientists from the Max Planck Institute for Cognitive and Brain Sciences and the Technische Universität Dresden. During a stress test, observers watched trial subjects struggle with difficult mental arithmetic tasks and interviews. Around a quarter of the observers showed a significant increase in the stress hormone cortisol in blood tests – a clear indication of the body’s stress response. Where the test subjects and observers were partners in a relationship, the stress level actually rose by 40 percent. Even when it came to complete strangers, stress has contagion potential that was able to be transmitted via a screen between a stressed test subject and an observer. Television programs depicting the suffering of other people can thus also transmit the stress to viewers. Furthermore, the researchers dispelled a common prejudice: men and women experience empathetic stress reactions with equal frequency.

(Psychoneuroendocrinology, April 17, 2014)
Neither Star nor Planet

They are often eclipsed by more attractive topics, like black holes or exoplanets. Even the name itself is less than sensational: brown dwarfs. But Viki Joergens and her colleagues from the Max Planck Institute for Astronomy in Heidelberg have gained fascinating insights in this research field.
The Milky Way probably has roughly as many brown dwarfs as it has planets. Astronomers don’t know the precise number, as these celestial bodies are small and very dim, and thus difficult to observe. They have, however, really shaken our tried and tested definitions of the terms “star” and “planet” of which we have grown so fond. Spots form on their surface like the spots on the Sun, and clouds form as if they were planets. “This is one of the most important characteristics of our research field: there are countless overlaps with the properties of both planets and stars,” explains Viki Joergens, who has been investigating these celestial bodies for more than ten years now.

Back in 1962, Shiv Kumar, who was then working as a post-doc at the Goddard Space Flight Center of the US space agency NASA, set the ball rolling. He asked himself how small a star can actually be, and what properties bodies that are just below this threshold possess. The fundamental characteristic of stars consists in the multi-step fusion of hydrogen to helium in their central region.

This process releases energy that, in the form of heat, creates an outward pressure against the gravity acting inward. If these two pressures balance, the star is stable. Our Sun has been in this phase for around 4.5 billion years.

To reach this state in the first place, the celestial body must have a certain minimum mass; otherwise, the pressure and temperature aren’t sufficient to ignite the hydrogen fusion and maintain it. As Japanese theoreticians Chu-shiro Hayashi and Takenori Nakano discovered back in 1963, this process requires a star to have at least 7 to 8 percent of the solar mass, corresponding to 75 times the mass of the planet Jupiter.

But bodies that are just below this threshold should initially still be sufficiently hot to fuse heavy hydrogen (deuterium) to helium-3 and thus generate energy. However, the raw material deuterium is present only in small quantities, so that the fire is extinguished after just a few million years. From then on, the celestial body slowly cools down. “Eventually, all brown dwarfs are approximately the size of Jupiter,” says Joergens.

**THE HYDROGEN FUSION STARTS DEEP IN THE INTERIOR**

In order for this deuterium burning to start, the body must have at least 13 times the mass of Jupiter. This represents the lower mass threshold of brown dwarfs according to the current definition of the International Astronomical Union. These objects thus form the link between planets and stars in a range of around 13 to 75 Jupiter masses.

Astronomers spent more than 30 years looking in vain for these failed stars until they finally found the first representative of this class of objects in 1995. Approximately 2,000 brown dwarfs have since been identified – some with surprising properties. “One of the most topical questions concerns their birth,” says Joergens.

Stars are formed when individual regions in the interior of a large cloud of gas and dust contract under the effects of gravity. The core of such a cloud rotates and forms a disk. The material in the cloud center becomes more and more compressed until hydrogen fusion begins. The young star is then stable.

Dust particles collide with each other in the disk that still surrounds them, clump together and finally grow into asteroids and planets. Earth and the gas planet Jupiter were also formed in this way. And the terms “star” and “planet” are defined in accordance with this scenario: a star is a stable ball of gas that generates energy in its interior through nuclear fusion; planets aren’t able to do this, are smaller, and orbit their sun. But which formation path do brown dwarfs choose?

“Since young stars are initially still surrounded by a disk of dust, the obvious thing was to look at whether brown dwarfs can also be surrounded by a disk,” explains Viki Joergens. The Heidelberg-based astronomers used Herschel, the space telescope of the European Space Agency (ESA), for this project. Equipped with a 3.5-meter diameter main mirror, it was the largest telescope ever launched into space. It was in operation from June 2009 for nearly four years, at which point the helium for cooling the instruments was exhausted.

Herschel observed exclusively in the region of mid- to far infrared at wavelengths ranging from 70 to 500 micrometers. “This is where the thermal radiation of cool dust, among other
planets such as Jupiter to form in the disks of brown dwarfs, but smaller rocky planets may very well do so. But to date none have been discovered.

Surprisingly, brown dwarfs follow a law that was discovered for young stars: the disks of dust always have around 1 percent of the stellar mass. Viki Joergens’ observations show that this applies down to a central mass of only 12 Jupiter masses. Thus, in this respect, brown dwarfs don’t differ from their big brothers. They are apparently also formed in the same way and not like planets. If this relation also existed for our Sun, it is possible to conclude from this that only around 10 percent of the dust was converted into planets.

Since brown dwarfs appear to overlap seamlessly with the range of the planets at the lower threshold of around 13 Jupiter masses, the Max Planck astronomers from Heidelberg searched through the Herschel observations to see whether any of the representatives with the lowest mass had a disk – and found a celestial body at a distance of 530 light-years with the designation OTS44. The intensity of its far-infrared radiation had to originate from a disk of at least 10 Earth masses. In addition, the researchers discovered that the ob-

Above: Presentation in the team: Viki Joergens (standing) and her colleagues Ian Crossfield, Niall Deacon and Esther Buenzli (from left). Below: The cosmos in art: The object PSO J318.5-22 (top) has around seven times the mass of Jupiter and travels through space alone, meaning without a parent sun. The picture of OTS44 (bottom) illustrates that this object, just two million years young, formed in a similar way to stars, namely from a disk of gas and dust. Even today, considerable quantities of matter still fall onto OTS44.

“Planets such as Jupiter to form in the disks of brown dwarfs,” says Joergens.

PACS, one of the three instruments aboard Herschel, was built under the direction of the Max Planck Institute for Extraterrestrial Physics with crucial contributions from the astronomers in Heidelberg. In return, they received guaranteed observation time with PACS. Working with colleagues from the University of Texas, they commenced a program to search for dust disks around brown dwarfs – with great success.

“For 36 of 47 carefully selected brown dwarfs, we found infrared emissions that originate from such disks,” says Viki Joergens. And the initiator of the project, Max Planck Director Thomas Henning, adds: “We therefore succeeded in carrying out the first survey for such disks in the infrared region, and in narrowing down their masses.”

“We find that disks around brown dwarfs have masses ranging from just below one Earth mass up to one Jupiter mass,” says Joergens; Jupiter, on the other hand, has 300 times more mass than Earth. However, not all the disk material is used to form planets. It therefore isn’t possible for large gas planets such as Jupiter to form in the disks of brown dwarfs, but smaller rocky planets may very well do so. But to date none have been discovered.

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ject, only two million years young, was still picking up matter from the disk, as young stars do.

Interestingly, OTS44 has only around 12 Jupiter masses and is thus still in the classical mass range of the planets. However, the object doesn’t orbit a star, but moves freely through space—a key piece of information for theories of star formation. “OTS44 can be designated either as a very low-mass brown dwarf or as a free-floating planet. In my view, there is no difference here, because the line between brown dwarfs and planets should be drawn with the aid of the formation history,” says Joergens. But this isn’t known in all cases.

**THE SIGNATURE CHANGES OVER TIME**

This was shown by a finding made with the Pan-STARRS1 telescope on Hawaii: At the end of 2013, a group of astronomers that included Niall Deacon from the Max Planck Institute for Astronomy discovered a celestial body that had only seven times the mass of Jupiter. The object with the catalog number PSO J318.5-22 at a distance of 80 light-years is travelling alone through space without a parent star. Did it also form like a star?

But the scientists haven’t yet detected any processes that are known from star formation, so it is still possible that PSO J318.5-22 was born as a planet and ejected from the system afterward. Theoretically, this can take place through the gravitational effect of a star passing nearby, or also as a result of instabilities in a young system with several planets. With OTS44, this was possible because it is part of a star formation region of known age in the Chameleon constellation in the southern sky. With PSO J318.5-22, on the other hand, the astronomers were able to measure the motion in space. In the process, they ascertained that it used to belong to a group of young stars that formed around 12 to 21 million years ago. But the researchers can’t always hope for such fortunate circumstances, and this makes the interpretation of observational data more difficult.

Although there have been many new findings concerning brown dwarfs in the past, questions about their formation remain unanswered. While all results of observations currently indicate that brown dwarfs are formed like stars in the center of a collapsing cloud of gas and dust, some theoreticians believe that the cloud fragments aren’t massive enough to be able to contract under their own gravity.

The researchers therefore devised different explanations. Most are based on the assumption that brown dwarfs are the consequence of a rudely interrupted star formation. This could occur by dynamic interactions in a group of

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**Size comparison:** The image shows the Sun, a red dwarf star, three brown dwarfs and Jupiter (from left) to scale. If the deuterium fusion extinguishes in a brown dwarf, it contracts further until the freely moving electrons in the interior build up a quantum mechanical counter-pressure and prevent the body from shrinking any further. This is the case when it is approximately the size of Jupiter.
stars that formed together if one of the members is ejected from this system before it has reached adulthood.

It would also be conceivable that there is a further, very hot star in the vicinity of a forming star. Its intense UV radiation could then vaporize the gas cloud from which the emerging sun is still collecting gas, and deprive the newcomer of “food.” According to these scenarios, brown dwarfs are failed stars in the true meaning of the word.

From the previous observational data, however, Viki Joergens concludes that there is no need to devise a special mechanism for the formation of brown dwarfs. The frequency of binary systems, which she investigates, is also interesting in this respect. The researcher was one of the first to use high-resolution spectroscopy to look for companions of brown dwarfs. Very large telescopes are necessary to apply this method, which is known from the search for planets.

Joergens and her colleagues started to scan brown dwarfs for companions with one of the 8-meter telescopes of the Very Large Telescope of the European Southern Observatory in Chile; these should become evident in the spectrum by virtue of a Doppler shift. Although the researchers haven’t yet found a brown dwarf with a planet, what they have found is one of the very few binary brown dwarfs, whose radial velocity orbit they were able to determine in full.

Astronomers have known for some time that around two-thirds of all stars exist in binary or multiple systems. With brown dwarfs, this proportion is only 10 to 20 percent, as was shown by Joergens’ survey, among others. However, the tendency toward togeth-
erness seems generally to decrease with decreasing mass. Astronomers in Heidelberg discovered a few years ago that only 25 percent of stars with very low mass, so-called M-dwarfs, are in binary systems. In this sense, brown dwarfs follow the trend set by the stars – they prefer life as a single with decreasing mass.

Brown dwarfs only ever appear as featureless points, even on images taken with the largest telescopes. The first surface map of a brown dwarf is therefore a sensation. It belongs to a binary system whose discovery by American astronomer Kevin Luhman from Pennsylvania State University in March 2013 caused a stir. It’s located at a distance of 6.5 light-years from the Sun – only two other stellar systems are closer.

Despite the proximity of the brown dwarfs, called Luhman 16A and 16B, it isn’t possible to observe any features on their surfaces directly. With the aid of a clever technique, two international teams working with Ian Crossfield and Beth Biller from the Max Planck Institute for Astronomy have succeeded for the first time in drawing up something like a weather chart of one of the two celestial bodies. Clouds form in the atmosphere despite the high temperatures of more than 1,000 degrees Celsius. These clouds obviously don’t consist of water, like on Earth, but of heavy elements such as iron and minerals.

Crossfield applied a method called Doppler imaging, which works as follows: Initially, the light of the brown dwarf is dispersed into its spectral colors. Lines that originate from the substances contained in the atmosphere then appear in this spectrum. Since the brown dwarf rotates, one half is always moving toward us and the other half away from us. This is evident as a Doppler shift in the spectrum. Furthermore, the regions near the equator rotate faster than those at higher latitudes, and this can also be seen in the spectrum.

Crossfield analyzed these changing spectral signatures with a computer program and used them to create two-dimensional surface maps. “It’s probably a non-uniform cloud cover – not unlike that of the planet Jupiter,” says the scientist.

**RESEARCHERS ARE LOOKING DEEP INTO THE ATMOSPHERE**

Beth Biller and her colleagues didn’t use a spectrograph in their work, but recorded light variations in the two brown dwarfs simultaneously in seven different wavelength ranges. Although the two-dimensional information was lost with this method, the researchers were able to look deep into the atmosphere: the seven wavelength ranges very probably correspond to different atmospheric layers with differing temperature.

“The cloud structure varies depending on how deep one looks into the atmosphere – this means there is definitely more than just one cloud layer,” says Biller. For the first time, theoreticians can now compare their models for the cloud structure of brown dwarfs with observations.

These fascinating new findings on the formation of brown dwarfs, the weather in their atmospheres, and free-floating planets open up new prospects for research. And not least, the Max Planck astronomers in Heidelberg have also succeeded in moving the brown dwarfs slightly out of the shadow of the black holes and into the limelight.

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**TO THE POINT**

- Brown dwarfs are a sort of halfway house between star and planet. At a mass below 75 Jupiter masses, no atomic fire burns in their interior.
- Brown dwarfs apparently form in gas and dust clouds and are therefore born in the same way as stars.
- Brown dwarfs prefer to be single. While around two-thirds of all stars exist in binary or multiple star systems, the proportion for brown dwarfs is only 10 to 20 percent.
- Max Planck astronomers recently succeeded in mapping the surface of a brown dwarf for the first time. This weather chart shows clouds in the atmosphere; but temperatures of more than 1,000 degrees Celsius mean they consist, not of water, but of heavy elements, such as iron and minerals.

**GLOSSARY**

**Doppler effect:** When a celestial body moves toward us or away from us, its light spectrum shifts to shorter (blue) or longer (red) wavelengths, respectively. Sound exhibits the same phenomenon: when a police car is moving toward us, the pitch of the siren is higher (shorter acoustic wavelength) than when it’s moving away from us.

**Spectroscopy:** One of the most important methods to determine the physical state and the chemical composition of a distant star. With the aid of an optical device (a prism, for example) the radiation of an object is dispersed according to its energy. Spectrometry provides quantitative data on the concentration of elements, pressure and electric or magnetic fields, for example.
Newts possess the almost magical ability to regenerate damaged tissue, making them unique among vertebrates. **Thomas Braun** of the Max Planck Institute for Heart and Lung Research in Bad Nauheim is studying the amphibians to learn how an organism can regrow entire organs. Perhaps one day it will help enhance the capacity for regeneration in humans.

**B**ad Nauheim – a small Hessian town that is a shining example of art nouveau, mineral springs, spas and clinics. The town’s website touts “innumerable little natural wonders” and promises health, recovery and complete renewal. However, few people would guess that the biggest regeneration potential can be found in the basement of the Max Planck Institute for Heart and Lung Research at the edge of the spa gardens. Two basement rooms hold countless aquariums, terrariums and aquaterrium that house more than a thousand specimens of the eastern newt (**Notophthalmus viridescens**).

The amphibians – which, incidentally, aren’t green as young animals, as their Latin name implies, but orange-brown with reddish spots – have a remarkable self-healing capacity. They’re able to regrow a severed leg or damaged eye lens completely within a few months. Even the heart is able to renew itself completely after injury.

Humans can only dream of such self-healing powers. Only a few organs in our body, the liver and skeletal muscles, are able to regenerate to any appreciable extent; blood cells are also constantly renewed. The heart, though, is an entirely different matter: After a heart attack, dead heart muscle cells aren’t renewed to a sufficient degree. Instead, scar tissue forms. The jury is still out on whether the pumping organ in our chest has a reservoir of stem cells that can develop into new heart cells.

Breeding the amphibians from North America is a complicated undertaking. They require different conditions depending on their stage of development. As larvae, they live in water, as young animals on land, and in adulthood they dwell both on land and in water. “In recent years we’ve observed that the adult animals feel more comfortable when they can walk on land and not just on a floating island,” says Miroslaw Grala. The keeper lovingly drapes moss and
lays fine white gravel in a freshly cleaned aquaterrarium that will soon serve as a newt home.

“Since we started providing adult animals with such aquaterraria, they’ve reproduced better,” says Grala. He’s clearly proud of his protégés – and not just because of the fact that the researchers based in Bad Nauheim have been the first in the world to succeed in breeding the newts in their own institute. “Although it takes a great deal of work, it’s also a lot of fun,” says Miroslaw Grala. “I think the animals are simply fascinating.”

Master of the newts is Thomas Braun, Max Planck Director and head of the Cardiac Development and Remodeling Department. He began working with the eastern newts in the 1990s at Martin Luther University in Halle-Wittenberg. “It was completely uncharted territory back then. We simply went to a hardware store and bought aquariums, ordered newts from breeders in the US and gave it a try.”

The animals are still exotics among laboratory animals. Thomas Braun therefore has mixed feelings about research with the amphibians. “They’re truly fascinating model organisms for studying organ regeneration. But from a technical point of view, they’re a nightmare.” Only around 15 research groups in the entire world are working with these animals. That makes life difficult for the scientists in Bad Nauheim.

Whereas copious information and technical know-how are available for common laboratory animals such as mice, fruit flies, zebrafish and the nematode Caenorhabditis elegans, there are no standardized laboratory protocols for working with the eastern newt – not even information on how best to keep and breed them.

What’s even worse for Thomas Braun is the fact that the newts’ genome hasn’t been sequenced and won’t be in the foreseeable future. The analysis of a genome that is about ten times larg-
er than that of humans would be an enormous challenge, even with modern methods. “Without this information, however, we’re unable to switch off genes and investigate what effect they have,” says Braun. “And until we know which genes are involved in the regeneration of tissue, we can only observe and describe the self-healing processes in the newt – but we won’t really understand exactly what’s going on.”

Braun and his colleagues have thus sought other ways to identify newt genes involved in regeneration. Instead of sequencing the entire genome, the researchers initially focused on those sections of DNA that are active and are expressed during development from the larval to the adult stage and during regeneration. To this end, they isolate messenger RNA (mRNA, the molecules that store genetic information before it is translated into proteins) from larvae and damaged tissue from adult animals. They then compare such samples with those of healthy adult animals.

The outcome of such investigations is initially a bewildering mass of data. Bioinformatician Mario Looso’s job is to
extract meaningful data from this flood of information. Instead of a pipette, his tool of the trade is a computer. Although Looso’s interests were originally mathematics and the development of databases, he has long been intrigued by newts. He isn’t in the least put off by the challenge – quite the contrary. “That’s precisely the attraction for me as a bioinformatician,” he says. “I have to devise suitable methods and am able to develop a newt database from scratch.”

**PROTEINS FOR SELF-HEALING**

In this way, the scientists in Bad Nauheim have identified nearly 15,000 messenger RNA molecules in the eastern newt that are translated into proteins. Of those proteins, 830 were previously unknown and apparently occur only in the newt – an astonishingly large number for a single species. Moreover, some of the new proteins belong to a previously unknown protein family that may play a key role in the self-healing capacity of the amphibians. In fact, the researchers have discovered protein families that control regeneration of the eye lens and heart.

A particularly exciting candidate is a protein called nsCCN, a member of the CCN family of proteins. These proteins stimulate cell growth and occur in very similar form throughout the animal kingdom – from zebra fish to humans. One representative, CCN4, for example, is active in mammals when the heart repairs itself to some extent after damage.

It’s possible that nsCCN is involved in the process when newt cells undergo reverse development. This is the very trick that newts employ. “The amphibians don’t regenerate defective tissue or amputated limbs from stem cells to any meaningful extent,” explains Braun. “Instead, cells that are already specialized regress, so that they behave much like stem cells.” Researchers call this process dedifferentiation. Heart muscle cells, for example, lose their specialization and begin to proliferate at an increased rate until a sufficient number of new cells have formed that will mature into new heart muscle cells.

Thomas Braun suspects that heart muscle cells in humans also simply shift into reverse gear. His team has discovered such dedifferentiated cells in the myocardium following a heart attack or chronic oxygen deficiency. This also explains why researchers find so few cardiac stem cells despite the fact that damaged cells are still partially replaced after a heart attack.

Another remarkable observation regarding damaged cardiac muscle is that, after a heart attack, inflammatory cells migrate into the heart. This also happens in newts and is essential for the amphibians to recover quickly and regenerate injured body parts. Is this the key to self-healing? Do the migrated cells release a substance that promotes dedifferentiation?

**ONCOSTATIN M PROMOTES REGENERATION**

Jochen Pöling, who also works as a surgeon at the Heart Center of Schüchtermann Hospital in Bad Rothenfelde in Lower Saxony, is therefore searching for such chemical messengers released by inflammatory cells. Together with his colleagues, he observed that, shortly after an infarction, the chemical messenger oncostatin M occurs in damaged tissue, where it stimulates cellular dedifferentiation. In genetically modified mice lacking fully functional oncostatin M, fewer heart muscle cells revert to their original undifferentiated state after an infarction. Moreover, they
are more likely to die from the consequences of the infarction.

**CHEMICAL MESSENGERS ADHERE TO OTHER RECEPTORS**

High oncostatin M levels could therefore stimulate the reverse development of cardiac cells and activate repair mechanisms in the heart. Unfortunately, things aren’t that simple. In humans, the signaling molecule also binds to other receptors, leading to, among other things, an increased tendency for the blood to clot – clearly a counterproductive effect for infarction patients.

The effect of the chemical messenger is also ambivalent in mice. Although oncostatin M and the dedifferentiated heart muscle cells initially protect the heart after an acute myocardial infarction, this is partly due to the fact that the dedifferentiated cells are much more able to cope with oxygen deficiency. “However, the longer oncostatin is released and the cells dedifferentiate, the more the function of the myocardium deteriorates,” Pöling explains.

The Max Planck researchers have identified a potentially key difference between the newt heart and the mammalian heart: whereas, in newts, it is primarily new heart muscle cells that form from dedifferentiated cells, in mice and humans it is mainly scar tissue. These cells aren’t muscle cells and therefore don’t increase the pumping performance of the heart after a heart attack. But why does dedifferentiation result in apparently useless scar tissue in humans, yet generate new healthy cells and even entire organs and limbs in newts?

It’s possible that the scar tissue isn’t as superfluous as it might appear at first glance; it could, in fact, serve to stabilize the heart. “The newt ramps down its entire metabolism and blood pressure during regeneration. In this way, its heart is able to undergo remodeling without bursting,” Braun explains. The human heart, in contrast, has to do a lot more pumping work. If repair work on the heart is too extensive, the heart would become unstable and would be unable to withstand the pressure.

**TIMING IS CRUCIAL**

The processes that occur in the heart after an infarction thus perform a balancing act between protection and loss of function. The researchers therefore describe oncostatin M as a Janus-faced protein. In this sense, despite all the adverse effects, the signaling substance could point the way to new forms of treatment – just a different one than the researchers had originally expected.

Furthermore, timing is crucial. In the early phase after a heart attack, it might be helpful to stimulate the secretion of...
Cardiac stem cells: Cardiac stem cells divide continuously during development from embryo to adult animal until a cluster of cells gives rise to a complex organ comprising ventricles, atria, heart valves and coronary vessels. Once this process is complete, most stem cells are switched off. But even in the adult mammalian heart, some stem cells remain. These cells divide throughout life to form new heart muscle cells. However, they are very few in number: within one and a half years, only about 5 percent of heart muscle cells are likely to be renewed – not enough to heal a damaged myocardium, for example after a heart attack.

Regeneration: Many animals are able to regenerate damaged tissues and organs. However, while simpler organisms such as jellyfish and flatworms are able to form a whole new organism from parts of the body, few vertebrates are able to regrow multiple organs. The masters of regeneration among vertebrates are newts and salamanders, followed by other amphibians, fish and – lagging behind by some distance – mammals.

**TO THE POINT**

- The eastern newt regenerates damaged tissue and amputated limbs only to a limited extent from stem cells. Instead, already specialized cells regress and begin to divide until enough new cells have been formed to regrow specialized tissue.
- In the newt, these dedifferentiated cells in the heart give rise primarily to new heart muscle cells. In mice and humans, it is mainly scar tissue that forms. Although this tissue can’t support the heart’s pumping action after a myocardial infarction, it protects the heart against oxygen deficiency and stabilizes it. In many patients, however, this later results in heart failure.

**GLOSSARY**

Cardiac stem cells: Cardiac stem cells divide continuously during development from embryo to adult animal until a cluster of cells gives rise to a complex organ comprising ventricles, atria, heart valves and coronary vessels. Once this process is complete, most stem cells are switched off. But even in the adult mammalian heart, some stem cells remain. These cells divide throughout life to form new heart muscle cells. However, they are very few in number: within one and a half years, only about 5 percent of heart muscle cells are likely to be renewed – not enough to heal a damaged myocardium, for example after a heart attack.

Perhaps after an infarction it’s all a question of finding the right balance between acute emergency repair and the gradual progressive loss of the heart’s pumping function,” explains Braun. A balance that the tiny regeneration artists in the basement of the Max Planck Institute in Bad Nauheim discovered a long time ago.
Steel portfolio: Today, materials are optimized for each individual application. In this context, increasing the lifespan of aircraft turbines poses a major challenge.
Quantum Mechanically Engineered Steel

Car bodies, aircraft wings or turbine blades – alloys today are customized for any purpose. Roughly 2,500 different types of steel already exist, and that number continues to grow. Jörg Neugebauer and Dierk Raabe, Directors at the Max-Planck-Institut für Eisenforschung in Düsseldorf, are also developing new varieties, and in their search for innovative materials, they even apply the laws of the quantum world.

You could try mixing the titanium with 30 percent niobium or molybdenum.” Several years have passed since Jörg Neugebauer gave Dierk Raabe this piece of advice. Back then, Raabe had been searching for a new titanium alloy for hip replacement implants. The material needed to be more elastic under pressure than pure titanium, meaning it had to be about as flexible as human bone. Up until then, titanium prostheses tended to become loose over time due to the fact that they are very rigid and therefore absorb a much greater amount of force than the bone. Since the bone is no longer challenged, it subsequently starts to recede. Jörg Neugebauer and Dierk Raabe developed a material that is more suitable than titanium, and a number of manufacturers have already started using this new alloy.

Raabe is head of the Department of Microstructure Physics and Alloy Design at the Max-Planck-Institut für Eisenforschung in Düsseldorf. Despite the fact that the institute’s German name contains the word “iron” (Eisenforschung = iron research), the research conducted there also focuses on other metals, and even on biomaterials.

Before Raabe begins examining specific material formulas, he first contacts his colleague, Jörg Neugebauer, head of the Department of Computational Materials Design, just as he had done in the case of the new titanium alloy. At the institute, they can almost wave at each other when standing at the right windows of their two buildings. However, as far as their respective work is concerned, they are orders of magnitude – or as Raabe calls it, many scales – apart. Neugebauer works with material samples that are merely nanometers (millionths of a millimeter) in size. He simulates these extracts using a computer.

QUANTUM MECHANICS REQUIRES POWERFUL COMPUTERS

All Jörg Neugebauer needed to do to later arrive at his precise 30 percent tip, he says, was “to conduct some quantum mechanics” with virtual atoms. As a theoretical physicist, he studies matter on a purely theoretical level, without having to carry out any experiments in a laboratory. He does, however, require powerful computers. It therefore comes as no surprise that the institute’s basement houses an infrastructure with computa-

TEXT: KARL HÜBNER
explained using classical physics, and simply exceed the human power of imagination. After all, who could conceive of an electron as a wave? Or comprehend why its energy doesn’t change in a continuous manner, but rather only in discrete quantum portions? Jörg Neugebauer believes that quantum mechanics starts to get really tricky when it comes to calculating the quantum mechanical behavior of systems consisting of many atoms. The problem is that all of the particles – the atomic nuclei and the electrons – are interrelated, the physicist explains. Calculating a structure made up of many atoms and their numerous electrons is thus such a profoundly complex task that even the most powerful computers reach their limits.

Thankfully, there are a number of simplifications that can be applied. One approach is the density functional theory (DFT), which dates back to the 1960s and for which a Nobel Prize in Chemistry was later awarded in 1998. This theory showed that one doesn’t necessarily need to know the exact position of every single electron in a system – only the electron density at a particular location is important. Over the course of the past decades, the mathematical formalism used to determine electron density has been significantly refined. Today it yields results that are also helpful for practical applications. And above all, it reveals the link between this density and the energy contained in a system.

Neugebauer is most interested in when performing his calculations, because it is precisely these energies that he calculates the properties of a material with the help of quantum mechanics. Based on these findings, Dierk Raabe then analyzes how an alloy’s microstructure influences the behavior of a large work piece. In this manner, the two Max Planck Directors and their teams jointly develop steels for the future.

THE DIVERSITY OF METAL LATTICES

In all metal elements, the atoms are arranged according to very specific rules. This arrangement takes the shape of three-dimensional lattices in which the atoms are evenly spaced in all spatial directions. In order to understand how the available space is used in the most efficient manner possible, the lattice can be compared to a pile of oranges. From the third layer onward, there are two different possibilities. Depending on how the depressions are filled, either the third or the fourth layer of oranges will be stacked directly in line with the first layer. The same principle applies to metal atoms. The different crystal lattice types are known as hexagonal close-packed and cubic close-packed (also called face-centered cubic). There is also another important lattice structure that experts call body-centered cubic.

The structure formed by a metal depends on various factors, including the size, nuclear charge and electron configuration of the atoms. Temperature and external pressure also influence the structure. As a result, there are numerous metals that change their preferred lattice structure depending on these conditions. Such phase transitions are of key importance for researchers studying the behavior of metals, and therefore also for materials developers seeking to create metals with specific properties.
One of the great achievements of Neugebauer’s department is the fact that they adapted the density functional theory so that it can also be applied to such complex systems as structural materials made from metal.

**ATOMS DON’T REMAIN FIXED IN ONE POSITION**

“We tell our computer program how 100 titanium atoms should be spatially arranged, for example,” says Neugebauer. The program knows that a titanium atom has 22 electrons, 4 of which are in the outer shell, where they play a role in binding to other atoms. It can also take into account the fact that atoms don’t remain fixed in a position without moving, but that they actually oscillate in relation to one another. The computations can even correctly reflect the magnetic properties of some chemical elements.

The great thing is that, in order to perform his calculations, Neugebauer doesn’t even have to know the actual position of the titanium atoms in a real metal lattice. “I can assign the positions at will – and then calculate the energy contained in the system. If I do that often enough using complex optimization algorithms, then the program will automatically come up with the structure that is most favorable in terms of energy at a given temperature,” the scientist explains.

This means that he can even specify completely unstable arrangements simply for the purpose of studying their mechanical properties, for example. That is exactly what Neugebauer did in the case of the titanium. “We simply computed a body-centered cubic titanium lattice,” he says. In real life, such a lattice would be stable only at a temperature of more than 882 degrees Celsius. But that didn’t matter initially. The physicist just wanted to find out how this type of titanium would react to external stress. Once again, he determines these results on a theoretical level. First he calculates the energy states of stretched or compressed atomic arrangements, then he uses this information to deduce the amount of force that would be needed to produce such deformations. “We can use these results to show that body-centered cubic titanium can, in fact, be more easily distorted in certain spatial directions – meaning it is also less rigid,” explains Neugebauer. A first step in the right direction.

The next task was to find a way to stabilize the body-centered cubic titanium (see box on p. 60) at room temperature. Other metals automatically form such a lattice, including molybdenum, vanadium, tantalum, niobium and tungsten. It therefore seemed an obvious choice to mix these atoms into the titanium. Once again, Neugebauer and his team first simulated this scenario on the computer, trying out different mixing ratios each time. “In the end it turned out that, if the amount of niobium or molybdenium exceeded 30 percent, then in terms of energy, a body-centered cubical arrangement would be more favorable than the compact hexagonal lattice of pure titanium,” says Neugebauer. His part of the work was thus complete, and the ball now in Raabe’s court.

Raabe was able to confirm the lattice structure predicted by the theory. “It turns out that the body-centered cubic structure is, in fact, stabilized when niobium or molybdenum is added,” says Raabe. Yet before the exact material mix was finalized, the results were analyzed by the computers in Raabe’s department, as well.

“You have to remember that quantum mechanics studies only a miniscule section of a given crystal,” the scientist explains. Metals, however, don’t usually exist as a single crystal in which all atoms are evenly arranged. What actually happens is that, when molten metal solidifies, countless tiny monocryals known as grains are formed, and these grains border on each other.

**THE ROLE OF GRAIN BOUNDARIES AND CRYSTAL DISTRIBUTION**

“My team studies how these grain boundaries and the distribution of crystals influence the macroscopically measurable mechanical properties,” explains Raabe. In the case of the titanium alloy, this task was still relatively simple. “In

From an electron to a hip replacement implant: The electronic structure can be used to deduce the atomic structure. This, in turn, produces the microstructure, which largely determines the properties of a macrostructure. By following this path, the researchers in Düsseldorf developed a titanium alloy for hip replacement implants that are more similar to human bone than pure titanium. As a result, the bone surrounding the implant doesn’t recede.
that case, the individual crystals are arranged in virtually no particular order, meaning there is no preference for any specific spatial direction,” says Raabe. Thus, with the help of simple statistics, it was possible to use the data that Neugebauer fed into the computer, and extrapolate it to a larger component, such as a hip replacement implant.

**PRECISELY PREDICTING THE DESIRED BEHAVIOR**

After completing all of their observations and experiments, the scientists had now defined a specific alloy that contained not only titanium and niobium, but also some zirconium and tantalum. Experiments showed that this material was only twice as rigid as human bone. Pure titanium, by comparison, is more than five times as rigid. Even after all this time, Raabe is still impressed by the quality of the predictions computed with the help of quantum mechanics.

Raabe and Neugebauer have been working together like a well-oiled machine on a regular basis ever since. And they certainly have their work cut out for them. New metal materials are needed for all sorts of applications. The more lightweight types of steel are preferred in automobile manufacturing to reduce fuel consumption. Improved metals could also increase the average lifespan of power plant and airplane turbines. And the ideal variants of steel for durable wind turbine transmissions have yet to be discovered.

These types of requirements are usually much more complex than in the case of the titanium alloy, due to the fact that some of these properties are often even required to change within the lifespan of a material. “A piece of sheet steel should initially be easily malleable so that it can be formed into a radiator hood, for example, without requiring a lot of energy,” says Raabe. As part of the car, however, the radiator hood must then be stable and robust so that it doesn’t instantly become deformed when subjected to external pressure. Yet it shouldn’t be rigid and brittle, either. “Otherwise it would shatter when you hit a tree with your car,” explains Raabe. “In the event of a collision, though, it should become deformed and, in the process, should absorb as much energy as possible.”

Adapting materials as precisely as possible so that they exhibit the desired behavior is one of the central aspects of the work carried out by the materials researchers in Düsseldorf. And just like in the case of the implant, they begin by observing the positions of the atoms in a metal lattice. “The deformability of metals is based largely on the crystallographic defects present in the crystal lattice,” explains Raabe.

**DISLOCATIONS FACILITATE DEFORMABILITY**

The arrangement of atoms in a lattice is never quite perfect. Individual atoms or even whole rows of atoms are missing at statistically distributed sites within the lattice. It is these line defects (also known as edge dislocations) in particular that facilitate the deformability of metals. “When you bend a piece of cop-
A migrating fault: An edge dislocation – in which a layer of atoms in the crystal lattice is incomplete – migrates through a crystal when a material is deformed. Figure 4 in this schematic sequence illustrates how such a dislocation leads to plastic deformation.

per wire, these line defects are each passed on to the next row, thus initiating one step in the atomic deformation process. This effect can propagate itself throughout an entire crystal so that, in the end, an entire layer of metal will have slightly shifted,” says Raabe. This scenario is comparable to a rug with an upward fold that travels forward as you push it along with your foot. By the time the fold reaches the end of the rug, the entire rug will have slightly shifted its position. And pushing it along in this way requires much less effort than if you had tried to move the whole rug at once. Today, the Düsseldorf-based scientists are skilled at using the atomic structure to deduce the force needed to deform metals. Neugebauer begins by observing a finite framework composed of roughly 100 atoms and determining the amount of external force needed to cause some of the missing atoms to dislocate by exactly one row. These findings then flow into Dierk Raabe’s observations of larger sections of the respective material. However, Raabe also has to take into account a series of other effects, such as the fact that dislocations can also encounter obstacles and subsequently split up into numerous new dislocations, for example. That is why the number of dislocations keeps growing as the deformation progresses. “In the case of a larger work piece with a size of about one cubic meter, the total length of such defects triggering the deformation can add up to one light-year,” says Raabe. That’s almost ten trillion kilometers.

If the external force persists, the dislocations eventually become so numerous that they start obstructing each other. “The deformability then starts to decrease,” says Raabe. This effect can be easily explained using a paperclip as an example. The pre-bent parts of the wire are especially hard to deform. Occasionally, they even snap.

The researchers in Düsseldorf specialize in modeling the behavior of dislocations. This field of research is known as crystal lattice defect dynamics. “We examine how fast the dislocations propagate within a crystal when subjected to force, where they fan out, where they become obstructed, and how they interact with each other,” says Raabe. This is an incredibly complex endeavor in light of the fact that a single miniscule crystal can easily contain one million of these line defects. And they even influence each other over a certain distance. “Imagine a bus jam-packed with passengers,” says Raabe. “If one more passenger boards at the front, the effect will be noticeable all the way in the back of the bus, because every single passenger has to scoot back a little bit – those in the front more so, and those in the back gradually less so.”

GPS FOR ATOMS

Quantum mechanical computations for small sections of material are only partially suitable for deducing the manner in which the atoms of different elements are actually distributed in a larger extract. That is why it is important to observe the conditions in the real materials once they have been created. Atom-probe tomography serves as a sort of GPS for the individual particles. High-voltage pulses knock out single atoms from the ultra-thin material sample one atom at a time, and an electrical field then steers them toward a detector. The time it takes them to travel this distance indicates their mass and charge, thus revealing the element to which they belong. In turn, the location at which they reach the detector allows researchers to draw conclusions about the position of the atoms in the sampled material. This method generates a three-dimensional image of the sample with a high enough resolution to even show individual atoms.

Especially when analyzing complex alloys, this type of imaging grants scientists interesting insights into the actual distribution of elements in a material. That was the case during the development of a new generation of materials for future power plant turbines: a nickel alloy that also contains boron. Not until the sample was subjected to atom-probe tomography did it become apparent that the boron atoms aren’t simply distributed in the nickel lattice. Instead, they prefer to settle by the grain boundaries between the individual crystals. There they evidently serve as a type of “cement,” strengthening the bond between the grains.

FROM AN INDIVIDUAL LATTICE DEFECT TO AN ENTIRE CRYSTAL

In the end, Raabe and his team are faced with a series of complicated equations that need solving. This is where the findings derived from Jörg Neugebauer’s quantum mechanical calculations come in handy again. “Here at the institute, we invented the method of deducing the mechanical behavior of an entire crystal based on the quantum mechanical description of a single lattice defect,” says Raabe.

The team also has to take something else into account, a factor that already
played a role in the titanium project: the fact that some metals can form different types of crystal lattices, each featuring different mechanical properties.

Sometimes an external force can cause certain points of a crystal structure to become altered. “Then a layer of atoms in one location is shifted into a less stable position, for example, triggering what is known as a stacking fault,” says Raabe. “This fault can cause a nanoscopically small zone of a face-centered cubic lattice to turn into a hexagonal lattice.”

STACKING FAULTS INFLUENCE DEFORMABILITY

And that has an impact on the material’s mechanical properties due to the fact that the boundary layer between two such types of crystal lattices serves as a stop sign for dislocations. Consequently, the deformability decreases at this site, and this part of the material becomes brittle – and can ultimately even break. Dierk Raabe and his team seek to prevent such premature fatigue. In order to do so, they increase the amount of energy required to cause a stacking fault and thus alter part of the structure. By now, Raabe is able to give his colleague Neugebauer a pretty precise description of what he is searching for. “For example, I ask him what an alloy would have to look like if I wanted the crystal structure to alter only after reaching a tensile stress of 0.8 gigapascals.”

Neugebauer and his team would then simulate the atomic shift that leads to a stacking fault and thus alters one part of the lattice structure. “We determine the exact energy threshold that needs to be overcome in order for this to occur,” says Neugebauer. This stacking fault energy is in defined proportion to the tensile stress. When performing his complex calculations, Neugebauer would then simulate random combinations of iron atoms and other types of atoms until one particular alloy exhibits the threshold value specified by Raabe.

In this very manner, the researchers in Düsseldorf created a new type of steel – a variant that sets the benchmark in more ways than one. “For the first time ever, we were able to incorporate so much aluminum into manganiferous steel that the resulting material is roughly 10 percent lighter than normal steel,” says Raabe. At 10 percent, the total weight of a car could easily be reduced by 100 kilograms. But that wasn’t the only highlight. “Until now, steel variants containing a noteworthy amount of aluminum were brittle, thus rendering them unusable,” explains Raabe. This new type of steel, on the other hand, is extremely deformable and would absorb a large amount of energy in the event of a collision. This behavior was further improved by the individual aluminum atoms in the crystal lattice.

There are currently around 2,500 different types of steel – more than twice as many as at the turn of the century. And the demand for further optimizing materials continues to rise. Today it is possible to predict a material’s properties solely on the basis of its chemical composition, and thus to design metals that fulfill the desired specifications. A mere ten years ago, that would have been virtually inconceivable.

TO THE POINT

- Two of the characteristics that the researchers try to customize for each field of application are how rigid a type of steel or other alloy is, and how easily the material can be deformed.
- Max Planck researchers compute the material’s properties, starting with the quantum mechanical interactions between a finite number of particles. They made it possible to calculate the quantum mechanical behavior of complex materials such as alloys with multiple components.
- The mechanical properties strongly depend on the material’s microscopic structure. Defects in the crystal lattice play an important role in this regard. The Düsseldorf-based researchers study what happens to such defects when the material is deformed, for example. This gives them clues about how a given material can be optimized for a particular application.

GLOSSARY

Density functional theory: In order to calculate the properties of a crystal or other system composed of many atoms, this method determines the electron density at each point within the crystal lattice. As a result, it is no longer necessary for researchers to observe the interaction of all the electrons within the entire lattice, thus drastically reducing the time needed to compute these results.

Stacking faults: If you imagine atoms as being spheres that are stacked on top of each other inside a crystal, the third layer of atoms can take on one of two different arrangements: either directly in line with the first layer, or offset to the first layer. This arrangement is predetermined for a given crystal structure, and deviations from this pattern are known as stacking faults.

Edge dislocation: If this fault (also called a line defect) is present in a crystal lattice, a row of atoms abruptly ends, so that the neighboring rows must be dislocated in order to fill the void.
Since 2006 the Ernst Haage-Prize awards young scientists for outstanding achievements on the field of chemical energy conversion and promotes particularly young academics. The award is given in honour of the entrepreneur Ernst Haage who lived in Mülheim and died in 1968. The Ernst Haage-foundation awards the prize which is supported with a prize money of € 7,500,-. Nominees shall be scientists with a doctor’s degree of a German research institution/university, who are in general younger than 40 years and have no permanent contract of employment.

Nominations can be submitted instantly until September 30th 2014 to the curatorship of the foundation. The following documents should be part of the proposals:

- Two pages of laudation
- Curriculum vitae in table form
- Complete publication list
- Up to three reprints of works of the nominated person.

Personal applications cannot be considered.

The prize shall award excellent scientific achievements on the field of chemical energy conversion, for example in the following divisions:

- Hydrogen as energy transfer medium and storage
- Photovoltaic storage solutions
- Electrochemical storage
- Biomass and bioenergy
- CO₂ transformation
- Hydrogen oxidation and electrolysis
- Reduction of nitrogen
- Artificial and natural photosynthesis
- Development of new experimental and theoretical methods to find new application areas in the energy research.

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Prof. Dr. Robert Schlögl
Prof. Dr. Wolfgang Lubitz
Prof. Dr. Frank Neese
Field research in the forest: Susan Trumbore seeks to understand how long plants and soils store carbon dioxide, and how climate changes influence the carbon balance.
Seeing the Forest for the Trees

Plants and soils play an important role in the global carbon cycle and in the Earth’s climate, not least because they absorb large amounts of carbon dioxide. Yet little is known about how global warming affects these natural sinks. Susan Trumbore, Director at the Max Planck Institute for Biogeochemistry in Jena, has dedicated her research to this subject, and even enjoys getting her hands dirty in search of answers.

TEXT TIM SCHRÖDER

I may quickly overtake you,” says Susan Trumbore as we part, glancing over to her bicycle helmet hanging on the coat rack. “Lately, I’m almost always faster than the bus. Due to the construction site.” Susan Trumbore doesn’t own a car – an attitude that certainly suits a scientist who has dedicated her career to researching the effect of global climate change. Every morning she pedals uphill to the institute. When not traveling by bike, she takes the train. “It really is a shame that they cancelled the high-speed train service to Jena. Now we feel even more cut off.” Truth be told, Jena is no metropolis, she concedes, soft-spoken as always. “But when I moved here, I happened to come across a ranking in the Econo- mist, according to which the people living in Jena are the most educated in all of Germany. Not bad, huh?” she says with a smile.

Susan Trumbore has been serving as Director at the Max Planck Institute for Biogeochemistry since 2009. To her, Jena feels very international indeed. Her research group currently consists of 40 researchers from many different countries. The walls in the hallway are decorated with photos of the field trips the Max Planck researchers from Jena have undertaken – photographs depicting a slim red-and-white tower observatory, and steel cases full of equipment in the Brazilian rainforest. Trumbore also spends several months out in the field each year. Her mission: to study the effects of climate change on soils, plants and forests in different regions around the globe. The western US has been experiencing increasingly long periods of drought for several years now, for example. Juniper forests have already started dying off in Arizona and New Mexico. Similar effects have been observed in Australia.

Researchers still can’t estimate exactly how much carbon dioxide is absorbed or released by soils and forests. As a result, most climate models are inevitably based on simplified versions of this carbon cycle, which flows through the leaves, trunks and roots down into the soil and back into the atmosphere. The computations are based on average

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MaxPlanckForschung

UMWELT & KLIMA

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worldwide or regional values. Yet the Earth is home to many different types of soils and forests.

As a climate researcher, Susan Trumbore wants to gather data on this subject, not only in hopes that it will help her hone her analyses, but also to show agricultural experts and politicians in no uncertain terms what happens when territories are altered by human activity. In her opinion, the most important region for this type of research is the tropics. “Due to the large amounts of direct sunlight they are exposed to, they serve as the Earth’s climate engine – what happens here has an impact everywhere else.”

For Susan Trumbore, travelling to the tropics herself means making a 36-hour journey by plane and bus. First the flight to Manaus, the capital city of the state of Amazonas in northern Brazil. Manaus is one of her favorite places, she says, reminiscing about the bustling city and the warm weather. She then continues her journey by bus for several more hours before finally reaching the areas in which she conducts her research: the forest along the Amazon River and the large soy plantations, the former increasingly being sacrificed for the latter.

Susan Trumbore studied geology because it is a subject that goes beyond pure chemistry: the history of plants, of the climate, of the entire Earth system. As a student at Columbia University she was told that having a solid grasp of chemical reactions, of stoichiometry and molar ratios, would suffice to comprehend the global cycle of chemical elements. Back then, biology was mostly relegated to the sidelines. “Today we know that biological systems have a significant impact on global material flows. There are feedback loops and adaptation mechanisms. Thankfully I work at an institute that focuses on a very central question: How does living nature influence the large-scale global cycles?”

Working on this question for so many years has given her food for

Actively protecting the climate: Susan Trumbore doesn’t own a car; she travels through Jena by bike, or else she takes the train whenever possible.
thought. She looks down at the table and pauses: “I wonder what kind of world we are creating with our actions. I mean, sure, people are making an effort to protect the environment and establish nature reserves. But what exactly are we protecting?” In this vein, she is thinking about the Hainich, a very old primordial forest, now a national park in the German federal state of Thuringia, where studies on plant stress are also being conducted. She is a cooperation partner in this endeavor. “Yet the Hainich is located on land that has been significantly shaped and altered by us humans – a very artificial situation,” she says. That isn’t yet the case in large parts of the tropical rainforest, but those forests are nevertheless endangered.

The German terrain is a prime example of how land management is changing the landscape. “This area used to be covered in forest, but it has since been converted into farmland. In terms of the carbon cycle, this transformation represents a radical change.” She explains that the cycle changes not only when fossil fuels are combusted, but also when forests are burned down or cleared. That’s why she believes it’s so crucial to understand how and why forests die in today’s world – not just directly at the hands of humankind, but also indirectly as a result of climate change.

The geochemist is fully aware that her research can’t change the world. “But the question we have to ask ourselves is how we intend to feed over nine billion people in the future.” The question of whether land management will continue to destroy forests isn’t a scientific matter, but rather a socio-economic one. Mankind needs protein, she explains – soy, if need be. And when the commodity prices for soy go through the roof because of the rising demand for biodiesel in the US, more and more Brazilian rainforest will be converted into plantations. She considers herself a realist, not a fatalist.

When conducting their field studies in the rainforest, for example, Trumbore and her team lug around the cases containing the gas measurement equipment. Even though she has a large staff working for her, she likes to pitch in herself. “I enjoy being outdoors and believe it’s important that I myself also take samples. One of my favorite places to be is outside in a soil pit!” Besides, she says, out in the field she and her crew are often faced with challenges that they would never come across in a laboratory. “Solving problems together and sharing experiences brings everyone in our group closer together.”

HOW MUCH GREENHOUSE GAS DOES THE SOIL CONTAIN?

The researchers place bottomless acrylic boxes on the soil surface and extract the air trapped inside. How much carbon dioxide does the soil release? How much nitrous oxide? How much methane? These are all greenhouse gases. The researchers shovel dirt into small sample flasks and drill holes into tree trunks. The soil and wood samples are later analyzed in Jena. Susan Trumbore has been using this method for years to gain valuable insight into the extensive carbon cycle.

The cycle’s underlying principle was discovered long ago. Plants take up carbon dioxide and convert it into sugars and other carbohydrates during photosynthesis. If the plants or their leaves are eaten by animals or decomposed by microorganisms after the plant material dies, these compounds are broken down again. The carbon dioxide is released. One key question with regard to climate change is how long the carbon dioxide remains in the plants or in the partially decomposed plant material in the ground. In other words, to what extent is less carbon dioxide absorbed if a forest is cut down by humans or destroyed in a drought?

Unfortunately, the carbon cycle is extremely complex because the essential factors that need to be taken into account include not only the plants, but also the soils, which – in the shape of dead leaves and other decomposing plant material – store roughly two to three times more carbon dioxide than the researchers place bottomless acrylic boxes on the soil surface and extract the air trapped inside. How much carbon dioxide does the soil release? How much nitrous oxide? How much methane? These are all greenhouse gases. The researchers shovel dirt into small sample flasks and drill holes into tree trunks. The soil and wood samples are later analyzed in Jena. Susan Trumbore has been using this method for years to gain valuable insight into the extensive carbon cycle.

Keeping track of plant metabolism: The researchers in Jena use glass flasks to trap the gases emitted by a tree trunk (left). They then analyze the isotopes present in the sample to determine how long carbon dioxide remains stored in the trunk. A device that measures gas exchange reveals the amount of greenhouse gases absorbed by plants during a drought experiment (right).
the atmosphere. Therefore, a number of different factors determine how much carbon dioxide is absorbed or released: the climate, the microorganisms in the soil, the type and composition of the plant material, and the geographical location. In the case of deep-frozen permafrost soil in the Arctic Circle, for example, no carbon dioxide is released at all until the soil thaws. Human activities have a significant impact on this whole process. By clearing woodland, we set free large amounts of carbon dioxide in one fell swoop – carbon dioxide that had been stored in trees and soils for a long period of time. Yet how much carbon dioxide is stored in the soil of the farmland that now covers a formerly wooded area? As yet, this question remains largely unanswered.

A NEW TECHNIQUE IN BIOGEOCHEMISTRY

Susan Trumbore was able to shed light on many details pertaining to the carbon cycle thanks to what could be considered her greatest contribution to science: she adapted a technique that was hitherto only applied in other fields, and rendered it suitable for research in biogeochemistry. This technique can be used to analyze precisely how long carbon compounds hidden in soils have existed there. With the help of accelerator mass spectrometry, she searches for radiocarbon, an isotope that can be used to date carbon compounds found in plant tissue or soil. Isotopes of any given element are defined as atoms with a different number of neutrons, the uncharged nuclear particles, which means they also differ in mass. An accelerator mass spectrometer sorts very rare isotopes, such as radiocarbon, by accelerating them very rapidly in a circular orbit using a magnetic field. Due to the fact that each of the particles has a slightly different weight, they hit the detector in succession, one after the other.

She familiarized herself with this technique after completing her doctoral thesis in 1989. Back then, she spent quite some time at ETH Zurich, which featured one of the world’s first accelerator mass spectrometry laboratories. She later switched to the Lawrence Livermore National Laboratory near San Francisco, where she helped set up a new machine.

Today she uses the accelerator mass spectrometer located in the basement of the institute in Jena: a piece of equipment made from stainless steel, the size of three oil tanks, to which countless steel pipes are attached. Fewer than one hundred of these devices exist worldwide, but Susan Trumbore explains the inner workings of this machine with such ease that one could believe she was talking about something as simple as the engine of a small car. A technician is busy adjusting the bolts on one of the pipes. She gives him a quick nod. He smiles. The ventilation unit starts up, so she raises her voice a little. Every now and again she briefly points to one part or another, to a curved steel tank or to a type of steel terminus toward the back.

Susan Trumbore and her team use the accelerator mass spectrometer to analyze the amount of a heavy carbon isotope known as 14C present in a given material in order to determine the age of a soil sample, for example. Archeologists have been applying the radio carbon dating method for decades to establish the age of organic finds and artifacts by means of the 14C content. They, however, are at an advantage, because the concentration of this radioactive type of carbon in the atmosphere remains relatively constant for thousands of years, since that is where the isotope is recreated over and over again by cosmic radiation.

When plants convert carbon dioxide into sugar, they also incorporate radioactive decay of the isotope causes the carbon share to decrease with a half-life of 5,730 years, meaning this factor can be used to determine the age of organic materials.

THE CARBON UPTAKE OF WOOD WAS OVERESTIMATED

Susan Trumbore uses a slightly different version of the radio carbon dating method, one that is suitable for analyzing samples taken within the past 60 years and for determining their age down to the exact year. The slow radioactive decay of the heavy carbon doesn’t play a role in this process. What did have an impact, however, was the fact that the amount of 14C in the atmosphere rose by a factor of 100 in the 1950s due to the atomic bomb tests that were being conducted above ground.
Ever since atmospheric nuclear tests were banned in the early 1960s, this concentration level dropped again; firstly, because plants, animals and the oceans absorbed large quantities of the isotopes, and secondly, because it mixed with less carbon dioxide containing 14C resulting from the combustion of fossil fuels. This caused the concentration levels of 14C to change radically, much more so than radioactive decay would have done. For the team of researchers headed by Susan Trumbore, this steep decline serves as a reference that allows them to calculate the exact year in which their new-age soil and wood samples originated.

Since her time in Zurich, Trumbore has analyzed and dated several wood and soil samples using the accelerator. While still in Zurich, her boss once even placed a fragment of the Turin Shroud on her laboratory bench for examination. The result: the shroud is considerably less than 2,000 years old. “The examination didn’t fascinate me all that much, because in the end, it didn’t change anything: the skeptics feel vindicated, and the believers continue to believe that the Shroud is sacred.”

She finds the results of her scientific work much more exciting. For example: Susan Trumbore and other researchers now know that the high-energy carbon compounds that a tree uses as its reserves are stored mainly in the middle section of the trunk for many years. On the other hand, large amounts of carbon dioxide escape via the leaf stalks or the trunk directly after they are absorbed. In the tropics, the conversion of carbon from photosynthesis to wood can be especially inefficient. “That’s why modern-day climate researchers overestimate the amount of carbon taken up by tropical wood,” she says – an error that is now being corrected in climate models.

The scientific findings relating to the soil are equally important. The most robust carbon compounds are the ones that are created by fire: charcoal-like substances that can survive in the ground for many hundreds of years. Furthermore, studies analyzing 14C have shown that a range of different environmental influences can accelerate the breakdown of old carbon compounds, for example when dry soil suddenly becomes waterlogged, when ground that has remained closed for a long time breaks open, when the vegetation changes, and of course when permafrost starts to thaw.

From among this list of factors that influence how long carbon dioxide is stored in plants and soils, the two that are of particular interest to Susan Trumbore are drought and heat, not least because both of these aspects are likely to become exacerbated and more frequent as a result of climate change. One of the questions the scientist seeks to answer is what happens to the trees and the soil when forests die off due to droughts and heat. Together with her students, she studies what happens when trees starve to death. Plants take up carbon dioxide via tiny stomata in the leaves. At the same time, water evaporates through
these same pores. If the weather is too hot and arid, the plants close the stomata, thereby also preventing the uptake of carbon dioxide—consequently halting the formation of sugar. The plant is thus forced to use up its stored energy reserves, namely the high-energy carbohydrates. If the drought persists, these reserves will eventually be used up, causing the plant to die, the theory states.

Adjacent to the institute, Henrik Hartmann, one of the Research Group Leaders in Susan Trumbore’s department, had a shelter built, under which six-foot tall potted conifers were placed—a rain exclusion experiment designed to simulate drought. Looking at the setup, one might think a Christmas tree delivery service forgot a whole truckload of trees underneath a carport. Trumbore reaches for one of the twigs and rubs the needles between her fingertips. A number of trees have been covered with large plastic bags, allowing the researchers to measure the gas exchange taking place underneath. Some of the tree trunks are surrounded by a cuff. The doctoral students use these cuffs to monitor the trunk’s change in girth as the tree takes up water. “We don’t yet fully understand tree mortality induced by drought. There are several possible explanations.” One is that the water shortage disrupts the transport of water up to the crown of the tree like a water column in a drinking straw—spelling certain death for the tree.

Susan Trumbore speaks English. Her German isn’t good enough yet, she says, with a hint of embarrassment. Yet it’s easy to forgive someone who is constantly travelling back and forth between the Old and the New World. She has little time to spare for language courses or other activities. She used to play the clarinet, mostly classical pieces. “When I have the time, I enjoy going to the opera or to classical music concerts in Jena, Berlin or Leipzig.” She has also been to the famous

New insights thanks to a new technique: Trumbore’s team uses an accelerator mass spectrometer to analyze the amount of heavy 14C carbon contained in plant and soil samples. These findings allow the researchers to deduce how long the carbon remains stored in the materials. Carlos Sierra prepares a sample tray for the measurements (top).
opera house in the Brazilian city of Manaus, where she has been teaching as a guest professor at the university since January. One of her colleagues in Brazil set up an initiative in which children craft musical instruments using wood from dead tropical trees. “The children demonstrated their instruments at a concert in the opera house.”

Susan Trumbore isn’t married. She doesn’t have children. “But I do have almost 40 doctoral students and postdocs,” she says, laughing. She lives for science, following in her father’s footsteps: he was a chemistry professor in her hometown of Newark, a small town in Delaware on the East Coast of the US. “He was the one who instilled in me this passion for science. He always put his heart and soul into it.”

THE FIRST WOMEN TO HAVE THE WORLD AT THEIR FEET

Susan Trumbore is a woman of a somewhat short stature, but a big name in the scientific community. She says that she is part of the first generation of women who have the whole world at their feet – with less chauvinism and no pressure to conform to traditional gender roles. Her mother was a librarian. “When I think of her, I realize how many opportunities were open to me.” As a student, for example, she also spent some time as a guest in the laboratories of Paul Crutzen – one of the scientists who discovered the hole in the ozone layer.

Despite these opportunities, she is one of only a handful of women in her field. In fact, only a small number of women have assumed management or director positions in Germany, she says. “At the University of California, 25 percent of the professors are women.” She still collaborates with her former work group at the University of California in Irvine, where she worked until 2009. She visits her colleagues every few months.

She has noticed numerous differences between Jena and Irvine. Irvine, for example, is a planned city that was built from scratch by a company in the 1960s. With a population of just over 200,000, it really could be called a large city. “But in Irvine you meet many people from many different countries, and I love that. It’s the same here on our international science campus, but not so much over in the town.” Suddenly, Jena starts to feel like a pretty small place again. Nevertheless, she likes Germany and Jena: Germans get down to work. They start projects with an extraordinary level of optimism. “I mean, it’s unbelievable that there are so many solar arrays here in Germany, but only a comparatively small number in California – even though we get less sunshine over here.”

Hanging on her office wall is a poster charting the hiking trails in the region surrounding Jena. She enjoys going for a stroll with friends through the forests directly bordering the city outskirts. The red trail is the longest. Once a year, a 100-kilometer footrace takes place along this route. “The sign-up sheets always fill up right away.” Has she ever taken part in the race herself? “No,” she answers. “But some of the people from my research group participate every year.” She prefers riding her bike. And Jena is the perfect place to do just that. In Irvine, she says, that was always a bit of a challenge – due to the long distances and the heavy traffic.

Glossary

Accelerator mass spectrometry: This type of mass spectrometry distinguishes between particles that differ in mass, thus making it possible to separate very rare isotopes of an element – such as 14C – from among neighboring molecules and molecule fragments that have the same mass. The molecules are broken down by first being accelerated and then being subjected to strong positive ionization in a gas or thin carbon foil.

Isotope: Variants of a given chemical element. Isotopes each have a different number of neutrons in their atoms, and therefore also differ in mass.

Carbon cycle: Geoscientists define the carbon cycle (also known as the carbon dioxide cycle) as the movement of carbon dioxide from the air through plants and soils, as well as through bodies of water and the organisms that live in them, and ultimately back into the atmosphere. Humans also heavily intervene in this cycle, especially by combusting fossil fuels and clearing woodlands. There are numerous feedback loops between the carbon cycle and the Earth’s climate.
The Night of the Comet

It was a historic event for researchers and a spectacle for the media: On the eve of March 14, 1986, the Giotto space probe hurtled past Halley’s Comet at a distance of 600 kilometers and sent back measurement data and close-ups of the nucleus. More than 220 European scientists were involved in the project, including 22 from Max Planck institutes.

The control center of the European Space Agency ESA has spruced itself up: Rugs cover the polished floors, flowers decorate the corridors. Several hundred journalists and a large number of celebrities including Her Royal Highness Princess Margaret of Hesse have come to Darmstadt on the evening of March 13, 1986. They want to experience “the most important event in space travel since the moon landing,” as Research Minister Heinz Riesenhuber puts it.

For the first time in history, an unmanned probe will execute a fly-by very near to the nucleus of a comet and photograph it close up. It’s not a rendezvous with just any comet, though: this is the legendary Halley’s Comet, which approaches Earth once every 76 years, and which inspired people the world over during its last guest appearance in 1910. Back then, the comet not only had to serve as an advertising medium for a range of products, such as typewriters and vanilla pudding, but it was also considered to be a harbinger of bad luck. It was said that its tail brought poisonous gases to Earth, against which allegedly only expensive comet pills could offer any protection.

And Darmstadt isn’t the only city where comet fever is holding sway on March 13, 1986. More than 50 TV stations want to broadcast Giotto’s cosmic encounter into the nation’s living rooms. Germany’s two public broadcasting companies, ARD and ZDF, both bring a “night of the comet,” with ZDF airing the show until the early hours of the morning. Later, critics would have nothing good to say about the show broadcast from Mainz, presented by Joachim Bublath and Bernd Heller. Celebrity astrologer Madame Teissier (“The stars are tense this evening”) is given on-air time, as is a woman who claims she observed a swarm of UFOs over Düsseldorf. Also featured are comet hairstyles and drinks, as well as a Halley’s breakdance. In short: a lot of silly jokes and very little science flicker across the screen for hours.

And this despite the fact that researchers pronounce the mission – which cost around 350 million Deutschmarks – outstanding, even before the first results are in. Giotto, stresses the then ESA Director General Reimar Lust, is ESA’s first interplanetary probe and the first scientific payload aboard an Ariane rocket. And never before has a vehicle built by humans come so close to a comet. Giotto is viewed as the flagship in an armada of five space probes – American, Russian and Japanese – that are flying toward Halley’s Comet.

The vehicle, named after the Italian Renaissance painter Giotto di Bondone, who immortalized Halley’s Comet as the Star of Bethlehem in a fresco, carries ten instruments: mass spectrometers, plasma devices, a magnetometer and a camera. The probe was launched on July 2, 1985. The rendezvous with Halley’s Comet is a remarkable feat by the trajectory engineers, as the comet doesn’t fly in the ecliptic plane in which the planets orbit the Sun like coins on a gaming table. A further complication is that it moves “the wrong way around,” namely in the opposite direction to Earth, and thus to the paths of space probes, as well.

On March 13, 1986, Halley’s Comet crosses the ecliptic from above – precisely the point where Giotto is to intercept it. The researchers have calculated that the encounter will be fleeting, at the inconceivably high speed of 250,000 kilometers per hour, or 68.4 kilometers per second. The separation from Earth is then around 150 million kilometers; signals that race through space at the speed of light require around eight minutes to cover this distance.

The scientists feel reasonably prepared for the rendezvous itself. Even if they don’t know precisely what Giotto can expect, they have an idea what comets are: dirty snowballs measuring a few kilometers in diameter. At least that’s how American astrophysicist Fred Whipple described them in his model back in the 1950s. Whipple has also come to Darmstadt, as has the father of cometology, Jan Hendrik Oort, and US media astronomer Carl Sagan.

Most of the time, comets remain far out in the planetary system, but periodic comets like Halley regularly leave their cosmic fridge. On an orbit that is usually elongated and oval, the huge chunks then set off on their journey toward the Sun, and their surface heats up.
When the comet comes within a certain distance of the Sun, the volatile components – mainly water and frozen gases – vaporize and carry away the embedded dust particles. The evaporated particles spread out uniformly to all sides and eventually form a cloud measuring several hundred thousand kilometers in diameter – the coma – around the nucleus.

High-energy UV light from the Sun penetrates this coma, breaking up molecules or snatching electrons from them. This creates a plasma, which ultimately flutters like a flag in the solar wind. It is this tail that gives the comet its characteristic appearance; it usually also contains a “dusty” component, which is generated by the pressure of the sunlight. The solar wind – an ever-flowing stream of electrically charged particles – had been predicted by Ludwig Biermann of the Max Planck Institute for Aeronomy (today: Solar System Research). On his lapel he wears a red ribbon – as do Reimar Lüst and Jochen Kissel from the Max Planck Institute for Aeronomy – representing the Gagarin Medal, which had been awarded to the researchers a short time before. On March 13, 1986, the day of the Giotto rendezvous, he would have been 79; however, the comet researcher had died two months prior.

Biermann thus didn’t live to experience the memorable night of the comet, which kicks off in Darmstadt at 2 p.m. with an initial press conference. The speeches and interviews follow at around 7 p.m. The VIP lounge fills up slowly, while the engineers and scientists sit in the darkened control room, staring ahead of them as the screens fill with numbers and letters. At around 9 p.m., at a distance of one million kilometers, Giotto passes the comet’s bow shock wave – the shock front that Halley pushes ahead of it and that is invisible in visible light.

“We are measuring the compression of the magnetic field, the heating up of the protons, and the first plasma particles of the comet,” says Arne Richter from the Max Planck Institute for Aeronomy (today: Solar System Research). On his lapel he wears a red ribbon – as do Reimar Lüst and Jochen Kissel from the Max Planck Institute for Nuclear Physics – representing the Gagarin Medal, which had been awarded to the researchers a short time before in Moscow.

In Darmstadt, while twenty cleaning ladies are busy emptying wastepaper baskets and cleaning windows, the hand of the clock jumps to 10:03 p.m. Horst Uwe Keller becomes restless. The Halley Multicolor Camera (HMC), whose project leader is the researcher from the Max Planck Institute for Aeronomy, transmits the first image. Giotto is now still 767,000 kilometers away from the nucleus. From now on, HMC provides images at a rate of one every four seconds.

As the scientists’ excitement increases, so does the confusion for the invited guests in Darmstadt. A computer converts the gray shades on the images into different, arbitrarily chosen colors in order to emphasize contrasts and highlight details. “It looks like a fried egg,” says one female visitor, disenchanted. “Or like the Galapagos Islands,” adds the person sitting next to her, with disappointment.

Horst Uwe Keller, however, is delighted. He can make out Halley’s nucleus on the photos! It is 15 kilometers long, twice as large as first thought, and looks like a peanut. It contrasts clearly as a silhouette against the bright background of the coma. On the side of the comet facing the Sun, at least two broad jets of dust shoot up into space. The raw data already contains a sensation: Some researchers had assumed that there was no solid nucleus under the coma, but a rather loose accumulation of dust and smaller rocks. In fact, the nucleus of Halley’s Comet is extremely dark and resembles more an “icy ball of dirt” than a dirty snowball.

Midnight in Darmstadt: In front of the control center, the special post office that has been selling Giotto stamps and postmarks has closed its doors. Inside, science carries on. The probe continues to send back new images. Just after 1 a.m.: 14 seconds before Giotto is to reach its closest point to Halley’s Comet, around 600 kilometers, the last image is produced. It shows only a bright fountain of dust. “Probably the one that hit the camera and knocked out the whole space probe,” says Klaus Wilhelm from the Max Planck Institute for Aeronomy.

At least 120 dust particles per second hit the vehicle – having, at those high speeds, the same effect as bullets. Even the two protective shields – an aluminum sheet 1 millimeter thick, and a second sheet made of Kevlar and rigid foam and measuring around 1.5 centimeters thick – are no longer a match for this. The probe starts to tumble, the temperature aboard and inside the camera rises by 12 degrees. The plan was actually for Giotto to observe the comet’s nucleus from the other side after the fly-by, but the screens in the control center remain dark. The Halley Multicolor Camera is out of action for the rest of the mission.

Nevertheless: The scientists are euphoric. At two o’clock in the morning on March 14, they again appear before the media. At an improvised press conference, Horst Uwe Keller explains the final images. Giotto had continued to operate almost up to the point of closest approach. “The probe has achieved the task for which it was built,” says ESA Director General Lüst with pride. The British Prime Minister, Margaret Thatcher, sends a congratulatory telegram. And in the Darmstadt media center, the lights are finally switched off.
The President – And His Start in Office

Martin Stratmann. The chemist was born in Essen and grew up on the Moselle. His career has taken him to places as far apart as Düsseldorf, Cleveland and Erlangen. And his links with the MPS date back more than 30 years.

Less than a week into his term of office in mid-June, he already made his first successful appointment. A special moment, says Martin Stratmann – not least because the appointee, Moritz Helmstaedter, like the President, is also deeply rooted in the MPS. A former Research Group Leader at the MPI of Neurobiology in Martinsried, Helmstaedter became Director at the MPI for Brain Research in Frankfurt am Main in August. One day after his appointment interview, he had accepted the position in writing – sealed by a handshake in the President’s office at the Max Planck headquarters in Munich.

MOVE TO MUNICH

And it is from this office that Martin Stratmann, who grew up in Traben-Trarbach on the Moselle, will shape the destiny of the MPS. He and his wife Lieselotte Stratmann, who also holds a doctorate in chemistry, have since moved to Munich. “But Düsseldorf will still be home,” says the father of three, whose career is closely linked with the MPI für Eisenforschung (iron research) in the Rhine-Ruhr metropolis. After completing his studies at Ruhr University Bochum, this is where Martin Stratmann wrote his doctoral thesis between 1980 and 1982, and the place to which he returned as a scientific staff member in 1984 after two years abroad at Case Western Reserve University in Cleveland in the US. Three years later, he took over as Leader of the Corrosion Research Group at the MPI.

During this time, he also earned much recognition for being the first to use the scanning Kelvin probe microscope to study corrosion processes, also under ultra-thin electrolytic films and insulating layers. Thanks to this method, it has been possible to largely explain the atmospheric corrosion of iron and iron alloys, and the detachment of polymer coatings from reactive metal surfaces. This research opened the way for the development of new kinds of plastic coatings that protect steel against rust and are self-healing when damaged.

In 1994, Martin Stratmann transferred to Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) where, until 1999, he held the Chair of Corrosion and Surface Technology as the successor to Helmut Kaesche. In 2000, he returned to the MPI as Director of the Department of Interface Chemistry and Surface Engineering before becoming Chairman of the Board of Executives two years later.

President Stratmann has received numerous awards for his research, among them the Masing Prize in 1990 presented by the Deutsche Gesellschaft für Materialkunde, the U. R. Evans Award in 2005 from the British Institute of Corrosion, and the Carl Lueg Memorial Medal in 2013 awarded by the Steel Institute VDEh for achievements in steel research. One of the first distinctions he received was the Otto Hahn Medal, which he received for his doctorate. As a result of the time he has spent as a Member of the Senate and his many years as Section Chairperson and Vice President representing the CPTS, he is also well versed in the workings of the governing bodies at the MPS.

INDUSTRY AS A PARTNER

The 60-year-old chemist also maintains close links with his alma mater, Ruhr University Bochum (RUB), where he is a member of the Materials Research Department. It is thanks to his commitment that the federal state of North Rhine-Westphalia and local industry agreed to fund three endowed chairs at the Interdisciplinary Centre for Advanced Materials Simulation (ICAMS), where the Max-Planck-Institut für Eisenforschung also plays a part: “We aim to enhance the attraction of Bochum by combining research, education, support for junior scientists, and industrial relevance,” says Martin Stratmann, whose perspective now extends beyond individual centers to research policy as a whole.
The Vice Presidents of the Sections

ANGELA D. FRIEDERICI, Director at the MPI for Human Cognitive and Brain Sciences in Leipzig, is the first woman to hold this position. She represents the interests of the Human Sciences Section, which comprises 22 Max Planck institutes. In addition, Friedericici will become Scientific Director of the Minerva Foundation, the subsidiary that promotes German-Israeli scientific cooperation and supports more than 20 Minerva Centers in Israel.

BILL S. HANSSON, Director at the MPI for Chemical Ecology in Jena, is Swedish by birth and is the first non-German Max Planck scientist to hold this office. During his six-year term of office, the 55-year-old will be responsible for the 27 institutes of the Biology and Medicine Section, including the Max Planck Florida Institute for Neuroscience in the US. He sees the organization of scientific quality assurance and the continuing development of internationalization at the Max Planck Society as two of his main tasks.

FERDI SCHÜTH, Director at the MPI für Kohlenforschung (coal research) in Mülheim an der Ruhr, previously chaired the Scientific Council of the MPS before being elected as Vice President. The 53-year-old scientist will now oversee the 32 institutes of the Chemistry, Physics and Technology Section. Among other things, he will also be responsible for major long-term projects and shared infrastructure, with particular emphasis on the IT infrastructure at the MPS. In common with the other Vice Presidents, Schüth will also continue to remain associated with his own research.

New Career Path for Young Scientists

Outstanding facilities at a Max Planck institute, professional networking at a supra-institutional level, and clear career prospects at a University of Excellence: the MPS and the Technische Universität München (TUM) are launching a program for junior scientists that is thus far unique in Germany. Together, they intend to appoint the most highly qualified junior scientists as both Max Planck research group leaders and assistant professors on tenure track at the TUM. Subject to positive evaluation, after six years they will then progress to a permanent W3 professorship at the TUM. “Max Planck research group leadership posts are highly coveted internationally. And with the new follow-up option of further career development, it is now even more attractive to relocate to Germany. This is a winning combination in the contest for the finest minds,” says Max Planck President Martin Stratmann.

MPRGs are initially set up for a five-year term, but extensions can be applied for, so that the step up to a W3 professorship at the TUM follows well, time-wise. Even during the first six years, while the successful Max Planck research group leaders are serving as assistant professors at the TUM, they will have the same rights as tenured professors, including the right to award doctorates. On a limited scale, they will also give lectures.

The Minerva-financed Max Planck research groups established to promote excellent female scientists are also integrated into the program. The TUM and MPS are expected to issue an initial coordinated call for applications in the fall, when the time comes around again to seek candidates to head open-topic MPRGs.
“More than just a plan B”

Marine scientists from six graduate schools sound out alternative career paths

Over 110 doctoral students met with professionals representing environmental associations, government ministries, industry, science management and public relations. The majority were alumni of the six graduate schools that initiated the event.

Greta Reintjes has been working on her doctoral thesis for a year now at the International Max Planck Research School of Marine Microbiology (MarMic) in Bremen. “Sometimes I find myself in the laboratory and nothing is going right,” she says. “But when I hear from alumni how important a doctorate was for their own career, it motivates me to keep working.”

In addition to practical career tips, the 19 specialists at the first “Career Paths in Marine and Climate Sciences” conference described their day-to-day activities, and they didn’t pull any punches. One laboratory manager remarked on the difficulties she faced after taking maternity leave, while a patent attorney referred to his stressful workload. “Even outside of science, all that glitters is not gold. That was an important lesson for me to learn,” said the student.

CREATING A NICHE FOR ONESELF

According to a current survey by the Federal Statistics Office, for many young scientists, the preferred first step after obtaining their doctorate is to seek a fixed-term post-doc position. Barbara Hoffbauer, managing director of Kepos GmbH, commented in her presentation that “those who don’t become group leaders at an early stage find it difficult to establish themselves in the scientific field.” Her advice to up-and-coming scientists who are seeking to follow an alternative career path: “It’s easier for someone who has created a niche for themselves, for example by studying environmental law as well as marine science, to find a job outside of science.”

Christiane Glöckner, Coordinator at the IMPRS MarMic in Bremen, was one of the organizers of the event. “Also on board were the Universities of Bremen and Oldenburg, along with the Alfred Wegener Institute (AWI), the Center for Marine Environmental Sciences (MARUM) and the Leibniz Center for Tropical Marine Ecology (ZMT). This was the first time we had jointly planned and held such a large event.” The alumni of the research organizations were available all day to talk and answer questions in roundtable discussions.

A TREND-SETTING CONFERENCE

Independent of other internal Max Planck resources, such as soft skills courses and “speed informing,” in which doctoral students meet with alumni, career events such as this are setting a trend at the MPS. Given that doctoral students are trained primarily for a career in science, information on alternative future prospects is frequently lacking. “However, our students are very interested in these alternatives,” says Christiane Glöckner. “The graduate schools are responding and communicating the fact that an alternative career is more than just a plan B – that it can often be a genuine option.” As a result, the conference on “Career Paths in Marine and Climate Sciences” will be repeated in two years.
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