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Peter Hergersberg (Chemistry, Physics, Technology; -1536)

Editors-in-Chief

- Peter Hergersberg (Chemistry, Physics, Technology; -1536)
- Editor: Christine Beck (cut)

Editors

- Susanne Beer (Culture, Society; -1342)
- Dr. Ellen Maier (Biology, Medicine; -1064)
- Dr. Noltschaf (Biology, Medicine; -1064)

Photo Editor: Susanne Schauer (-1562)

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ON LOCATION

… is not at all where the researchers from the Max Planck Institute for Gravitational Physics want to be. The issue at hand is nothing less than the base of one of the pillars of our modern world view, the theory of general relativity. In 1915, Albert Einstein formulated, among other things, the theory that the accelerated movement of masses causes disturbances that move through space at the speed of light. He called these disturbances gravitational waves. The Earth, for instance, creates a bulge in space-time on its annual orbit around the Sun, emitting gravitational waves in the process. Given the enormous number of planets and binary stars, space must be utterly teeming with these waves. In most cases, however, the cosmic ripples are too weak to be detected with terrestrial detectors. Fortunately, there are far stronger tremors in the universe: the dance or collision of neutron stars with black holes, or the explosion of a massive sun into a supernova.

Such violent events are what scientists around the world are waiting for – for example out in a field in Ruthe, near Hanover. This is where GEO600 stretches out its two 600-meter-long arms. The evacuated stainless steel tubes measure 60 centimeters in diameter and are corrugated to increase their stability. They house the second-longest laser beam interferometer in Europe. The measuring principle is based on the fact that gravitational waves alternately compress and stretch space. If they speed through GEO600, they will also change the paths of the laser beam that runs through the two perpendicularly arranged tubes. This tiny length difference on the order of $10^{-19}$ meters causes the light waves in the detector to fall out of step. A signal appears. Alarm! To date, however, there have been only test alarms. The researchers are working on continuously increasing the system’s sensitivity. When the cosmos quakes again, they want to finally capture the gravitational waves and thus open up a new window into space.

Left out in the cold …

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**Children**

**18 The Upside of Sharing**

Even if stressed-out parents may not fully agree: Children are born helpers. Even infants are surprisingly cooperative and willing to share, as researchers at the Max Planck Institute for Evolutionary Anthropology in Leipzig have now shown. Humans evidently have a natural propensity for helpfulness – quite unlike our closest relatives, the chimpanzees.

**26 Letter by Letter**

Children learn to speak almost effortlessly, even in multiple languages. But why are reading and writing often so difficult, even despite years of instruction? Scientists at the Max Planck Institute for Human Development in Berlin are investigating this question. Their findings provide important starting points for systematically supporting children with reading difficulties.

**34 Take a Bite or Resist?**

From a very early age, children exhibit a remarkable sense of fairness and justice. The older they get, the more they develop such social skills as compassion and empathy. Researchers at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig are analyzing how the social behavior of children develops, and which regions of the brain play a role in this.

ON THE COVER: Resisting a sweet temptation is hard even for most adults. Children will grab one of their favorite cookies much faster if the plate is within reach. We aren’t born with the ability to control impulses – it must be developed over time. Researchers are taking a closer look at children’s behavior.
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The research being undertaken by the scientists at the Max Planck Institute for Polymer Research in Mainz could not only put an end to the annoying smears on window panes, it could also make it possible to produce self-cleaning solar panels or even more effective heart-lung machines.

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Facebook didn’t exist, and the idea for the microblogging service Twitter, now blithely quoted on television, hadn’t yet entered anybody’s head. But in 2003, the Internet was already an important presence. And because it made comprehensive, universal and free access to information possible for the first time, the Max Planck Society decided ten years ago, together with other German scientific organizations and international institutions, to sign the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities.

Since then, the Berlin Declaration has proved extremely potent and has become a cornerstone of the open access movement. It not only formulated the goal of open access, but also proposed concrete measures for achieving it. While 19 institutions were involved initially, it now has the support of over 440. That is impressive development. And yet academia, which largely created and co-developed this medium, doesn’t exploit its full potential. Unlike social media, for example, open access still lags behind the possibilities it has to offer.

Nevertheless, a lot has happened over the past ten years. Despite the obstacles, we have already made crucial progress on the path toward fulfilling the Berlin Declaration’s goal of promoting “the Internet as a functional instrument for a global scientific knowledge base.” Open access, the system whereby published research findings should be made universally available free of charge and for further use, is here to stay.

Around 10 percent of the specialist publications produced each year are now available via the “gold road,” through direct publication in open access journals, and the trend is rising. A further 12 percent are added to this via the “green road,” which involves publication in a free online repository following primary publication. The number of such repositories has risen to 2,400; more than 9,900 titles are listed in the Directory of Open Access Journals. This represents an increase of almost 30 percent since May 2012.

This ongoing dynamic development is very positive given that open access is hugely important for science. First, as the Berlin Declaration states, “Our mission of disseminating knowledge is only half complete if the information is not made widely and readily available to society.” Second, research thrives on the exchange of the very best ideas. The more comprehensively and immediately this exchange can take place and the greater the freedom we have to reuse results, the more effectively scientists can work.

In the case of interdisciplinary projects, in particular, new search methods will improve the processing of results from different disciplines. The advantage here is that information can be obtained faster and research will become more effective in terms of serving the common good. Given these benefits, almost 90 percent of the scientists who participated in the EU SOAP study presented in 2011 rated open access positively.

Its implementation, however, is taking time, as important adjustments have to be made to a system that is crucial to the world of science. The system in question is, of course, publishing, the lifeblood of science and research. There is a long tradition here whereby researchers regard scientific journals that have been established for decades and that are thus held in high regard as the crucial yardstick in evaluating the quality of their work. Through this publication process, they hope to gain the best possible reputation in the scientific world and to find stimulus for their careers. Accordingly, publishers can charge high prices when selling these journals to libraries.
This model has been around for a long time. However, given the significant increase in the price of journal subscriptions and the restrictions placed on open access for academia, it is no longer acceptable. Instead of the black box of subscription price calculations, we need models based on actual publication costs and characterized by transparency and sustainability. The money from existing subscription budgets must be transferred to publication budgets from which the authors’ publications can then be financed via open access.

This paradigm shift is already under way in many places. At the MPS, we have the Max Planck Digital Library, which acts as a joint service facility. It finances central open access publications and also improves the conditions for open access for all of our institutes by negotiating contracts with open access publishers and developing infrastructure like our own open access repository. In this way, standards are created that can benefit all of our scientists.

To ensure that free publication becomes as attractive as the conventional route, we are also doing everything in our power to promote high-class open access publications. These are being developed bottom up from within the scientific community. A good example is the journal LIVING REVIEWS IN RELATIVITY, which was established at the Max Planck Institute for Gravitational Physics in 1998 and which, based on its international citation ranking, has become the top place for publications in this field. In the humanities, publications like DEMOGRAPHIC RESEARCH are also well established.

Together with the Howard Hughes Medical Institute and the Wellcome Trust, the Max Planck Society also founded the online journal eLIFE in 2012 with the aim of establishing a top international journal as an open access alternative in the biosciences. The editorial board, staffed by renowned active scientists, views the authors as customers. The reviewing process – carried out by independent researchers – was therefore optimized to guarantee maximum quality and ensure that the publication process is less burdensome for the authors in terms of the amount of work they have to do and the timescales involved. Publication decisions take no more than 77 days on average.

Moreover, eLIFE consistently exploits the possibilities offered by the Internet. These include the fact that it enables the easy dissemination and further processing of knowledge – and that authors can track how demand for their publications is developing in real time. eLIFE is very innovative in offering this diverse mix of possibilities. Of course, it can’t catch up with Cell, Nature or Science overnight, but having already published around 190 scientific articles, its prospects are very promising.

Because open access is a global initiative on the part of academia, these two important approaches to the reorganization of the publication system must also be coordinated on an international level. We are fully involved in this process, including as a co-organizer of the follow-up conferences on the Berlin Declaration, which have evolved into a permanent platform. The eleventh conference is due to take place in Berlin on November 19th and 20th. This year’s agenda also includes the discussion of political strategies. After all, open access has long featured on government agendas throughout the world.

However, the approaches differ. The German political system ultimately chose not to focus on the concept of open access as a whole, but on one of its key components: copyright. The adopted legislative amendment guarantees the authors of scientific papers the right to provide open access to their work following its primary publication in a subscription journal. However, there are too many conditions associated with the provisions and, due to the almost complete exclusion of university-affiliated scientists, they don’t apply to a large proportion of German researchers. Hence, we support further improvements to the legislation. This also concerns the general waiting period between primary and secondary publication, which, at 12 months, is too long. Moreover, the federal government should adopt an official political position and a national strategy on open access that is tailored to the European context.

The European Union is already one step ahead with the implementation of open access through its new Framework Programme for Research and Innovation that goes into effect from 2014: in principle, the results of all projects funded through Horizon 2020 are to be published through open access – and the associated costs covered by the funding granted. This will provide important impetus for the European research area, and will also act as a driving force for attaining the goal of the Berlin Declaration.

PETER GRUSS
President of the Max Planck Society

The federal government must adopt a political position
Strong Podium for More Research

Discussion at the new premises of the Max Planck Society’s Brussels office

Five experts with a single view: In the podium discussion on the topic “More investment in research – one way out of the European crisis?” conducted at the new premises of the Max Planck Society’s Brussels office, there was broad consensus between the speakers. In front of more than 40 prominent guests, they highlighted the importance of science as an engine for economic growth, while also pointing out that not only the volume of funding but also the structures and principles of the research need to be improved. "The association is obvious: investment in science, especially basic research, is a key factor for technological leadership," said Max Planck President Peter Gruss. According to him, the contribution of elite research is particularly significant.

“The EU member states that have joined since 2004 attract only 2 percent of the European Research Council’s grant, even though they account for 20 percent of the population. Enormous potential is still lying fallow here, and Europe needs to utilize it if it is to hold its own in the international context,” emphasized Gruss. This is the aim of the EU’s new Teaming Excellence instrument, in which leading research facilities join up with partners in less developed regions in a bid to develop internationally visible local research centers. “You could say that Teaming Excellence creates an evaluation system for excellent research structures,” said the Max Planck President. The instrument’s true effect lies in mobilizing significant sums from the structural funds for research sponsorship.

Strong Podium for More Research

License Goes to Dolby

Company aims to refine image processing technology

HDR imaging has been used in photography for many years, and is now also finding increasing application in movies. Such images are shot using a wide range of brightness levels, from very light to very dark. This broad spectrum makes it possible to reproduce realistic light intensity and coloration even more precisely than in previous digital images. However, the high volume of data involved requires a more sophisticated processing method to ensure compatibility with standard LDR systems. Along with their team from the Max Planck Institute for Informatics, Hans-Peter Seidel and Karol Myszkowski developed a new method of HDR image data processing that greatly reduces the data volume. Dolby now wants to develop an application of this technique for its next-generation screens. "Dolby Laboratories is the perfect licensee, as the company has the capability to turn this invention into fantastic image processing technology that provides outstanding experiences in entertainment," says Bernd Cttortecka, License Manager at Max Planck Innovation.
“South Korea backs a success story”

Why the high-tech country is setting up research centers based on the Max Planck principle

Basic research according to the Max Planck Society model: South Korea’s government has explicitly named the prototype to be used in founding its Institute for Basic Science (IBS). By 2017, it is due to comprise fifty research centers. This is the core of the “International Science and Business Belt (ISBB)” initiative. We interviewed Peter Fulde (77), who established the first Max Planck Institute in Dresden after German reunification, and is now advising the team responsible for the IBS.

Mr. Fulde, it’s a long way from Dresden to East Asia. How did you get involved? Peter Fulde: Shortly after the Max Planck Institute for the Physics of Complex Systems was founded in Dresden, the physics societies in the Asia-Pacific region decided to establish a similar institute. After my retirement, I was asked to drive forward the inception of the Asia Pacific Center for Theoretical Physics in Pohang as President. I have been there since 2007, and now spend more than half of my year in South Korea, and the Center has been established, thanks in part to the support of the Max Planck Society, which financed a junior research group. This type of model, giving a lot of freedom to talented young people, had not been seen in South Korea before. Now it’s hard to imagine life without it, and it’s being nationally funded. There are six of these groups at present. A similar program is also in place at the Institute for Basic Science, the Korean version of Max Planck.

South Korea is regarded as a high-tech country – why does it need the IBS program? When it comes to industry, South Korea is certainly high-tech, and the same applies to its infrastructure. However – and this was also made clear by the country’s President Lee Myung-bak when he introduced the ISBB Act – while applied and industrial research are well positioned, basic research still has a long way to go. The aim of the IBS is to fill this gap. The idea goes like this: up till now, South Korea has seen itself as a “close follower” in the high-tech world, with the ability to adopt the innovative basic ideas of others and to use them to develop products that are even better than their prototypes. The disputes between Samsung and the US corporation Apple are characteristic of this phenomenon. The government now feels that China will soon be taking over this role. South Korea wants to realign itself to become a technology leader and make its own groundbreaking discoveries. Sound basic research is to play a key role in this process.

How is the setting up of the IBS being guided by the Max Planck Society? Every country needs to find its own format for an optimal organization, but it’s always good to stay informed: how was it done by others who are particularly successful? For this reason, IBS employees have visited Max Planck Institutes and the MPS’s Administrative Headquarters. General Max Planck principles now apply at the IBS Centers: autonomy and freedom for the researchers, along with the Harmonack principle. To attract the best, international calls for applications are sent out and the bids subjected to a critical review by a Selection and Evaluation Committee. The evaluation process will be similar to that practiced by Max Planck. It’s no coincidence that a foreign scientist has now taken the chair of the Committee alongside me, and that half of its members come from overseas. The aim is to make the appointment process – the key aspect in ensuring excellence – as objective as possible and to open it to international candidates. Incidentally, two more Max Planck scientists, Jos Lelieveld and Hans Wolfgang Spiess, have now been appointed to the Committee.

The IBS started working over a year ago. How do things stand now? The IBS itself is not an actual institute, but an umbrella organization under which fifty independent centers are to be established. Each center will have an annual budget of about 10 million US dollars, will be headed by a prominent researcher, and will employ around sixty other scientists. The focus is on natural sciences, including the life sciences. About twenty centers have already been founded. The headquarters office, headed by IBS President Se Jung Oh, is being established in Daejeon. South Korea’s new President has been in office since early this year. As the country is now focusing on various new issues, the setup process has slowed down a bit. But, since the IBS was founded with the aid of a law, it stands on solid ground.

How is the IBS integrating into the research landscape with its centers? The universities are already conducting basic research, but not in such a concentrated way as at the IBS. Moreover, few of the many universities may be rated as excellent according to German standards. The IBS is therefore gaining a great deal of importance. After a lengthy political debate, it is now clear how the centers will be distributed regionally. This decentralization is plausible, because it is also being guided by research specialisms. If we add the existing centers for applied research, this seems to be a solid development that should give the system a bit of impetus.

Do you see parallels with the establishment of the Max Planck Institutes in the new federal states in Germany? Prosperity, performance and quality in a country need to be developed where suitable conditions for them already exist. This becomes possible if particularly successful models are used as a guide, as was the case in the new federal states with the establishment of elite research there. The Koreans are now taking the same way forward: they are adopting Max Planck Society practices that have proved to be successful. This isn’t copying; as we have said, that can’t be the aim. It’s more the ability to be open to the best way of doing things. In this respect, the Koreans are outstandingly good learners, and they are prepared to listen and then implement the necessary changes. This is impressive.

Interview: Jens Eschert
A Systematic Understanding of Criminality

Max Planck Partner Group with the University of Zagreb established

The Balkans live with prejudices, such as the one that says that the region is a particularly dangerous place. The fact that recent studies show the opposite, and that this reveals differences between reality and perception, is one of the aspects to be investigated by the new Max Planck Partner Group “Balkan Criminology.” Anna-Maria Getoš, the group’s head, is following a systematic approach to “pool criminological research in southeast Europe, develop it further and increase awareness of it in Europe and beyond.” The criminologist obtained her doctorate at the Max Planck Institute for Foreign and International Criminal Law and is now working as an assistant professor in the Faculty of Law at the University of Zagreb. The Partner Group is being funded by both institutions. The inauguration symposium took place in Zagreb at the end of June. The main research areas are “Violence, Organized Crime and Illegal Markets,” “Feelings and Perceptions of (In)Security and Crime” and “International Sentencing.” The latter also involves research on the impact of the relatively lenient sentences imposed by the International Criminal Tribunal for the Former Yugoslavia on legal culture in the region and on the normative evolution of international criminal law.

www.balkan-criminology.eu

PianoText

When pianists like Chinese virtuoso Lang Lang do it, it looks easy: expertly and at lightning speed, their fingers glide along the piano keyboard, playing pieces by Mozart, Rachmaninoff or Tchaikovsky. IT experts from Saarbrücken have used this dexterity as a model, developing a method that uses piano keys to write texts. How this works and sounds can be seen in a film on the Max Planck Institute for Informatics website.

pianotext.mpi-inf.mpg.de

Human Images

Sculptor Andreas Kuhnlein doesn’t work with gouges, mallets or woodcarving knives. When he makes sculptures out of elm or oak, he uses only his chainsaw. This results in human images that look rough at first glance, but radiate primal power and beauty. The artist’s works were on show at the Max Planck Haus in Munich until November 29, and also during the “Lange Nacht der Münchner Museen” (Long Night of the Munich Museums) event on October 19. Art lovers can find a selection of the sculptor’s current projects on his website.

www.kuhnlein-bildhauer.de/index-EN.html

Galactic Showdown

There is a supermassive black hole at the center of our Milky Way. Not even light can escape the pull of its gravity. But infrared cameras fitted to the Very Large Telescope in Chile are delivering fascinating images of stars that are circling the black hole, and of a gas cloud being attracted by this massive monster. The latest computer simulations, which can now be seen on our YouTube channel, show how the cloud is likely to be partially destroyed and sucked in over the coming years.

www.youtube.com/maxplanckscociety

The Power of a Breath

Taking a breath consciously is a very simple act – but it can create feelings of connectivity, empathy and compassion, the conscious feeling of being present to one another. The twelve-minute short film “Where mind and body swing back and forth” by Berlin-based artist Olafur Eliasson provides an opportunity for outstanding thinkers to have their say: What does our awareness of breathing do to our understanding of ourselves, of each other and the world around us? An exciting art project.

www.vimeo.com/74357590
Max Planck Innovation is responsible for the technology transfer of the Max Planck Society and, as such, the link between industry and basic research. With our interdisciplinary team we advise and support scientists in evaluating their inventions, filing patents and founding companies. We offer industry a unique access to the innovations of the Max Planck Institutes. Thus we perform an important task: the transfer of basic research results into products, which contribute to the economic and social progress.

www.max-planck-innovation.de
It was around the early 1980s that the term “microcredit” was coined to describe the lending of small sums, often to those involved in small business in the informal sector of developing countries. 2013 marked the thirtieth anniversary of the founding of the legendary Grameen Bank, which came to the notice of a wider audience in 2006 when its founder Muhammad Yunus was awarded the Nobel Peace Prize. Thanks not least to generous public sector support, microloans are now one of the most popular and well known instruments in the field of economic cooperation and development. They increasingly constitute a financial market of their own that has caught the attention of big investors like George Soros and Bill Gates.

Between 2001 and 2011, lending in this sector rose from just under 3 billion US dollars to almost 90 billion, distributed to over 200 million men and women worldwide. The microfinance sector has grown dramatically, gaining more and more people in the “global South” – as developing countries are often collectively referred to – as borrowers. Microloans, so the theory goes, help women emancipate themselves by enabling them to earn an independent income. Such loans are also said to generate momentum for local development. Of course the term microfinance refers to more than just lending – insurance and savings, for example – but the emphasis remains on loans. These are generally repaid in weekly installments over less than one year, at average interest rates of around 27 percent.

Microfinance is now a transnational industry that is ever more closely interlinked with the traditional financial markets, directing capital from donor organizations and investors to the remotest reaches of the global economy. Unfortunately, however, for all the development policy hopes riding on this flow of funds, no sustained changes are visible to date – no clear reduction in poverty. A series of broad-based studies carried out in recent years found no improvements in living conditions and only a minimal increase in business activity among the poor as a result of microfinance. These studies reveal that, while the poor work somewhat harder when in receipt of a microloan, they don’t earn more.

The problems are fairly evident: Even if microloans were only ever invested in entrepreneurial proj-
A fate is sealed: Women in India use a thumb print to sign their loan agreements.
ects, the creation of countless new mini-businesses doesn’t constitute actual economic development. It simply continues and expands the bazaar-type economy that, at best, already represents a forced self-help solution for those who would otherwise have no employment at all. What’s more, the majority of loans aren’t used to run a business, but to fund consumption: to overcome emergencies such as illnesses, and to survive day to day. It is hardly surprising that, in these cases, it is tough for the borrowers to scrape together the money for interest payments and loan installments.

On what foundation, then, did development policymakers build their hopes? Newspaper readers will be familiar with the stories of small businessmen and -women (around three quarters of borrowers are female) who, thanks to a microloan, have worked their way up, if not to the ranks of millionaires, then at least out of the bonds of hopelessness to be able to provide for their families with the income they earn as hawkers or food vendors. Such reports from countries like Nigeria and Bolivia have established microfinance in the eyes of the public as a kind of silver bullet in the fight against poverty.

Collectively, these stories form a narrative telling us that it isn’t primarily business skills, education, or public services that the poor lack so much as access to capital to develop their potential. The microfinance industry and its adherents interpret poverty as a problem that is best solved transnationally with the resources of the financial markets. Many donor organizations in recent years have even gone so far as to distance themselves from the goal of supporting predominantly business borrowers, preferring instead to pursue a more comprehensive program of “financial inclusion.” The idea is that not just entrepreneurs, but all poor people should be able to access funds via the microfinance industry in any situation, from a sudden family illness to a daughter’s dowry payment, and thus use credit to deal more effectively with the financial problems inherent in their poverty.

It’s remarkable how this narrative has mobilized donors and investors to become part of the recipe for success. By investing in microfinance organizations, so the story goes, holders of capital in wealthy countries can generate small economic miracles in Africa and Asia, and even turn a profit in doing so. Microloans are meeting the recent increase in investor demand for “social investments.” The idealistic – but also market fundamentalist – overtone of this narrative of aid through the financial markets is that nobody should be demeaned by the gift of alms. Microfinance merely establishes a commercial relationship that presumably benefits both sides. One party pays for the fleeting hope of escaping poverty, while the other makes a modest return. The investor or donor who enables a borrower to incur debt, so the narrative goes, actually behaves more ethically than a do-gooder whose gift of alms patronizes, pampers or demotivates the recipient.

The unequal balance of power between the lender and the borrower, however, is kept out of sight. On closer inspection, the microfinance system establishes a chain of discipline and punishment between the owners of capital (lenders or investors) and their debtors, the effects of which are becoming ever more powerful as microfinance becomes more directly integrated into the mainstream financial markets. To illustrate this chain, let us begin at the top: Most private individuals, development organizations and commercial investors today channel their commitments to microfinance through special investment funds or bonds that are frequently managed by commercial investment banks. Even charitable organizations and state-owned development banks are happy to invest in such profit-oriented microfinance investment funds because of the cost efficiency they offer and the simplification of the process of identifying suitable investment targets.

The funds, generally based in Europe, the US or various tax havens, demand that loan defaults be kept to a minimum, and that payments be sufficiently high and regular. Microfinance institutions must therefore ensure that their funding providers regularly receive high payments, leading them to implement
strict controls and incentive systems. The typical weekly (rather than monthly) repayments required from borrowers constitute an important control mechanism in their own right, in that any slippage in discipline can be quickly identified. Additionally, as an incentive, loan officers are paid large shares of their income as performance bonuses that are linked to loan volumes and repayments, with the result that they continue to collect loans even in the face of natural disasters or epidemics.

Most microfinance company employees are men, while most borrowers are women. Even the first signs of tardiness on loan repayment often incur a penalty. For example, all the members of a borrower group may be detained at a meeting point until the one woman who is late with her payment comes up with the money – which can cost as many as 40 families their daily wages. For this reason, the groups keep a close eye on their members. Non-payment is punished by social exclusion, which is often even more serious than financial penalties. The groups can seize, so to speak, the “social capital” that poor people pledge as security for their debts. In traditional societies such as Bangladesh, the public humiliation of women is a very effective means of applying pressure. In the worst cases, group members – often urged on by the loan officer – will even resort to tearing down houses or abducting children. As people find themselves backed into a corner, the consequences range from domestic violence to fleeing the village or even suicide.

Nevertheless, active disciplining, or actual use of force, remains the exception. The players in the chain of observation and punishment are expected to keep their own proverbial houses in order so as to avoid negative consequences. The structure of the microfinance system ensures that the last links in the chain exercise self-discipline in the interest of the capital providers. Researchers in India, for example, found that borrowers reduced their spending on little luxuries such as tea or food consumed outside the home, or took out extra loans to repay their old loans. As a result, business is booming again for traditional loan sharks in regions where microfinance has a high penetration. It comes as little surprise that, in other studies, borrowers describe themselves as less satisfied with their lives than those without a loan.

Although poverty as such is not being reduced, this discipline is definitely leading to a notable siphoning off of payments from the poor population. The microfinance system effectively creates new relationships between capital and labor – relationships that are of no clear benefit to the poor, but that are demonstrably positive for the finance industry. Interest rates of over 100 percent are by no means rare among microloans, particularly among the more economically successful microfinance banks. For instance, the Mexican industry leader Compartamos Banco, which is listed on the stock exchange, charges annual interest rates of up to 195 percent. Despite the high costs involved in administering tiny, labor-intensive loans, they harbor the potential for very high profits, which debtors must pay out of their earnings.

Calculations using data on loan portfolio size and loan yield show that microfinance banks earned a total income of almost 19.6 billion US dollars in 2010.

Late payments incur immediate penalties; borrower groups react with social exclusion

In other words, microborrowers paid more in interest on their loans than the 16.6 billion the Greek government spent in the same year to service its debt. This clearly shows the “systemic relevance” of the present scale of microfinance. Despite its promise to bring development for the poor, microfinance reveals itself to be an instrument with which to “financialize” poverty. Microloans grant financial markets and market players access to the activities that people in the global South do in order to survive, even to the extent of making these activities attractive or profitable.

However, all of this – the positive narrative, the disciplinary measures and the successful siphoning off of surplus labor – remains an analysis of the norm. But the system of microfinance is not a stable monolith, as the remarkable series of crises in recent years demonstrates – Bolivia in 2000, Nicaragua, Bosnia-Herzegovina, Pakistan and Morocco in 2008, India in 2010 – each of which the microfinance industry has interpreted variously as inadver-
tent hiccups or illegitimate political interference. Overall, however, these crises reveal that, under the weight of its success in selling debt, the sector continually pushes the limits of what its customers can sustain, and then collapses.

The case of India vividly illustrates the process: The subcontinent was considered a late-starter; with such a vast potential of new clients, the market potential appeared infinite. Particularly the southern state of Andhra Pradesh, a paragon of the structural reforms of the 1990s, was hailed by investors as the new “Mec- ca of microfinance.” Many of the non-governmental organizations founded here around the millennium with charity money were, within a matter of a few years, privatized as profit-oriented institutions that went off in search of investment capital to finance annual growth rates of, in some cases, more than 100 percent. This growth came at the price of the constant erosion of lending standards: more and more loans were simply used to pay off existing debt, and individual employees were tasked with managing hundreds of customers. In addition, many groups of borrowers were simply “poached” from the state self-help group-lending program and provided with loans upon loans. Still, Andhra Pradesh was regarded worldwide as a model of how, despite fierce competition in the microfinance market, private investment capital could achieve the full “financial inclusion” of an entire population within just a few years.

The crash came just after the euphoria reached its peak – three months after the largest institution, SKS Microfinance, was floated on the stock market amid loud applause, and SKS founder Vikram Akula pocketed 60 million dollars for his services to the poor. Amid countless reports of violence and exploitation, early autumn of 2010 saw a wave of borrower suicides sweep Andhra Pradesh. In some cases it was the loan officers themselves who drove their customers to take their lives, so that the bank could cash in the life insurance policies sold as an obligatory add-on to the loans. The government of Andhra Pradesh abruptly issued a decree putting a stop to all microfinance business, prompting an outcry from banks and investors and an accusation that the government was intervening only to protect its state-led self-help credit system against superior competition.

Although this assessment wasn’t entirely inaccurate, it clearly revealed the extent to which India’s microfinance industry was focused on preserving its business model, no matter the cost. The argument the banks put forward – that many of the dead bor- rowers were in default on loans issued, not by them, but rather by their competitors – says more about the success of their collection techniques than about the fairness of their business model. It turned out that the majority of households in Andhra Pradesh had taken out four or more loans. The target of “financial inclusion” had been overshot by far; loans issued by microfinance banks had risen faster than any other type in the last years.

Since 2010, the microfinance business has stagnated throughout India, and has almost entirely collapsed in Andhra Pradesh. The industry is evidently struggling to understand its own demise, since it had adhered precisely to the rules of “financialized” microfinance – that is, a system that decoupled itself from benevolent donors and subordinated itself to the laws of the financial market: satisfy demand, work hard to achieve growth, attract investors, achieve efficiency, compete fiercely, make profits, become more efficient, continue to grow, and so on. But it was precisely these factors that triggered the crisis. Rather than as a victim of politics, it is perhaps better to describe the finance industry as having been brought down by its own ostensible success. The demand to which it responded was generally prompted, not by entrepreneurial opportunities, but by the opposite: the lack of opportunities and the desperation of peasant farmers, slum dwellers and the unemployed, especially in the neoliberal pioneer state of Andhra Pradesh. Much of the demand was merely to refinance existing loans. Competition and a glut of capital didn’t clean up the market, but rather amplified the incentives to lend more generously, erode internal controls and ultimately drive customers into a debt trap.
To ultimately assess microfinance, it is therefore important to consider the causes and effects of the general expansion of the financial sector ("financialization") in recent decades, and to ask where the limits lie. It is evident that financial markets and market participants are playing an ever greater role in meeting and directing social needs, from making provisions for our old age and putting a roof over our heads – think of the US mortgage bubble – to climate protection (emissions trading) and the provision of public goods. It also becomes apparent that it is precisely the supposed successes resulting from the expansion of financial markets that render us more susceptible to crises.

In the case of microfinance, the positive spin put on the emancipatory power of loans played a central role. "Financial inclusion" was expected to enable poor people to satisfy their needs more effectively, with the holders of capital helping as investors and providers of funding. The promise that poverty would be reduced with the aid of the financial markets seemed to be coming true. In reality, however, the positive effects of microloans – at least according to the current state of research – haven’t materialized. Instead, the microfinance system has constructed a transnational chain of disciplinary measures that, in the interests of regular capital flows, compels poor people to tighten their belts yet another notch and hand over a sizeable share of the surplus value created by their work. But Andhra Pradesh proves that there are also limits to this system.

Overall, this analysis of microfinance reveals that the financial markets have a tendency to exacerbate the existing unequal distribution of wealth – even where the markets operate under the banner of poverty reduction. The desire to create social justice through debt has proved to be an unfulfillable promise and a poor replacement for public welfare or redistributive development policies.

The unequal distribution of wealth is worsening

THE AUTHOR

Philip Mader (29) is a researcher at the Max Planck Institute for the Study of Societies. He studied economics at the University of Sussex in Great Britain before completing a master’s degree in development studies at the University of Cambridge. He began working toward his doctorate at the Max Planck Institute for the Study of Societies in 2008, heading for Andhra Pradesh in spring 2010 to undertake fieldwork before moving on to Harvard as a visiting scientist. He has been co-editor of the research blog "Governance Across Borders" since 2009. He completed his doctorate at the University of Cologne in 2012. Philip Mader was awarded the Otto Hahn Medal in June 2013, and in November, the Körber Foundation’s German Thesis Award (1st prize) in the social sciences category.

FIRST MEETING OF CRITICS

In August 2013, Philip Mader joined forces with Journalist-in-Residence Gerhard Klas at the Max Planck Institute for the Study of Societies in Cologne to organize the first conference to bring together critical voices in the German-speaking world. Under the title "Three decades of neoliberal development policy and microfinance: Taking stock," the conference provided an opportunity for around 40 participants to assess the growth of the microfinance industry in the context of global development policy and the continuing crisis of capitalism. The development practitioners, scientists and journalists who assembled in Cologne also evaluated alternative strategies for North-South cooperation and discussed potential solutions. In essence, these included supporting local debtor organizations and (re)developing public welfare systems and helping people demand their basic rights – instead of debts. The results of the conference have been integrated into an edited book to be published in early 2014 with Campus.
“Mine!” This all-too-familiar children’s cry can drive parents to distraction. Nevertheless, Michael Tomasello from the Max Planck Institute for Evolutionary Anthropology in Leipzig firmly believes that—unlike our nearest animal relatives, the great apes, who largely lack the capacity for collaboration—children are naturally cooperative and helpful.

Moritz pulls his father through the entrance hall: “There, monkey, there.” The enthusiastic two-year-old points to the enormous ape faces that adorn the display cases in the foyer of the Max Planck Institute for Evolutionary Anthropology. Moritz is well informed. He has participated in a behavioral study at the Department of Psychology three times already. The leader of today’s experiments, Robert Hepach, walks toward them and then accompanies them to the play room on the first floor. At the stairs, Hepach drops the key for the electronic door lock. Moritz is immediately on the spot. He bends down to pick up the blue plastic disk and holds it out to the unknown man.

“We regularly observe such spontaneous gestures of helpfulness in our studies,” says Michael Tomasello, Hepach’s doctoral supervisor and Director of the Department. What is a matter of course for us adults is a fascinating phenomenon from the developmental psychologist’s perspective. Tomasello has been researching the social skills of children and how they learn language at the Max Planck Institute in Leipzig since 1998. Since his undergraduate studies, the American scientist has focused his attention on the origins of behavior. “The question ‘Where does a particular behavior come from?’ is what interests me most. How does it develop in childhood and how did it emerge over the course of evolution?”

The Max Planck Society’s Wolfgang Köhler Primate Research Center opened twelve years ago at Leipzig Zoo. “There are very few places where you can do experimental studies with apes. And Leipzig is the only zoo where all great ape species are kept—chimpanzees, orangutans, bonobos and gorillas,” gushes Tomasello. “This is a huge advantage, as when we compare the behavior of humans and chimpanzees, for example, we don’t know what the original state is and which of the two species has changed. However, if we examine all four ape species and discover, for instance, that none of them communicate with pointing gestures, but one-year-old children do, we can assume that this gesture was invented by the direct ancestors of humans.”

Today, the Department of Comparative and Developmental Psychology is
the world’s largest research facility dedicated to this topic. Tomasello is currently supervising 22 doctoral students and collaborating with 20 scientists on site at the institute. Through their cleverly devised studies, he and his colleagues aim to explain the specific features of human psychology. Though considerable gaps still exist in our knowledge about the mosaic of human evolution, the institute’s psychologists and biologists are constantly adding new tiles to the overall picture with their approximately 100 publications each year.

In his latest book, “A Natural History of Human Thinking,” which will be published in early 2014, Tomasello explains that humans’ unique cognitive skills arose when environmental conditions in Africa changed. Back then, our

Children are born helpers. They show a distinct propensity for helpfulness long before they are called upon to be helpful.
Cooperation is a human specialty: No other living creature relies as much on cooperation and rejects direct gain for the benefit of others.
Our closest relatives, for instance, the chimpanzees, rarely share their spoils with other members of their species.

ancestors could survive only by collaborating when foraging.
“Unlike apes, who usually search for food individually and consume what they find on the spot, humans hunt together and return their spoils to a central location where they are distributed,” says Tomasello.

Chimpanzees, which sometimes hunt colobus monkeys in groups, are the only exception to this rule. Nevertheless, they still tussle over the prey, each one taking what he can grab. Some scientists classify this as sharing. “However, I believe the prey is simply too big to be claimed by a single animal alone. So the catcher accepts that the other apes will take some of it. However, chimpanzees don’t know how to share.”

THOSE WHO GET NOTHING STOP HELPING
Tomasello draws this conclusion from studies carried out at Leipzig Zoo, in which two chimpanzees no longer cooperate when the reward is available in a pile in the middle of the room. The dominant ape then takes everything and the subordinate animal is left empty-handed and refuses to cooperate from then on. In contrast, in comparable studies, children share the reward.

Tomasello believes that the last ancestor shared by modern humans and Neanderthals over 500,000 years ago relied on the availability of trustworthy partners and the smooth coordination of their actions for the success of their joint hunting ventures: everyone fulfilled their individual tasks, relied on each other and eventually benefited from their collaboration as they each received a fair share of the spoils. Tomasello thus refers to his evolutionary scenario as the interdependence hypothesis. He sees the origin of many typical human patterns of behavior in the collaborative search for food, which was essential for the survival of our species: our enthusiasm in pursuing shared goals, our willingness to share knowledge voluntarily, our instinctive desire to help the needy, and our tendency to share resources fairly.

Tomasello’s colleagues were able to observe all of these behavioral patterns in young children. “The comparison of apes and young children is particularly interesting because children under the age of three don’t yet act on the basis of the social norms and moral rules of their culture.” In a number of studies, Tomasello’s colleagues were able to show that children don’t learn to deal with norms and rules until their fourth year of life, for example by protesting or admonishing each other when they break such rules. “And yet, our young study participants are cooperative, communicative and helpful.”

Tomasello is convinced that the forms of cooperation visible in young children largely reflect the very earliest collective activities in human history.

The Leipzig team of psychologists succeeded in showing that small children have an instinctive desire to help others: they clear obstacles out of the way, pick up fallen pens and point to...
sought items. The question is: why is this desire to help observed in children as young as two years old? Do they empathize with the other person and want to help them overcome their predicament? Or is it, perhaps, that they want to gain the approval of their parents?

To find out more about the children's motives, the scientists used a new technique: two-year-old children sitting on their mothers' laps watched Robert Hepach stack cans on a table to form a tower. When the last can fell off the table, he tried, unsuccessfully, to reach it. Some of the children were allowed to help: almost all of them retrieved the can and gave it back to the researcher. The mothers of a second group of children were asked to hold their children back if they tried to reach the can. The children in a third group weren't allowed to help either, instead they saw a second adult come to the assistance of the researcher.

Meanwhile, a hidden camera recorded the diameter of the children's pupils. “This is a good indicator of their state of arousal: the more agitated a person is, the more the pupils dilate,” explains Hepach. The scientists compared the widths of the children's pupils immediately after the mishap and after their successful or prevented efforts to intervene. The measurements showed that the children who helped were less agitated than those who weren't able to intervene themselves; the diameter of the former group's pupils had contracted again markedly. The same effect also arose in the children from the third group: they calmed down when the third person intervened. “So children don't need to intervene and help themselves, the help itself – even if given by a stranger – is the main thing. This shows that helpfulness in young children isn't only a reaction to parental expectation; it's actually about the wellbeing of other people,” concludes Hepach.

THE ONLY WAY FORWARD IS TOGETHER

Even infants have a sense of cooperation. American scientists observed that six-month-old babies judge people according to whether they help or not. Accordingly, they show a preference for helpful people over those who don't help or who actually cause harm – a further indication of the fact that helpfulness isn't an acquired behavior but a natural one.

At the age of three, children develop an increasing sense of the social

Children help not only because it is expected of them – they want to support other people.
rules of behavior, such as the feeling that partners should help each other when completing a task. For her doctoral thesis, Katharina Hamann examined the extent to which two children support each other when they have to perform a joint task. To reach two building blocks they want, two three-year-olds must use a multi-level apparatus together. However, one of the children reached her block earlier than the other and could have stopped cooperating at that point. “Many children actually stayed with their playmates and helped them to reach their goal,” says Hamann.

When the apparatus was set to ensure that only one child was reliant on cooperation and the other one could take the block immediately, there was far less spontaneous helpfulness. “Children obviously feel a greater obligation toward a partner if they have engaged in a joint effort,” assumes Hamann.

So three-year-olds sense that cooperation ends only when everyone has attained their previously agreed objective. Michael Tomasello adds: “There are many examples of prosocial behavior in the animal kingdom. Chimpanzees also present themselves as helpful in our studies. What is unique to human morality is the feeling of mutual obligation: we should behave like that.” In his view, moral values arose in response to the increasing complexity of social life. “We subsume under the concept of morality several psychological mechanisms that people developed to adapt to their hyper-collaborative lifestyle. The group is the only place in which morality can arise. Unless you believe in God.”

SELF-CONTROL THROUGH GUILTY CONSCIENCE

Tomasello shows this using the example of a guilty conscience. “I don’t feel guilty because the others condemn my theft, but because we condemn me! I am part of the group and ought to punish myself.” Therefore, a guilty conscience is a kind of involuntary self-castigation to protect oneself against committing further unauthorized actions and, in this way, avoiding sanctions. As soon as a thief is caught, he openly displays his feelings of guilt – according to Tomasello this, again, constitutes an adaptation to group life and conveys the message “Look, I know the rules and I know that I should follow them. I am already punishing myself.” This is meant to show that he is still a cooperative member of the group.

The concern about one’s own reputation is typically human. For Tomasello, it originates in collaboration in the search for food. The more our ancestors depended on collaboration during hunting, the more important it became for each individual to have the reputation of being a good collaborative partner: “See, I’m a skilled hunter and am happy to share my spoils. Take me with you when you go hunting a zebra again tomorrow.”

Even preschool children engage in strategic reputation management, but chimpanzees don’t. This was the conclusion reached in a study carried out by Jan Engelmann. He investigated whether chimpanzees and five-year-old children behave differently when someone is watching them. “Chimpanzees will always give the same amount of food to another animal, or steal it from them, irrespective of whether an alpha animal can see them doing it or not,” says Engelmann. “In contrast, children appear to consider their reputation when deciding how to act.”

In this behavioral study, the children experience joint success. They must push their blocks up the steps using a stick (left). Even if one child can pull her block through the opening in the cover earlier than her partner, she continues to help until her partner can also remove her block (right).
The psychologist thought up a task for the five-year-olds that prompted them to steal: the children were given different stickers, which they were asked to stick into a sticker album. However, one sticker needed for the album was missing. On the other side of the table there was an empty album and several unused stickers for use by the next child. “When the researcher left the room, we observed with a hidden camera whether the child would take a sticker from the opposite side of the table.”

INTENT ON A GOOD REPUTATION

Some of the young participants were left alone in the room, while others were observed by a child of the same age. The result was clear: the children were less likely to take the unauthorized sticker when someone was watching them. To test their willingness to help, Engelmann reversed the situation: he gave them an extra sticker and explained that there was one missing on the other side of the table. “When they were being watched, more children left the extra sticker for the next child instead of taking it home with them.”

The researcher also demonstrated that five-year-olds weighed up their actions and prioritized earning a good reputation with members of their own group: they were more willing to share when a child from their own group was watching. “This points to strategic thinking: ‘The children from my own group are more important because I am more likely to need their help in the future. For that reason, I act in a completely moral way in their presence and share my stickers fairly,’” extrapolates Engelmann.

Human beings have an entire arsenal of psychological mechanisms for maintaining cooperation in larger groups: the awareness of their personal standing, a feeling of fairness, an aversion to cheats and a propensity for conformism. When did these mechanisms become necessary in our evolutionary history? According to Tomasello’s theory, these characteristics arose as far back as the emergence of the first modern human, around 150,000 years ago. Population growth and increasing competition between groups for living space and food made it necessary for them to collaborate more and more closely.

Related groups amalgamated into clans, and several clans developed a sense of belonging to a tribe. Life in such large societies introduced completely new challenges for our ancestors: they no longer knew all members of the group in person. They constantly encountered strangers who belonged to their tribe, but they were unable to assess their reputations and capacity for cooperation.

CHEATS PUT COMMUNAL LIFE AT RISK

They solved this problem by highlighting the characteristics necessary for membership in a group: “The stranger speaks my language, dresses like I do and cooks in the same way – I may assume that he or she follows the same social norms and values as I do,” says Tomasello, describing one possible scenario. Moreover, the success of communal life in larger anonymous societies was threatened by cheats and freeloaders. The specific function of many of our morals is to counteract this threat: We keep our word. We punish thieves. We pay our dues. We ostracize lazy people.
Even infants are willing to share, and display helpful behavior toward others. Humans evidently have a natural propensity for cooperation.

The visible forms of cooperation among today’s young children are probably a reflection of the earliest collective activities in human history: over 500,000 years ago, effective collaboration ensured survival in the search for food and was the decisive factor behind the further development of the unique cognitive capacities and inner drive of human beings.

From the age of three, children develop a sense of the social group and gradually adopt the moral values of their culture. Modern humans probably developed social norms to overcome the challenges presented by increasingly complex societal structures.

TO THE POINT

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- From the age of three, children develop a sense of the social group and gradually adopt the moral values of their culture. Modern humans probably developed social norms to overcome the challenges presented by increasingly complex societal structures.
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Letter by Letter

Children learn to speak simply by imitating what they hear, but only very few learn to read and write without some instruction. Sascha Schroeder and his REaD research group at Berlin's Max Planck Institute for Human Development are investigating just how this works. Through their research, they are creating the basis for effectively supporting children with reading problems.

TEXT PETRA MIES

Mia was delighted with her birthday present." Then: "Tina kicked the ball across the field." Then: "The dog was furious because the goose had bitten him."

Letter by letter, word by word, Zoe reads the sentences that flash up on the screen in front of her. By clicking the blue button on the input device she holds in her right hand, the girl herself determines when a sentence has ended and the next one appears. The elementary school student from Berlin has her chin on a chin rest, something she has only ever seen before at the optician. Her head must remain as still as possible. Her pupils, on the other hand, must move. A camera records exactly where Zoe looks when she reads and how she progresses through the sentences. Eye movements are of great interest in the test lab at Berlin's Max Planck Institute for Human Development.

"Great!" says Sascha Schroeder, praising the seven-year-old. "You read very quickly for your age." Zoe beams, proudly stating: "I love reading!" Schroeder and his colleague Simon Tiffin-Richards also have some very different young test subjects in their longitudinal eye-tracking study. Schroeder stretches out his arms: "The spectrum of reading speed is huge, some children look at each word umpteen times." Zoe completes the test, scheduled to last as long as a school lesson and consisting of 96 sentences and short pauses, in just 20 minutes. Less able students take 80 minutes.

ONE IN FIVE ADULTS CAN'T UNDERSTAND SIMPLE TEXTS

Why is that? How exactly do children learn to read? What subprocesses are relevant to written language acquisition? And how important are verbal skills in transferring from the spoken sound to the written letters and vice versa? Schroeder and his six-person research group called REaD (Reading Education and Development) aim to find the answers to these and other questions in a number of studies they are carrying out.

How is reading internalized? The letters in this word game, at least, can be eaten ...
Since the middle of last year, Sascha Schroeder's team has focused on a topic that, up until now, hasn’t received enough attention in Germany. With disastrous personal and social consequences, believes the group leader. According to Schroeder, one in five adults in Germany can’t understand simple texts. And these aren’t just individuals from challenging social backgrounds or people whose first language isn’t German. Problems arise across all social strata.

“In our modern information society, individuals with weak reading skills are relegated to the margins,” says Schroeder. “For the people affected, this is a disaster that causes them great shame and social isolation. Added to this is a huge economic cost, as they often don’t have access to the working world.” Not forgetting the political dimension: “The great thing about reading is that it provides enlightenment at a personal level. A person who can read can acquire information independently.”

Schroeder sees the vicious cycle that can occur. A person who finds reading difficult will often avoid it. “It’s stressful, it’s exhausting, so what does a person do? Nothing.” The result is a build-up of negative effects. “One thing is very clear: the only way to learn to read is by doing it.”

The scientist believes that even the most attractive reading corners are pointless if children haven’t mastered the cultural skill of reading. “Anyone who can’t read can’t participate.” The reading support programs set up after the first PISA studies did little to change the situation. In Schroeder’s opinion, they are often largely ineffective, as the processes on which reading is based are still unclear. “That is our basic premise: before continuing to support reading, it would be better for us to take a step back and look at the cognitive mechanism behind it.” He says that basic research first needs to be carried out before practices can be improved.

In order for support projects to really bear fruit in the future, the psychologist, linguist and musicologist believes that much more information is needed. To date, there has been a lack of such relevant knowledge here in Ger-
So ungefähr sehen typische Blickbewegungen beim Lesen eines Satzes bei Kindern aus.

It looks like a visit to the optician: The eye-tracking device follows and records the eye movements of the young test subjects while they read.

Beginning readers make their way letter by letter and have sometimes forgotten the beginning of a long word by the time they get to the end of it. It is a case of taking one step back before they make significant progress as their skills improve.

Circle size indicates how long the eyes pause on words.

Children generally learn to speak solely by interacting with their parents and others. According to the research group leader, the current research assumes that the better developed a child’s verbal skills are, the easier it is for him or her to learn to read. However, reading and writing don’t just come to them in the same way that speaking does. They need to be taught how to assign the speech sounds they know to the correct sequences of letters. And they often need to practice for years until they understand just how it works.

The fact that the German word for “bee” (Biene) needs an “ie”, whereas “tiger” (Tiger) is written with just an “i”, though the sound is the same, can’t simply be deduced. Sascha Schroeder points out that many people later forget how difficult it is for beginners to solve the puzzle of sounds and letters.

**BACK AND FORTH ON THE WAY TO THE END OF THE SENTENCE**

For anyone learning to read, conquering the written world is an arduous journey, and progress is erratic. “We think our eyes move over the lines in a nice, even manner, but that isn’t the case. Instead, we jump across a text in so-called saccades.” Our eyes pause in between the jumps and, during this time, we process the information that we have read. These pauses are necessary because only an extremely small part of our field of vision – also known as the foveal area – is sharp enough to be able to identify letters and words. This vision cone isn’t round like the beam of light from a flashlight, but is somewhat bigger and wider to the right in the direction of reading. This allows us to guess what the eyes are about to read. In the area to the left, the outlines tend to be less distinct.

However, not all languages read from left to right and top to bottom. Arabic, for instance, is read from right to left. It is convenient, therefore, that a reader’s sharp field of vision always expands in the direction in which a text flows, depending on their native language. This means that it expands to the left in Arabic-speaking people. It’s just a matter of practice.

Beginners don’t know anything about reading direction. They first have to learn that writing arranges language in lines and separates words from one another. Compared to experienced readers, they move their eyes across the text in two different ways. “Initially, children tend to read sequentially. They work through a text letter by letter, much in the same way as you would cut a sausage into slices,” says Schroeder. “Word length is therefore an important factor for beginning readers.”

It is precisely at the beginning that the struggle to move from word to word requires effort and time, with the result that children have forgotten the beginning of a word by the time they have reached the end of it. They then need to find their way back to the start of the word and fixate on it again. On average, children perform two to three fixations per word, as it’s called in linguistic jargon: “That’s why we observe their erratic eye movements.”

Skilled readers approach the issue in a more practiced and thus more holistic way. They also jump around, but mostly in a forward direction, namely to skip words. Experienced adults ignore 20 to 30 percent of all words. And, in the case of the words they do read, they don’t go through them letter by letter. They rarely need to look at a word more than once to process it. The trained eye flits over the lines much faster and the experienced individual reads fluently.
Reading performance frequently declines as people age, partly due to failing eyesight. Yet older recipients still don’t jump around in the texts as much as children do. Do people over the age of 65 ‘unlearn’ how to read? The researcher’s answer to this is an emphatic “No.” He talks about phases. “The difficult learning phase lasts up to the age of 16. This is followed by the stable plateau phase, which extends beyond middle adulthood. In old age, there is something of a decline again.”

But back to the beginners. One of the fundamental issues being investigated by the team in Berlin relates to the changes in the speed and intensity of eye movements during reading development. As Schroeder says: “Is it related to the fact that children’s eyes are still developing, or that children are constantly improving linguistically?” And also: “What controls eye movements? How do the eye movements of children with reading difficulties differ from those of children who don’t have reading difficulties?”

Schroeder hopes that studying eye movements during reading will also be of practical use. Knowledge about eye movements helps uncover problems with reading. According to Schroeder, in the 1970s, it was still believed that poor readers had problems primarily with the coordination of their eye movements. At that time, it was assumed that, in children with reading disorders, the system controlling the movement of the eyes wasn’t yet mature – that is, not sufficiently developed.

**FINNISH CHILDREN FIND IT EASIER TO LEARN TO READ**

“New research results refute that,” explains Schroeder. “Children with reading problems actually do have unusual eye movement patterns, but that isn’t the cause of their problem. Rather, it is more likely to be a consequence of their linguistic deficits.” One benefit of the eye-tracking approach is thus that it has clarified a completely erroneous belief. Eye-tracking studies are also helping to answer the question of what linguistic information is actually used during the reading process.

The longitudinal eye-tracking study focuses on the traditional elementary school age at which reading skills develop most rapidly. As the eye is an organ common to all human beings, an international comparison also reveals interesting results. If the eyes and their fine-tuning develop at the same speed in all children, a study comparing eye movements in different languages would help to separate the effects of visual and linguistic influences. To explore this, English and Finnish children read translations of the texts developed by Schroeder’s team in Berlin. It’s important that the level of difficulty, for example the ratio of known and unknown words, and of long ones and short ones, be very similar in all three languages.

Transparency is one of the keywords in the international comparison: so: how directly does a language transfer its sounds to letters? According to Schroeder, German lies somewhere in the middle. English is the most complicated, and Finnish is the easiest because the language is written the way people speak it. Because of this, it makes sense for children in the UK to be sent to school at the age of five, and also to be introduced to reading before starting school, explains Schroeder. “In Germany, first-graders can often read after six months, or at the latest by the end of the school year; in the UK, it takes much longer.” Researchers haven’t yet definitively figured out the different rates of progress and the reasons for them.

In their study on the eye movements of child readers, the researchers...
in Berlin discovered that children find it easier to read words that they already know, irrespective of the language. To find out more about how children try to read known and unknown words differently, the researchers first had to gain an overview of the children’s vocabulary: which words, phrases and grammatical constructions do German children know?

German children have an average vocabulary of 5,000 words when they start school. Schroeder explains that, at a minimum, they should have a vocabulary of 20,000 words by the time they leave school. “This means that we have to learn 15,000 words by then. Due to the sheer lack of time, this may not occur during school hours only.” It has been proven that children expand their vocabulary mainly through books they read outside of school. Or don’t.

Analyzing the language in children’s books also provides information about the words that children may know. This is exactly what the Berlin team, together with the Berlin-Brandenburg Academy of Sciences and Humanities and the University of Potsdam, did. One year later, the partners are now presenting the relevant data for Germany for the first time. childLex is the name given to the collection of words and linguistic constructions that children encounter in age-appropriate books.

ON THE TRAIL OF A VOCABULARY WITH CHILDLEX

It was a huge undertaking. The researchers analyzed around 10 million words in 500 children’s books. They assigned a syntactic category to every word, classifying it, for example, as a noun, verb or adjective. They counted the frequency with which particular words are used in books for different age groups. As Schroeder says, it’s easy to see that words like “pirate”, “elf” or “dragon” belong in a child’s vocabulary. “But how do children react to conjunctions like ‘therefore’ or ‘thus’, which introduce inferences? And do books that are intended for girls differ in their linguistic complexity from boys’ books?”

The childLex database of vocabulary – linguists refer to it as a corpus – distinguishes between three age groups: 6- to 8-year-olds; 9- and 10-year-olds; and 11- and 12-year-olds. The analysts also paid attention to the way in which words in books change between the individual groups. Schroeder cites a few examples: “From an early age, children find it easy to understand everything to do with time, such as ‘quickly’, ‘after that’ and ‘before that’ – that all works well.” They find it more difficult to deal with causal relationships and consequences for the future. “For instance, German beginners often confuse ‘therefore’ with ‘which is why’ [the respective words in German are ‘deshalb’ and ‘weshalb’] and struggle with the difference.”

childLex has now helped to answer these questions. The authors of the books play a crucial role in this regard. They choose a language that they believe corresponds to a level that is understood by the relevant target group. Or they deliberately use constructions, such as inferences, so that children become familiar with them. In this way, authors are fundamental in determining their readers’ vocabulary.

Schroeder sees the corpus as the input that is passed on to adolescents. Similar studies have already been done for Spanish, French and English. However, he notes: “Compared with these other languages, German has by far the most word forms.” Each verb alone can be conjugated in at least 13 different variants. And if something new needs to be named, German can quite happily coin new terms from existing words.
The German word for “nurse” [Krankenschwester, literally “sister of the sick”) is a case in point. Viva the compound noun! The childLex project has now been completed and an online database is available. Interested parties are free to use the website. It also provides information about the frequency with which certain words appear in children’s books. Books frequently contain not only function words like “and”, but also words like “mom” and “dad”.

The children’s corpus also provides important material for a further study. In the DeveL (Development Lexicon) project, the researchers selected 1,200 words from childLex with different linguistic properties, such as frequency, word length and number of syllables. In their research, they observe how long children in the second, fourth and sixth grades take to read them. Another important area of interest is the mistakes that they make when reading them. The researchers want to figure out the determining linguistic criteria for reading speeds at specific ages.

At the same time, the team also asked young and older adults to read the words in order to explore how reading changes over a person’s lifetime. “Of course, adult word recognition models already exist,” Schroeder clarifies. “But to date, no research has been conducted on how development reaches that stage. We need this empirical data, which will map the path from childhood to adulthood.”

The older the reader, the bigger the linguistic units become. While beginning readers make their way from one letter to the next, more advanced readers process words in syllables or in even larger units. According to some theories, word lengths initially determine reading speed to a very great extent, though this does decline. The frequency with which a word is used then becomes an increasingly important factor in reading time.

DO MAGIC WORDS LIKE “GLUSS” AND “BRABBEL” REALLY EXIST?

DeveL will explore whether this is true. One task in the DeveL project involves asking children and adults to read words as quickly as possible. In a second task, the test readers must decide as quickly as possible whether a word on a computer screen is correct and really exists or whether it is actually a nonword. Right key, word is correct. Left key, word is wrong – words such as “Gluss” and “Brabbel”.

If children are taking the test, the newly coined words are known as “magic words”: it’s important that the research be fun for the children. The researchers therefore explain to them that a word blitz has smashed into the castle of the word wizard Baldrian. Everything is in chaos and, on the computer, the children are supposed to help him to restore order. The response times in the lexical decision task provide information about how common words are in particular age groups. The series of studies isn’t yet complete, so the team still has plenty of work ahead of it.

Zoe, on the other hand, has completed her test. She and her mother quickly leave the Berlin institute by the side exit. She is smiling. Perhaps because she has a good book waiting for her at home.

**TO THE POINT**

- In contrast to the spoken word, written language doesn’t develop without instruction and practice. One in five Germans doesn’t have good written language skills or can’t write at all.
- Early beginning readers, on the one hand, process texts letter by letter and word by word. In doing so, however, they fixate on words several times, with the result that their eyes jump around in the text. Advanced readers, in contrast, also jump through a text, but they often skip words.
- Research findings about how children’s eyes move when reading provide starting points for optimizing support programs for children with reading difficulties because they reveal in detail where the children have difficulties.
- The greater a child’s verbal skills and word knowledge, the easier it is for him or her to transfer sounds to letters and words (and vice versa) when acquiring written language skills.

**GLOSSARY**

Fixation: A pause in eye movement.
Corpus: A sample of speech, such as a collection of words; a corpus provides the basis for linguistic analyses.
Saccade: A fast movement of an eye.
Semantic: Relating to semantics, that is, the meaning of letters and words.
Syntactic: Relating to syntax, that is, the structure of a sentence. Words can be classified into syntactic categories. This means they can be ordered according to their function in a sentence, as so as a noun, verb or adjective, for instance, or as a subject, verb or object.
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Not giving in to sweet temptations calls for self-control. Children are capable of resisting only when their brain is mature enough.
Take a Bite or Resist?

From a very early age, children exhibit an amazing sense of fairness and justice. The older they get, the more compassion and empathy they develop. Nikolaus Steinbeis from Tania Singer’s department at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig is studying how the social behavior of children changes as they get older, and which of the brain’s networks play a role in this.

TEXT MARTIN TSCHECHNE
Children who have better control over their impulses display enhanced thickness of the dorsolateral prefrontal cortex.

Nikolaus Steinbeis looks like someone who understands children: a friendly, youthful smile, colorful sweater and casual pants. A study of social skills and how they are represented in the physiology of the brain is the last thing that comes to mind when the psychologist from the Max Planck Institute for Human Cognitive and Brain Sciences enters a room full of children and takes out the goodies he’s brought with him: picture books, games, colorful stickers and movie tickets. The Swiss being skeptical of tooth-rotting treats, candy was off limits as incentives in Switzerland, where the series of experiments began at the University of Zurich a few years ago. But still, Steinbeis is a bit like the marshmallow man in American psychologist Walter Mischel’s experiments in the 1960s. And nothing about him gives any hint that he’s about to plunge the children into the midst of major conflict.

RESISTING TEMPTATION

Mischel gave his test subjects a marshmallow and promised them another one if they managed not to touch the first one – it was all about impulse control. Then he left the room, leaving the children to their dilemma. There was only a camera there to record the chil-
Games in the service of science: Nikolaus Steinbeis uses behavioral tests from the field of game theory along with computer programs he developed himself to analyze the social behavior of children in different age groups.

Children’s struggles, their losses and triumphs against temptation. The test results demonstrate that children who manage to resist in this situation go on to be more successful in school and in their working lives. This kind of perseverance, where the reward comes after a certain delay, is associated with success in school and professional life. It’s an even more reliable indicator than intelligence. And grown-ups find it extremely amusing to watch the little ones squirming in front of the plate, hardly able to bear the conflict going on inside them.

The Leipzig-based scientist’s studies are also about forgoing an immediate reward, about impulse control and about sharing fairly. Steinbeis breaks down complex value systems such as empathy and fairness into small, measurable units. He puts children in front of a computer screen and asks them to react to quick symbols, he shows them the results of the other players and watches how they behave when they feel like the loser or think they’re ahead. Or he gives them play money to spend. Two coins: one colorful sticker. Ten coins: one visit to a Harry Potter movie.

Which of them share and which keep it all for themselves? The scientist’s findings show that six-year-olds have a hard time giving things away, while older children are more disposed to sharing.

**GENEROUS DICTATORS**

The game is called the “dictator game” in its simplest variation. It’s well known because of the experiments conducted by Swiss behavioral economist Ernst Fehr, with whom Steinbeis and Tania Singer, Director at the institute in Leipzig, previously worked in Zurich. Scientists working in the field of economic and behavioral research use this lab experiment to study something known as social preferences – in short, altruism. Participants are given a number of coins and asked whether they will give any to another person who isn’t in the room. There’s no pressure, no discernible benefit, but many do it anyway. Contrary to economic textbook theory, the dictators don’t keep all the money for themselves. On average, they give 20 to 30 percent of it away to the other player.

This is a finding that challenges the long-dominant concept of *Homo oeconomicus*. The model starts from the idea of a completely rationally thinking person who, faced with a decision, weighs up all of the available alternatives based on his or her own decision-making criteria, and only then selects the optimum choice. But we aren’t that objective. There’s something called a social conscience, a moral conviction, that things should go well for other people, too. Of course people are envious, greedy and mean at least as often, also without any rational evaluation. But how do these kinds of value systems develop, and which networks in the brain play a role in this?

Working with his colleagues Boris Bernhardt and Tania Singer at the Max Planck Institute in Leipzig, Steinbeis plans to find out by studying children between the ages of six and thirteen. Relatively big kids, really, given that childish egocentricity begins much earlier, doesn’t it? And can’t even younger children be observed sharing, empathizing and giving a bit of what they’ve got to others? “True,” admits the scientist. “But it’s not the origins of these behaviors we’re interested in. What we want to do is observe how behaviors evolve, and connect this with changes in the brain. This age group is ideal for that.”

In the phase between starting school and reaching puberty, children’s knowledge of norms and standards has already been formed. The youngsters have done quite a bit of their growing up by then. They have a concept of the fact that it’s fair for others to get a little bit of what they’ve got, too. But have their brains reached the same stage of maturity?

Variation number two: the “ultimatum game.” Now the responder can also react. If the responder rejects what
the proposer offers, both of them get nothing. So the proposer has to think very carefully:

How will the other person react? How would I react if it were me? A *Homo oeconomicus* would accept everything offered. It’s better than nothing, after all. However, in real life, people don’t react that way. They are indignant if someone offers them a pittance while keeping the lion’s share for themselves. They’d rather have no reward for neither of them. As a rule, the share that players offer is between 40 and 50 percent. Offers below 30 percent are frequently turned down.

So what’s needed is empathy and knowledge of social norms. Whereas the dictator need only follow his or her own sense of justice and fairness, anyone playing the ultimatum game has to guess how the other will react. They have to adopt and sum up three standpoints simultaneously: their own interest in getting a reward, their sense of fairness, and the other player’s sense of justice. Because, as the scientists’ findings have confirmed, people generally won’t be content with a few crumbs.

The use of magnetic resonance imaging (MRI) enables the Max Planck researchers to measure the size and activity of individual regions of the brain while playing the game. What they found is that the brain weighs up such complicated interrelationships in a special region of the cortex known as the dorsolateral prefrontal cortex. It’s located just above the temple, right where you’d tap yourself on the forehead if you wanted to show how brainy you were. The region is most notably active during highly complex operations, when telling a lie or forecasting the future, weighing up pros and cons or making long-term plans. Moreover, when assessing a situation and using acquired norms and one’s own experience to predict how another person will react is also when this area of the brain comes into play.

**THE BRAIN TAKES TIME TO DEVELOP**

The dorsolateral prefrontal cortex matures at a relatively late age. Consequently, older children should be able to deal with tasks like these more confidently. The findings of researchers in Leipzig indicate that this is indeed the case. Older children factor the possibility of being turned down into their offers and are firmer in their convictions and reactions. Six-year-olds, on the other hand, are easier to persuade and can end up accepting offers they previously regarded as unfair. Although they already have a keen sense of fairness, they give in more easily to temptation.

Anyone who’s ever watched children in the schoolyard swapping trading cards or, indeed, ever wanted to swap one major league player for another major league player, knows the power of temptation and persuasion. Children may have values and beliefs, but they’re not firmly enough entrenched to reliably control their behavior. All it takes is a couple of years’ age difference, and the best cards always end up in the hands of the bigger kids.

The scientists measured stronger brain activity in the dorsolateral prefrontal cortex of the older children, particularly in the left hemisphere of the brain. Irrespective of age, children who are better able to control their impulses have more nerve fibers there, too. Furthermore, the researchers noticed a surprisingly large discrepancy between a child’s belief and its actual behavior: of the 85 percent of younger children...
who wanted to reject an offer they thought was unfair, only just under 13 percent actually did so in the end.

Naturally, this triggers negative emotions of weakness, jealousy and frustration in those who feel they’ve been cheated. “It’s only when children reach the age of four or five that they begin to compare themselves with others,” says Steinbeis. “Three-year-olds won’t usually be bothered if someone else manages to do something better than they can.” What’s responsible for that is evidently the activity of a region deep in the brain’s interior, the temporoparietal junction. It works like a switch for aligning intrinsic and foreign states and needs.

WHEN THE RULES OF THE GAME CHANGE

That switch is easy to study in the dictator game. It’s enough to change the game rules slightly: increase the possible gain, give the players the option of first protecting their own gain before having to give anything away; give the other player a bigger reward if you yourself get relatively little; or relinquish what you have so that the other player also gets something. Using the MRI, the scientists can also observe what effect it has on the brain when
you’ve given it your best shot but are outdone by an opponent. The power game is an opportunity to be fair and generous – or an occasion for pettiness, greed and revenge.

Among six-year-olds, feelings of envy and gloating are especially pronounced. As they grow older, however, these often diminish. Evidently, children of this age already have a highly developed awareness of the happiness of others. It’s their ability to control their impulses that lags behind.

The temptations are great, and their knowledge of social rules and expectations is often fairly well developed, too – the only thing lacking is the strength to act on this knowledge.

**MEDITATION IMPROVES SOCIAL SKILLS**

This sounds like difficult and painful experiences. But why do older children and adults manage it so much better? Improved self-control is how the scientists in Leipzig explain the diminution of jealousy and gloating. “Don’t forget the regulation of feelings,” adds Steinbeis. “Through meditation, for instance: we are capable of freeing ourselves of needs. We can train insight. Think of what Buddhist monks can do. That’s going to be very important to all of us.”

The researchers’ long-term goal is to use MRI to seek out the critical periods in a child’s development when such capabilities are especially easy to cultivate. Steinbeis points out parallels in language development: “A language acquired by the time a child reaches the age of five or six is so embedded in
We strongly suspect that there are one or more critical periods for certain aspects of social behavior.

The manifestation of social behavior in childhood follows the course of development of the underlying brain regions, such as the dorsolateral prefrontal cortex and the temporoparietal junction.

Since many of these regions are relatively late in maturing fully, younger children are less able to predict how others will behave, and find it hard to resist their own impulses.

Similar to language acquisition, scientists suspect that there are one or more critical periods for social behavior where it should be possible to exert special influence on certain social skills.
Depressed Fish
Zebrafish could help in the search for new drugs

Fish are generally not very good at expressing their feelings, so they aren’t an obvious research object for psychiatric disorders. This may be about to change, as research suggests that the zebrafish could be a suitable model organism for the development of new psychiatric drugs. Scientists from the Max Planck Institute of Neurobiology in Martinsried, near Munich, and the University of California have observed that zebrafish suffering from chronic stress show signs of depression. Fish that lack the receptor for cortisol as a result of a genetic mutation can’t regulate the stress hormone, they explain. They are then unable to adapt to new situations. Left alone in a new aquarium, the chronically stressed fish stayed quite still at the bottom of the tank. Their behavior returned to normal when an antidepressant was added to the water. The findings suggest that chronic stress isn’t just a side effect, but may be a trigger for depression and anxiety. (Molecular Psychiatry, June 2013)

Nanocomponents Made to Spec
A precise and efficient method makes it possible to manufacture nanostructures with diverse shapes and complex material composition

Nanomachines are a step closer to reality and researchers at the Max Planck Institute for Intelligent Systems in Stuttgart are helping them along the way. They have developed a method for combining materials with very different chemical and physical properties into diverse nanostructures such as rods, hooks, screws and zigzag structures. By depositing the vaporized material onto a cooled, rotatable disk, the team working with Peer Fischer has even grown antennas for visible light. They had previously provided anchor points on the surface of the disk in the form of countless tiny gold dots. This process allows nanocomponents to be manufactured with greater precision than previous methods, and at the same time, in batches of billions. (Nature Materials, online, June 23, 2013)
Jupiter’s Double

Subaru telescope snaps image of exoplanet GJ 504b, which orbits a sun-like star

Using the Subaru telescope in Hawaii, a team including scientists from the Max Planck Institute for Astronomy has taken the portrait of a Jupiter-like planet that orbits a sun-like star of spectral type G. At a distance of 60 light-years from Earth, GJ 504b is the coldest and probably also the lightest exoplanet yet imaged. It is extremely difficult to obtain direct images, but they yield important information about physical and chemical state variables such as atmosphere and temperature. Estimates of the planet’s mass are based on models of the rate of cooling since its formation; most researchers put it in the region of three Jupiter masses. The distance of this exoplanet from its star is 44 times the mean distance between the Earth and our Sun, that is, about six billion kilometers. (Astrophysical Journal 774, 11, 2013)

Experienced Minds Are More Reliable

Cognitive performance in older people is more consistent than in younger adults

In the working environment, older adults encounter the persistent preconception that they may have more experience, but they are less productive than their younger peers. This is only half true: more experienced, yes, but they may not be any less productive. Scientists from the Max Planck Institute have found that the cognitive performance of older adults varies less from day to day than that of younger adults. Working with a group of more than 100 adults aged 20 to 31 and a similarly sized group aged 65 to 80, researchers set them 9 tasks each on 100 days. The older group didn’t fare as well as the younger ones in terms of average performance, but their results were less dependent on their daily condition. It appears that, through experience, older adults learn strategies for completing tasks properly, and they are consistently motivated and more balanced and stable. The indication that older people’s cognitive performance is more consistent fits with the findings of researchers at the Max Planck Institute for Social Law and Social Policy. They have found that older adults are more reliable and, on balance, more productive, and they are also less likely to make serious and costly mistakes. (Psychological Science, July 10, 2013)

More Brain through Gameplay

The influence of computer games on children and young people is contested in terms of both positive and negative impact. A study by researchers from the Max Planck Institute for Human Development and Charité Berlin now suggests that games increase spatial awareness. Using magnetic resonance imaging, the scientists found that the longer the subjects had spent playing video games during their life, the larger the entorhinal cortex was. The entorhinal cortex plays an important role in spatial awareness. Logic and puzzle-type games such as Tetris and Minesweeper had the biggest impact on this part of the brain, along with jump-and-run games like Super Mario, while the effect on players of action-based role-play games was less pronounced. These results suggest that enthusiastic gamers may be better able to get their bearings in their physical environment. (Molecular Psychiatry, online, August 20, 2013)
Climate Change Picks Up Speed

Global warming may be reinforced by extreme meteorological events

Extreme weather events could become more frequent as a result of climate change, and may further reinforce it. Lengthy droughts, heat waves, heavy rains and violent storms apparently result in terrestrial ecosystems such as forests, grasslands and agricultural land absorbing about eleven billion tons less carbon dioxide through photosynthesis each year than areas not exposed to these extreme events. This is the finding of an international team working with Markus Reichstein, Director at the Max Planck Institute for Biogeochemistry, using satellite images and surface measurements from some 500 stations around the world. The carbon dioxide remaining in the atmosphere as a result of extreme weather events is equivalent to approximately one third of global CO₂ emissions per year. Terrestrial ecosystems absorb about the same amount each year, storing it as biomass in the longer term. Without extreme weather events, they could remove twice the volume of greenhouse gases from the atmosphere, but if extreme events increase, forests and other ecosystems will be less able to help with climate protection. (Nature, August 15, 2013)

A Magnetar at the Heart of the Milky Way

Radio astronomers use pulsar with strong magnetic field to investigate supermassive black hole

Astronomers have detected a magnetar at the center of our Milky Way. Emitting extremely precise radio pulses, much like a cosmic lighthouse, this extremely compact neutron star (pulsar) measuring just 20 kilometers in diameter possesses an extraordinarily strong magnetic field. Its presence enables researchers to investigate the direct vicinity of the black hole at the heart of the galaxy. Using the magnetar as a magnetic probe, a team headed by the Max Planck Institute for Radio Astronomy in Bonn has made preliminary findings that indicate the existence of a strong magnetic field at the center of the Milky Way. The magnetic field is generated by ionized matter that is swallowed up by the black hole. This explains the emission of radiation ranging from radio waves to X-rays that has long been associated with the immediate vicinity of the black hole. Superstrong magnetic fields directly at the black hole may also explain why it absorbs comparatively little matter, giving the impression that it is on a diet, unlike the black holes observed in other galaxies. (Nature, August 14, 2013)

At the center of the galaxy: This artist’s impression shows the magnetar PSR J1745-2900, a pulsar with an extremely strong magnetic field. It is located in the direct vicinity of a supermassive black hole with approximately 4 million times the mass of our Sun.
Harmless Terror Bird

The prehistoric bird Gastornis was probably not a bird of prey but an herbivore.

It seems that the prehistoric bird Gastornis has been wrongly accused of being a terrifying predator. For decades, paleontologists speculated that it used its huge beak to snap its prey’s neck, and gave it the moniker “terror bird”. Now it seems it was actually a vegetarian. This is the conclusion reached by a German research team including Stephen Galer of the Max Planck Institute for Chemistry in Mainz, based on analysis of the calcium isotope composition of fossilized Gastornis bones. Isotopes are forms of an element that have different weights. The relative amount of “light” and “heavy” isotopes changes as calcium passes along the food chain, and this can be used to differentiate between herbivores and carnivores. And the Gastornis, which lived more than 40 million years ago, apparently belonged to the former. (Goldschmidt-Konferenz, August 25–30, 2013)

Prehistoric Softeners

Neanderthals made tools similar to those still used by leather workers today.

Without clothes, Central Europe is an inhospitable place, and this was certainly the case throughout the last Ice Age. It’s not surprising, then, that even early humans developed techniques for producing clothes from animal hides. They did this using tools that were very similar to the lissoirs still used by modern-day leather workers to make the material softer, smoother and more water-resistant. Scientists from the Max Planck Institute for Evolutionary Anthropology in Leipzig and the University of Leiden in the Netherlands discovered this type of Neanderthal bone tool at their respective excavations in southwest France. The prehistoric lissoirs, fashioned from the ribs of deer, are approximately 50,000 years old, predating the first evidence of modern humans in Western Europe. This is the first indication that modern humans acquired cultural achievements from Neanderthals, and not only the other way around. However, it isn’t yet possible to exclude the possibility that modern humans entered Europe and influenced Neanderthal behavior earlier than we can currently demonstrate. (PNAS, August 12, 2013)
The hippocampus region of the brain has long been considered a center for the long-term storage of memory. Now, however, according to scientists at the Max Planck Institute for Medical Research in Heidelberg and the University of Seville, neurobiology textbooks will have to be rewritten, since their findings show that memory is actually stored in the cerebral cortex. The scientists studied the learning behavior of genetically modified mice in which NMDA receptors are turned off only in the motor cortex. Without the NMDA receptors in the primary motor cortex, the genetically modified mice can’t remember the connection between a sound and an electrical stimulus. This is consistent with the findings of another team at the Max Planck Institute in Heidelberg, that mice without NMDA receptors in the hippocampus can still learn and store spatial associations. (Nature Communications, August 27, 2013)

A Quick Test for the Black Death

Diagnosing the presence of Yersinia pestis, the cause of the plague, may soon be easier than ever before. Scientists working with Peter Seeberger, Director at the Max Planck Institute of Colloids and Interfaces in Potsdam-Golm, developed a simple, inexpensive and reliable test for detecting the bacterium. The researchers first identified and synthesized an oligosaccharide (complex sugar) found on the bacterial surface, before combining it with a protein to heighten its immunological effect. The resulting glycoprotein can locate the pathogen in two ways, the first being to act as an antigen and detect Yersinia pestis in the blood of infected patients. However, the Potsdam-based scientists also used it to generate antibodies that can detect the plague pathogen directly in infected tissue. (Angewandte Chemie International Edition, online, July 10, 2013)

No Silver Bullet for Voter Satisfaction

Referendums are regarded as an effective way to counteract disenchantment with politics, but it isn’t necessarily true that they increase the level of satisfaction with political decisions, according to the findings of an international team working with researchers at the Max Planck Institute for Research on Collective Goods. Shortly before regional elections in the German state of Rhineland-Palatinate, the scientists interviewed 615 citizens between 18 and 70 years of age. Taking the themes of nuclear phase-out, centralized school-leaving examinations and Islamic religious instruction in public schools, they presented different scenarios in relation to how positive or negative decisions had been reached. These included a form of direct democracy such as a referendum, an expert committee, a parliament dominated by a particular political party, and a cross-party parliamentary majority. According to the study, respondents were more ready to accept referendum results over other scenarios only in the case of issues that were important to them. Perhaps there is no silver bullet for voter satisfaction after all. (Preprints of the MPI for Research on Collective Goods, Bonn 2013/10)

Memory in the Cerebral Cortex

The hippocampus region of the brain has long been considered a center for the long-term storage of memory. Now, however, according to scientists at the Max Planck Institute for Medical Research in Heidelberg and the University of Seville, neurobiology textbooks will have to be rewritten, since their findings show that memory is actually stored in the cerebral cortex. The scientists studied the learning behavior of genetically modified mice in which NMDA receptors are turned off only in the motor cortex. Without the NMDA receptors in the primary motor cortex, the genetically modified mice can’t remember the connection between a sound and an electrical stimulus. This is consistent with the findings of another team at the Max Planck Institute in Heidelberg, that mice without NMDA receptors in the hippocampus can still learn and store spatial associations. (Nature Communications, August 27, 2013)
An Early Start for the Rosetta Comet

Celestial bodies don’t always respect astronomers’ schedules. On its way toward the Sun, comet Churyumov-Gerasimenko will begin to give off gas and dust earlier than previously expected. Rosetta, a space probe of the European Space Agency (ESA), is due to rendezvous with the comet next year and deposit a lander on its surface in the autumn of 2014, but the comet’s activity should be measurable from Earth by March 2014. This is one of the findings of a team of researchers under the lead of the Max Planck Institute for Solar System Research in Katlenburg-Lindau.

The scientists analyzed observational data that ground-based telescopes recorded during the comet’s last three orbits around the Sun. The analyses haven’t yet given a very clear picture of the comet, since it was far from the Sun and barely visible against the bright background of the center of the Milky Way. The breakthrough came with a process developed for detecting exoplanets. Using this method, consecutive images were subtracted from each other, making the starry background disappear and Churyumov-Gerasimenko stand out more clearly. (Astronomy & Astrophysics, August 20, 2013)

Flatworms like Schmidtea mediterranea just won’t die. Cut one into 200 pieces, and each and every piece will regenerate into a new worm. The closely related Dendrocoelum lacteum, on the other hand, hasn’t quite mastered the trick and is incapable of regenerating heads from its posterior half. Researchers at the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden discovered a signaling pathway in the cells of Dendrocoelum lacteum that prevents new heads from growing from the back half of its body. By blocking the end product of this “Wnt signaling pathway” and thus switching it off, they found that the flatworm could now grow a new, fully functional head even from the tip of its tail. This indicates that just a few switches are sometimes enough to influence an organism’s regenerative capacity. (Nature, July 25, 2013)

An Eye for Complex Connections

Scientists succeed in fully reconstructing a piece of retina

The complex connections of the retina hold some of the secrets to understanding the human brain, which has a hundred billion nerve cells, each of them in contact with thousands of other cells. Researchers from the Max Planck Institute for Medical Research in Heidelberg and the MPI of Neurobiology in Martinsried, near Munich, have now taken a first step on the road to decoding the puzzle. After taking a month to gather the data, and four years to analyze it, they created a precise diagram of all neurons and their connections in a piece of mouse retina. Even though the cube of retina was only a tenth of a millimeter on each side, it contained nearly a thousand neurons and about half a million connections. Computer algorithms aren’t yet reliable enough to follow the neuronal processes over long distances, so 200 students spent 20,000 hours manually analyzing the countless microscope images. Part of the solution may be an online game called Brainflight, which will allow Internet users all over the world to fly along nerve paths, thus helping develop better algorithms for computer-aided data analysis. (Nature, August 8, 2013)
How Cosmic Clocks Tick

Pulsars are the most compact material objects in the universe. Their diameter is approximately equal to that of the city of Munich, but they contain the mass of the Sun. These extreme conditions make them ideal test objects for the theory of general relativity, as the work of Michael Kramer and his colleagues from the Bonn-based Max Planck Institute for Radio Astronomy shows.

The story begins in late August 1967, when 24-year-old astronomy student Jocelyn Bell, using a new radio telescope, received signals that repeated exactly every 1.33730109 seconds. She and her dissertation advisor, Antony Hewish, jokingly named the source Little Green Man, thinking of signs from an extraterrestrial civilization. This, at least, seemed to Hewish to be the most obvious explanation for the rapid succession of radio pulses from the constellation Vulpecula.

Soon, however, Hewish and Bell ruled out aliens as the cause. The researchers eventually discovered the real explanation: it is a compact object, a neutron star, that rotates extremely rapidly. It has a diameter of about 20 kilometers, but its mass is approximately that of our Sun. This makes neutron stars the densest of the celestial bodies: a bit of matter the size of a cube of sugar would weigh around a billion tons on Earth.

Moreover, a neutron star is surrounded by a strong magnetic field that, similar to the one on Earth, is substantially bipolar. Along the axis of the magnetic field, these bodies emit radiation within a narrow cone. When the rotation axis and magnetic field axis are tilted toward each other, the beam sweeps through space like the beam of a lighthouse. If it happens to strike the Earth, short pulses are registered whose frequency corresponds to the rotation frequency of the celestial body. Neutron stars that become noticeable in this way are called pulsars.

700 REVOLUTIONS PER SECOND

“Today, we know of around 2,200 pulsars with periods between 1.4 thousandths of a second and 8.5 seconds,” says Michael Kramer, who has been focusing on the physics of these cosmic lighthouses for two decades and is now a Director at the Max Planck Institute for Radio Astronomy in Bonn. So the fastest pulsar rotates about its own axis more than 700 times per second. The theoretical maximum limit is around 2,000 revolutions per second; if it were any faster, centrifugal forces would tear it apart.

In the past decades, pulsars were detected in all regions of the electromagnetic spectrum — from the radio-wave to the gamma range. Still, it isn’t yet fully clear how the radiation is generated. Early this year, an international collaboration in which the Max Planck group in Bonn participated observed for the first time an unexpected correlation between radio and X-ray pulses: when the radio pulses are strong, the X-ray radiation is weak — and vice versa.

Surprisingly, this switch occurs within seconds. Thereafter, the whole thing remains stable in the new state for a few hours. The astronomers’ explanation for this variable behavior is that the two types of radiation are generated in different regions.

“The surface of the pulsar, the electrical force induced by the magnet-
Spotlights in space: A neutron star rotates rapidly about its axis and, in the process, emits radiation that sweeps across space like the beam of a lighthouse. Astronomers currently know of about 2,200 such pulsars.
rons shoot into space in two cones, emitting radio radiation,” says Kramer, as he calmly sketches this hellish scenario on a piece of paper.

Researchers explain the latest observation of the switch between pulsed radio and X-ray radiation as being due to rearrangements of the approximately 100,000 kilometer magnetosphere within just a few seconds. Just exactly how this occurs and what triggers it isn’t completely clear. However, the fact that most pulsars tick extremely precisely despite such changes seems noteworthy. The regularity with which the pulses reach the Earth can definitely achieve the precision of atomic clocks.

This makes pulsars the best-suited celestial bodies for testing Einstein’s theory of general relativity. And this is precisely the task to which Michael Kramer’s Bonn-based Department of Fundamental Physics in Radio Astronomy is dedicated. Perhaps they will even be the first to detect gravitational waves directly. But first things first.

When Albert Einstein completed his theory of general relativity in 1915, the gravitational force – also referred to as gravitation – was no longer a force, but a geometric property of time and space. Celestial bodies curve the space around them, similar to how balls dent a stretched cloth. If another body enters such an area, it will deviate from a straight path and follow the curvature. The same applies to light. In addition, time near a star – that is, near a large curvature – passes more slowly than it does in open, flat space.

So far, Einstein’s theory has passed every test. Very precise tests are difficult, though, because the effects are relatively weak. The theory of general relativity has been tested in a variety of ways in our solar system, but particularly in regions of strong gravitation – that is, strong curvature – it has, to date, only rarely been put to the test.
Pulsars, as the most compact celestial bodies known, offer unique opportunities. Only black holes could top them.

For such tests, the astronomers need pulsars in binary star systems. About one in every ten stars has a companion, but not all such systems are suitable. Most binary systems comprise a pulsar and a white dwarf, a burnt-out star that has shrunk to the size of the Earth. Since a white dwarf isn’t nearly as compact as a neutron star, it also doesn’t cause a very strong spatial curvature. Thus, systems comprising a pulsar and another neutron star are most suitable. The researchers know of about ten of these.

Astronomers discovered their absolute favorite one in 2003, using the Parkes radio telescope in Australia: the first and currently only system that consists of two pulsars. “It’s really fortunate for us, because not only are the two pulsars like two extremely precise clocks, they also happen to have some particularly favorable characteristics,” says Kramer’s colleague Norbert Wex, an expert on the relativity theory.

Both bodies have approximately the same weight and contain 1.3 solar masses. One of them takes 23 thousandths of a second to rotate once about its own axis, and the other 2.8 seconds. At a distance of 900,000 kilometers from one another, they are very close together – a good twice the distance between the moon and the Earth. But while the moon requires 28 days to complete one orbit around the Earth, the two pulsars circle each other in less than two and a half hours – at a speed of around a million kilometers per hour.

**LITMUS TEST FOR THE RELATIVITY THEORY**

Michael Kramer and his colleagues belong to an international group of radio astronomers who regularly observe this double pulsar and use it to put Einstein’s theory through its paces. For example, the orbit of the two pulsars rotates in space. This effect occurs in our solar system particularly strongly in the innermost planet Mercury.

The explanation of this so-called perihelion precession was the first triumph of Einstein’s theory. But while it takes three million years for a complete period in the case of Mercury, it takes just 21 years for the double pulsar – a clear indication of how much stronger the effects of the relativity theory must be in this system.

Moreover, the astronomers are fortunate that they look almost directly at the edge of the orbit. This means that the two pulsars are nearly exactly one behind the other for every orbit. In this situation, the signal of the rear pulsar passes the one in front at a distance of just 20,000 kilometers. Since, in doing so, it has to pass through the spatial depression, its path is extended – which is evidenced by a ten-thousandth of a second delay in the arrival time of the pulse. Thanks to the extreme synchronization of the two pulsar clocks, this effect can be precisely measured.

The researchers have since registered further phenomena predicted by the theory of general relativity. All of these findings confirm the theory to a precision of within a few per mil. Einstein’s theory also postulates that two celestial bodies orbiting each other emit gravitational waves that propa-
gate at the speed of light. In the analogy with the dented cloth, they can be visualized as waves that go out from the double pulsar in, to put it in simplified terms, concentric waves – similar to the waves on the surface of a lake into which a stone has been thrown.

Due to the emission of gravitational waves, the two bodies lose a portion of their orbital energy. As a result, they slowly come closer together on a spiral-shaped path. “We discovered that this causes the orbit to shrink by 7.12 millimeters a year,” says Kramer, and adds with a grin: “with an uncertainty of nine-thousandths of a millimeter.” This incredible precision leads to the prediction that the two bodies will collide in 85 million years and merge together in a gigantic ball of fire.

More than 30 years ago already, American astronomers Russell Hulse and Joseph Taylor detected gravitational waves indirectly, in another binary star system with only one pulsar, based on the decrease in the orbiting time. They were awarded the Nobel Prize in Physics in 1993 for this achievement. The new measurement data from the double pulsars, however, is even more precise and is particularly well suited for testing alternative theories to Einstein’s crowning achievement.

The most well known example of one of these alternatives is likely the so-called MoND (modified Newtonian dynamics) theory of Israeli physicist Mordehai Milgrom. He had already modified the Newtonian law of gravity 30 years ago in such a way that it explains the rotation of spiral galaxies without the assumption of the hypothetical dark
matter. Then about ten years ago, theoretical Jacob Bekenstein gave Milgrom’s theory a relativistic form by introducing, besides the curvature of space, two further auxiliary fields.

THE HUNT FOR GRAVITATIONAL WAVES

Bekenstein’s alternative, called TeVeS, differs from Einstein’s theory in the prediction of the emitted gravitational waves primarily in strong fields. That is why the double pulsar is uniquely suited for the acid test. The result is unambiguous: the measured values agree to within 0.05 percent with the prediction of the theory of general relativity. Bekenstein can explain this only if he assumes very specific, non-physical conditions. “In our view, this refutes TeVeS,” says Norbert Wex, summarizing the results.

So once more, Einstein passed all tests with flying colors. But the Max Planck astronomers in Bonn have their sights set on another major goal – the direct detection of gravitational waves. And it goes like this: A gravitational wave compresses and stretches the space it crosses. In the process, the distances in this space are briefly shortened and lengthened. Physicists have already been trying for some years now to measure such microdistortions using laser interferometers. GEO600, one of the instruments working in the international network, is located near Hanover and is operated by the Max Planck Institute for Gravitational Physics.

These instruments are designed for gravitational waves with frequencies between tens of hertz and a thousand hertz, corresponding to wavelengths between 100 and 10,000 kilometers. They should originate primarily from merging neutron stars and from black holes and exploding stars (supernovae). The radio astronomers in Bonn, in collaboration with colleagues from around the world working on the Pulsar Timing Array, want to expand this range on the order of nanohertz – that is, at wavelengths of tens of light-years.

Here, the researchers are expecting signals from two merging, supermassive black holes, like those that exist in the centers of galaxies. “In the young universe, when the star systems were even closer together, there should have been more frequent collisions and mergers of black holes,” says Michael Kramer. But how can this be determined with pulsars?

When a gravitational wave approaches Earth, it distorts the space in the vicinity of the solar system and changes the distances between the incoming pulsar signals. Due to a special quirk of these waves, the distance is diminished in one direction and increased in the perpendicular direction. This is expressed in a change in the arrival times of the pulsar signals that is correlated in the sky: while the signals from the one direction arrive earlier than normal, the signals that come from a region of the sky that is offset by 90 degrees arrive later.

COSMIC LIGHTHOUSES ILLUMINATE THE ASTRONOMERS

For their search for gravitational waves, the astronomers need around 40 pulsars with maximum precision throughout the sky. They are currently observing about 30 to determine their precision over the course of the experiment. To track down further cosmic lighthouses, the researchers in Bonn are collaborating intensively with their colleague Holger Pletsch at the Max Planck Institute for Gravitational Physics in Hanover.

Pletsch, who was recently awarded the Heinz Maier-Leibnitz Prize, developed a method for analyzing the enor-
mous amounts of data from gravitational wave detectors like GEO600. But it can also be used to track down the beeps of the pulsars in the radio telescope data. “We’ve already found more than ten additional pulsars with this method,” says Kramer.

THE CURVATURE OF SPACE CAN’T BE NEGLLECTED

However, only a few pulsars are suitable for this project, as the researchers have to record the pulses over a number of years with an accuracy of better than 100 nanoseconds. Moreover, they have to take into account the curvature of space caused by the bodies in our solar system, as it, too, delays the arrival time of the signals. If, for instance, the mass of Jupiter isn’t known precisely enough, then the solar system’s center of gravity isn’t known exactly either. As a result, the calculated arrival times fluctuate precisely with Jupiter’s orbital period.

For this reason, an international team headed by Kramer’s colleague David Champion undertook a precise measurement of the masses of the giant planets. “This allowed us, for the first time, to weigh planets in their entirety, including all moons and rings,” says Champion. And they did it with a precision that was previously possible only with space probes.

For the Pulsar Timing Array, the radio astronomers are currently using multiple antennas that are distributed throughout the world, including the 100-meter radio telescope in Effelsberg. Starting in the next decade, they will have access to the new Square Kilometre Array (SKA) being developed in South Africa and Australia. The final design will be a hundred times more sensitive than the “giant of Effelsberg.”

“If we don’t detect any gravitational waves with the SKA, then there’s something wrong,” says Michael Kramer. In that case, either the cosmologists’ models for the merging of black holes in the young universe would be incorrect, or Albert Einstein would have been wrong after all with his prediction of gravitational waves. But the radio astronomers in Bonn almost entirely rule out the second possibility.

TO THE POINT

- Astronomers currently know of around 2,200 pulsars, or compact neutron stars.
- Due to their large gravitational force and their uniquely precise rotation, pulsars are suitable for all kinds of physics tests.
- Researchers check, for example, statements from the theory of general relativity, or test alternative models to Einstein’s ideas.
- Pulsars also serve in directly detecting gravitational waves, though none have been found yet.

GLOSSARY

Theory of general relativity (TGR): The theory presented by Albert Einstein (1879 to 1955) in 1915 describes the interaction of matter with space and time. A key player in the TGR is gravitation, which is considered to be a geometric property of curved, four-dimensional space-time.

GEO600: The installation in a field outside Ruthe, near Hanover, comprises two 600-meter-long trenches covered with corrugated sheet metal. Inside these run the beams of a laser; they are reflected at the ends of the tubes, converge again at the beam splitter, and strike a detector there. If gravitational waves pass through the installation, the space-time will be compressed, and the light will exhibit tiny but measurable run-time differences.

Neutron star: When a star has used up its fuel, energy production stops. The gas pressure disappears, and the gravitational force causes the interior of the star to collapse within fractions of a second. If the mass of this nucleus is between 1.4 and about 3 solar masses, a neutron star forms. Less massive stars end up as white dwarves, and heavier ones as black holes. The outer shell is blasted into space, lighting up as a supernova.

Square Kilometre Array (SKA): The Square Kilometre Array is a radio telescope with a total collection surface of around one square kilometer. Its sensitivity is expected to be many times that of conventional antennas. Furthermore, this facility will allow astronomers to scan the sky ten thousand times faster than before. The SKA is being built in South Africa and Australia and is expected to be fully completed in 2023.
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In the Shadow of Tuberculosis

At the Max Planck Institute for Infection Biology in Berlin, the focus is on such unpleasant companions as chlamydia, HIV and tubercle bacilli. Stefan H. E. Kaufmann, as Founding Director, helped establish it 20 years ago. Since then, the scientist has been researching the strengths and weaknesses of the tubercle bacillus. Modern tuberculosis research would be inconceivable without him – and he without it.

TEXT CATARINA PIETSCHMANN

Two billion people are infected worldwide, and one in ten will develop the disease – an old specter has reappeared: tuberculosis. But how can that be? Wasn’t this lung disease a scourge of the 19th and early 20th centuries? “That’s true, but tuberculosis was never really gone, it just went off our radar screen,” says Stefan Kaufmann, Director of the Department of Immunology at the Max Planck Institute for Infection Biology in Berlin. Now tuberculosis, to which Thomas Mann erected a literary monument in his novel “The Magic Mountain,” has returned – and with it, images of emaciated people who are literally coughing their lungs out.

And the much-vaunted modern medicine? It stands there nearly empty-handed. “We have an almost one-hundred-year-old vaccine that is barely effective, and antibiotics that are increasingly powerless against resistant bacterial strains. And there are no tests to distinguish between infected people who won’t become ill and those who will develop the disease.”

HISTORICAL LOCATION

Kaufmann is one of the world’s leading infection biologists. There is hardly any other who has such an extensive knowledge of tuberculosis as the 65-year-old scientist. The fact that his office is located on Berlin’s Charité campus just a few steps away from Luisenstraße, where Robert Koch discovered the tuberculosis pathogen Mycobacterium tuberculosis in 1882, is no coincidence. “That’s one of the advantages of being a Founding Director,” says Kaufmann, smiling. “You already have a finished institute lined up.” Kaufmann pleaded the case
Time and time again, toward the end of the 19th century, Robert Koch studied tissue from infected guinea pigs. Only after numerous attempts did he succeed in staining the rod-shaped tuberculosis bacteria and making them visible. At that time, one in every three people in Berlin, Paris and London died of consumption. Since 1950, the numbers in Germany have continuously declined, but there are still more than 4,000 cases reported every year.

“Tuberculosis is a disease of poverty that has much to do with public health. That is also why it made a comeback after both world wars. Unfortunately, when it disappeared here in Europe, we lost sight of the rest of the world,” says Kaufmann.

Many people in a very cramped space plus catastrophic hygiene conditions – that’s a perfect environment for tubercle bacilli. With the start of urbanization in poorer countries, the pathogen spread like wildfire in slums and townships, for instance in southern Africa. Like the coal mines in Great Britain and Germany at one time, there, gold and gemstone mines became an eldorado not only for those seeking their fortune, but also for agents of disease. “People come together there from throughout Sub-Saharan Africa to work. Lonely men who seek out prostitutes and additionally con-
tract HIV,” says Kaufmann. HIV and tuberculosis make an infernal duo. HIV weakens the immune system, allowing the tuberculosis to truly blossom. Then a latent infection can turn into an active illness. HIV literally dragged tuberculosis in tow.

THE DISEASE IS ADVANCING

India and China likewise have a huge tuberculosis problem, and Eastern Europe joined the ranks in the 1990s. The collapse of the Soviet Union also led to the collapse of its previously quite functional health system, and the pathogen was able to spread throughout all of Eastern Europe. Breeding grounds include Russia’s crowded prisons: one in every ten inmates suffers from a highly contagious active tuberculosis.

*Mycobacterium tuberculosis* is clever. “It’s quite a lazy character, dividing only once every 16 hours, but it chose the most effective means of transmission: droplet and smear infections.” Once inhaled, the pathogens get into the lungs, where they are confronted by the immune system. Phagocytes move in and surround the bacilli, but don’t kill them. Additional helper cells form a solid wall and encapsulate them in so-called granulomas.

This is no pleasant situation for the microbes, but they make the best of it: they reduce their metabolism almost to zero and wait, slumbering, for better times. This “dormancy,” something like Sleeping Beauty, can last ten years or more, and the infected person has no idea the intruders are there.

“But once in a while, a pathogen awakens – we call it a scout – and checks out the situation.” If the immune defense is still standing with guns at the ready, it dies. But if the immune system is distracted because it is currently battling on other fronts – for instance against HIV or another infection – the scout awakens its cronies. The late risers are hungry. So what they do is first eat, then multiply. “The granuloma gives them all the nutrients they need. More and more tissue dies until the granuloma finally dissolves,” explains Kaufmann. Every coughing fit now catapults the active pathogens into the environment, to new hosts – an active tuberculosis has emerged.

Kaufmann’s team is researching the metabolism processes of sleepers and scouts, their communications and the signals between the scout and the host. Born the son of a chemist in Ludwigshafen, Kaufmann made his acquaintance with the microbe during his biology studies in Mainz. Classical biology topics didn’t interest him much, but then he attended a medical microbiology lecture by Paul Klein, a renowned immunologist and microbiologist.

“Klein was a charismatic, eloquent teacher and mentor. He taught me just how exciting science can be.”

CAREER IN GERMANY

Kaufmann had found his topic. He completed his doctorate at the University of Mainz in 1977, qualified as a professor four years later at Freie Universität Berlin with a thesis on the characterization of T cells in bacterial infections, and was authorized to teach immunology and microbiology.

His next stop was Freiburg, where he spent six years conducting research at the Max Planck Institute of Immunobiology. In 1987, he answered the call to relocate to the University of Ulm, resisted various attempts to lure him away, and was granted a full professor-
ship in 1991. Kaufmann did all the hard work on his own: “I never had a great mentor in the US – which, looking back, I don’t actually regret. It had its advantages: I had to learn early on how to organize things.” The Max Planck Society got him back in 1993 and asked him to establish an institute for infection biology.

Kaufmann’s research career began with Listeria, a simple model pathogen. The infection runs a course that is very similar to that of tuberculosis, but listeriae are faster. At that time, the established dogma was that, in bacterial infections, special immune cells known as CD4 T cells appear, while in the case of viral infections, it is CD8 T cells. Kaufmann discovered that, though the tuberculosis agent is indeed largely controlled by CD4 T cells, CD8 nevertheless become active. This was preliminary work for Kaufmann’s endeavor to create a better vaccine, which he began in the 1990s.

Up until 1970, every infant in West Germany was vaccinated against tuberculosis, while in the East, vaccination continued until German reunification. Does this mean that seniors are safe? Kaufmann shakes his head. “Then, as now, the only vaccine in existence was Bacillus Calmette-Guérin, BCG, an attenuated agent of bovine tuberculosis. Today we know that it protects only infants.” So everyone reading this article could be infected – Stefan Kaufmann himself was, too.

**AIM: A NEW VACCINE**

A new vaccine is thus at the top of epidemiologists’ wishlists. Kaufmann’s hypothesis is that BCG stimulates primarily CD4 T cells. That’s enough to hold the bacteria in check. Then, however, a broad immunological arsenal is needed to kill the pathogens. “Upon learning that, we inserted a listeria gene into the genome of the vaccine,” says Kaufman. “In this way, the formerly weak vaccine also became a stimulator of CD8 T cells, which generates a strong defense.”

The candidate vaccine is currently in clinical phase II and is being tested in South Africa – even on newborns, the primary target group. “We have to conduct such studies in areas with large numbers of tuberculosis cases, because ultimately that’s the only way we can determine whether the vaccination truly provides protection against the disease.”

One of the partners in the vaccine study is Vakzine Projekt Management GmbH, a company initiated by the German Federal Ministry of Education and Research. Now, one of the world’s largest vaccine manufacturers, Serum Institute of India, is also on board. “One thing I learned in the past few years is that the exciting new things we learn about infectious diseases don’t come from basic research, but from clinical studies. They show us what we have to look for in the lab.”

From their studies on patients, the scientists are currently learning that tuberculosis isn’t a single disease. Rather, the many granulomas in the lungs are individual units. In addition to active lesions, there are also solid ones in which the germs still lie dormant. Treated in this phase, the active lesions recede, since the active pathogens are vulnerable. That is why active tuberculosis must be treated for six months in order to also kill all the pathogens that are gradually awakening from their slumber.

A cocktail comprising at least three antibiotics is used for this purpose. But the bacilli have armed themselves. They have since become resistant to many antibiotics. The bill for treating a
A patient infected with multidrug-resistant germs can quickly run up to 50,000 euros. So it’s clear that such patients can be treated only in rich countries.

There are already 50 million people infected with multidrug-resistant strains. Extensively resistant strains have already been discovered in 85 countries, and completely resistant pathogens have even emerged in India, Italy, Iran and South Africa. Not a single antibiotic can fight these strains.

Besides his research into a new vaccine, Kaufmann is also searching, with support from the Bill & Melinda Gates Foundation, for biomarkers that will allow doctors to tell who is going to come down with tuberculosis and why some people – like himself – are able to shake off the pathogens. After all, only one in ten people actually develop the disease. Several thousand test subjects from families with a tuberculosis patient are being monitored over two years in seven African study centers, and their blood regularly analyzed.

**BIOMARKERS FOR DIAGNOSIS**

According to this study, those who have a latent or active tuberculosis differ in the expression of nearly 2,000 genes. Kaufmann plans to select four to six such unusually strongly regulated genes to define a distinct signature that shows, as early as a few months following infection, who will get sick and therefore be given prophylactic treatment. Stefan Kaufmann could have become Director of the Robert Koch Institute in 2010, but he turned down the offer. Not just because he greatly values the independent research at the MaxPlankResearch institute.
Planck Society, but also because he believes that he can accomplish far more, scientifically and socially, by being active in international organizations. In the GAVI Alliance, for instance – a public-private partnership that advocates the use of existing vaccines for the benefit of poor countries, not just the rich. Or as a member of a Bill & Melinda Gates Foundation committee of experts that assesses the feasibility of ideas of scientists from poorer countries.

Furthermore, he has his sights set on collaboration with doctors and scientists on the ground. This requires good partners. “That is why I am also proud that, on my initiative, two Max Planck research groups with a focus on tuberculosis and HIV were set up in Durban, South Africa.” Beyond this, as President of the International Union of Immunological Societies (IUIS), he aims to close some gaps: communication gaps between young and more experienced scientists, between basic and applied research, and between scientists from different cultures.

On the conference table, two small Buddha figures that Kaufmann brought back from China and Cambodia urge tranquility. No, he isn’t particularly patient. Not even with himself, he admits. Fruitless meetings are anathema to him. “As short as possible and as long as necessary,” is his motto. But impatience also has its advantages. “Everyone is usually satisfied when I’m appointed to chair a committee. Because they get to leave with an outcome after one or two hours,” he says grinning. “But I’m still something of a long distance runner, otherwise tuberculosis wouldn’t have been the right subject for me.”

Kaufmann has seen and experienced a lot in his travels, which have taken him to every continent, but especially frequently to Africa and India. The interwovenness of poverty and disease and the disinterest of the pharmaceutical industry in developing drugs “that don’t generate much profit” disgust him and spur him on. The biologist, who is father to two grown sons and recently became a grandfather, is far from entertaining any thoughts of quitting.

On the seat next to Kaufmann lies a well-stuffed backpack. It contains a fat binder for working at home, a laptop and workout gear for the evening. For the short route between the institute and his home, he jumps on his bike, as usual. Kaufmann has consciously chosen not to own a car for some time now.

**A LIBRARY IN THE OFFICE**

His fascination for microbes has also become a personal hobby. Kaufmann stands and opens the large library cabinet next to the desk that has nearly disappeared under neat stacks of paper. Behind tinted panes and between well-thumbed leather-bound volumes stands a treasure trove: bound original works of famous researchers. Among them are the complete Berliner klinische wochenschrift with all of Robert Koch’s important articles, and the 16th century work of Girolamo Fracastoro, who first described infections with syphilis and tuberculosis. Some of the images are not for the faint of heart.

One of his favorite books is by Antoni van Leeuwenhoek, published in 1685. The cloth merchant was the first person to behold bacteria, under a microscope he built himself. “He had scraped them from his teeth. From then on, he supposedly drank only very hot tea,” says Stefan Kaufmann with a laugh, “because he believed he could kill the germs that way.”

So much for the history. What does the future of infection biology look like? Since 1980, more than 30 potentially dangerous new pathogens have been discovered, and others will surely follow. Due to globalization, infectious diseases can quickly turn into pandemics that can reach anywhere on Earth. “Vaccinations are the key – prevention is always better than cure. The pathogens are largely powerless against vaccines, because there are always only a few of them in the early stages.”

Kaufmann publishes books and articles in which he urges society, politics and industry to act in unison – particularly against the main risk factor for disease: poverty. In that regard, Stefan Kaufmann likes to cite Voltaire. “We are responsible for what we do, but also for what we do not do.”
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A model for materials scientists: Water runs off the surface of a lotus leaf without a trace. Researchers in Mainz use this concept to develop coatings that repel both water and oil.
A Slippery Slope for Every Drop

The research being undertaken by Doris Vollmer and Hans-Jürgen Butt could not only put an end to the annoying smears on window panes, it could also make it possible to produce self-cleaning solar panels or more effective heart-lung machines. The scientists from the Max Planck Institute for Polymer Research in Mainz are developing surfaces that are extremely water and blood repellent.

Just picked these lotus leaves from the botanical garden,” says Doris Vollmer emphatically, as she proudly presents a fresh bunch of large leaves with long stalks. Vollmer is a group leader in the department of Hans-Jürgen Butt, a Director at the Max Planck Institute for Polymer Research in Mainz. The surfaces of the leaves shimmer mysteriously and indeed, evolution has given them a particularly sophisticated design.

Periklis Papadopoulos, a young postdoc in Vollmer’s team, takes a lotus leaf and sprinkles a drop of water onto it. The drop briefly remains in a small indentation in the center of the leaf, as if slightly undecided. It then slides off the leaf like a miniature spherical hovercraft, without leaving a damp trace behind. It finally ends up on the Greek physicist’s trousers. The wet spot on the denim creates an impressive contrast to the lotus leaf, which looks perfectly dry, as if no water drop had ever landed on it.

The plant uses the lotus effect to keep its leaves, which float on the water, not only dry but, most importantly, clean. As the water runs off, it rinses away the dirt, which is why the lotus is held to be a symbol of purity in some cultures. This allows the plant to catch as much sunlight as possible. And it is precisely this ability to clean itself that has been fascinating scientists ever since the German botanist Wilhelm Barthlott first studied lotus leaves under an electron microscope in the 1970s.

A MICRO-FOREST MAKES SURFACES SUPERHYDROPHOBIC

The first coatings that apply the lotus effect are even available on the market. They haven’t been very successful yet, because they still have too many disadvantages. Doris Vollmer’s team is now using new ideas in the battle against the annoying smearable film that gets left behind. Reliably self-cleaning...
Vollmer points at them and says: “These are important in making the surface of the lotus leaves really superhydrophobic.”

CANDLE SOOT AS A TEMPLATE FOR A SUPERAMPHIPHOBIC COATING

The lotus plant has been optimizing its water-repellent properties for many thousands of years. Since the middle of the 1990s, research has become better and better at imitating the lotus effect with artificial micro- and nanostructures. Doris Vollmer’s computer contains a whole collection of electron microscope images of tiny pillars, raspberry-like micro-spheres with nanobumps, and other structures from the laboratory in Mainz, all of which are very good at repelling water.

The difficulty arises when these surfaces need to additionally repel oil, blood or soap solutions, because these liquids can wet many materials. “Until a few years ago, it was unclear whether superamphiphobic surfaces were possible at all,” explains Vollmer. It wasn’t until 2007 that American researchers succeeded in making a breakthrough with mushroom-shaped microstructures. Since then, the physicist in Mainz, who obtained her German postdoctoral lecturing qualification in chemistry in the course of her career, has advanced the development of superamphiphobic materials.

Surfaces that even particularly low-viscosity oils can’t wet are quite demanding from a scientific perspective. This makes the simple manufacturing process discovered by the Mainz-based researchers all the more surprising. And it is precisely this simplicity that could give rise to completely new technical applications. Hans-Jürgen Butt is working on a self-cleaning membrane that could enrich the blood of patients on heart-lung machines with oxygen much more efficiently than today’s machines, for example.

But more on this later. First we will step into the lab. Here we find Periklis Papadopoulos, who demonstrates the surprising simplicity of the Mainz recipe for superamphiphobic coatings. The first step, at least, is simple enough to do at home. The physicist takes a thin glass plate and a candle. He lights the candle and then holds the glass car windows, glass facades and solar panels would truly be significant progress. Just like lotus leaves, solar cells would no longer suffer from light loss as they get dirty.

The precise scientific term for extremely water-repellent surfaces is superhydrophobic. Superamphiphobic surfaces are an even greater challenge, explains Hans-Jürgen Butt, because they repel even oily substances without a trace. It’s this second property that makes them a perfect anti-smear coating. However, for applications such as coating solar cells, they also have to be transparent, and the transparency presents a real challenge.

Superhydrophobic and superamphiphobic surfaces aren’t perfectly smooth, as one might assume. Quite the contrary: Microscopy images of lotus leaves reveal a complex micro-forest of treelike protuberances that measure roughly ten micrometers (thousandths of a millimeter) wide and high. At even greater magnification, one can see that they are covered with fine rods measuring a few dozen nanometers (millionths of a millimeter) in diameter and a few hundred nanometers in length.

Hans-Jürgen Butt, Frank Schellenberger and Doris Vollmer (from left) are investigating the conditions under which surfaces like those of a lotus leaf repel water and when they even repel oil. They use their findings to help them develop coatings from which nearly all liquids run off.
above it. It quickly becomes black with candle soot. And this layer of soot is very special.

Under the microscope one can see a conglomeration of tiny spheres of soot that are surprisingly uniform in size, but deposited one on top of another in quite a disorderly fashion. The layer is still pitch black, however, and can easily be wiped off. Further steps are necessary before a transparent and more wear-resistant coating is achieved, but these can be undertaken only in a well-equipped laboratory and require experimental skill.

The sponge-like structure of the spheres of soot provides only the template – that’s the art of it. The researchers in Mainz now deposit a volatile, organic silicon compound onto the soot. The recipe also requires a pinch of ammonia. The two substances react chemically on the surface of the soot particles to form silicon dioxide – that is, glass. All the soot spheres are gradually coated with a thin, porous layer of glass. The researchers then heat the finished, glass-coated structure to 500 degrees Celsius and thus burn off the soot, which consists essentially of carbon, with oxygen.

What remains at the end are hollow glass spheres – colorless, nano-sized Christmas tree baubles that stick together. They are roughly 60 nanometers in diameter, making them about as tiny as many viruses. The sponge-like glass layer is now transparent. As the view through a microscope shows, the sponge of glass spheres features overhangs. These are necessary for the surface to repel water and oil. The Max Planck scientists finally coat the surface with a fluorinated silicon compound so that oil droplets are guaranteed not to wet the surface. “The surface then repels oil much better than a non-stick frying pan,” explains Periklis Papadopoulos.

THE DROPLETS’ RIDE ACROSS NANO-STUBBLE FIELDS

The postdoc presents some glass slides with the finished superamphiphobic glass coating. They still look slightly frosted. “We are working on improving the transparency,” says the physicist. He sprinkles some water onto one of the glass slides and it rolls off as if it were on a perfect playground slide, even when the glass slide has only a slight inclination. This is the lotus effect. But even more impressive, at least for those in the know, is the demonstration with hexadecane. This low-viscosity oil is a component of, for example, heating and lubricating oils. Even the hexadecane rolls off without a trace. Only a few years ago, many experts would have hardly believed this to be possible.

The delicate sponge of glass spheres is still quite sensitive. Nevertheless, it still works after sand has been sprinkled onto it for a while from a height of 30 centimeters. “Although the top particles are gone, the thickness of the layer means there are still enough sitting on the surface,” explains Papadopoulos. The group in Mainz is just working on an improved method that bakes the glass spheres to each other and makes the coating more wear resistant.

But why do such micro-landscapes repel drops of water or oil so perfectly? Vollmer and Papadopoulos turn to the computer to demonstrate at large magnification what happens to the drops of liquid. The researchers use a particularly high-resolution microscope, which scans the droplets on the surfaces with a very fine laser beam. The instrument is called a confocal microscope, and provides the researchers with complete, A glass micro-forest that repels water and oil: The image from a scanning electron microscope (left) shows the spherical structures that make up the surface coating. Liquids form the same wetting angle on the spherical surfaces as on a plane surface of the material. With water, this angle can be up to 120 degrees, much less for oil, here 50 degrees. An oil-repellent surface thus requires overhanging structures. If the overhangs aren’t pronounced enough for oil to assume the wetting angle, it sinks in through the pores.
three-dimensional information on the ride of the tiny droplets across micro-forests and nano-stubble fields.

The important thing is that the droplets lie only on top of the microscopic pillars, bumps or spheres. They roll off easily as long as they don’t come into contact with the actual surface at the base of these structures and have the opportunity to wet them. The impression that the drop on the lotus leaf moves like a small hovercraft isn’t far removed. On the microscopy images, the drops on the superhydrophobic micro-structures resemble tiny, spherical fakirs sitting on a bed of nails. And, in fact, this sitting on the very tips is called the fakir or Cassie state, because it was British researcher A. B. D. Cassie who first described it scientifically in 1944. Underneath the drop is mainly air, so it easily rolls off the surface.

There is one thing you wouldn’t wish on a fakir: that he sinks into his bed of nails. Yet the researchers get their tiny water drops to slip through the micro-forest – and observe them as they do so. The superhydrophobic property then breaks down. Precisely what was happening on the microscopic level was previously a mystery. In order to find out, the Max Planck researchers put droplets measuring only a few hundred micrometers in diameter onto a grid of fine plastic pillars that they produced just for this purpose: the pillars were 10 micrometers thick and 23 micrometers high, for example, giving them a slightly stocky design. As long as the drop rested only on their upper, circular surfaces, the roofless hall of micro-pillars behaved superhydrophobically.

The researchers then made the droplet, and thus its contact surface, shrink on the grid of pillars. They did this by simply letting the droplet slowly dry up. The video – taken from below through the transparent floor of the micro-pillar hall – shows how the contact surface of the drop shrinks. At the receding edge, the water tries to wet the pillars at the top as long as possible. As the protrusions get longer and longer, the drop clings to the pillars before it is forced to let go. Eventually, these water threads tear off, and quite suddenly the drop becomes a dark spot. At that moment, the area of the pillar tips is no longer sufficient to keep the drop at the top. It sinks through to the bottom.

**ONE POSSIBLE APPLICATION IS HEMODIALYSIS**

As the lateral view shows, the bottom of a water drop hangs ever lower between the decreasing number of pillars. “It’s as if someone were lying in a hammock and getting heavier and heavier,” comments Doris Vollmer, narrating the images. With the aid of these high-resolution images, her group found out that some details of Cassie’s original model need to be corrected.

“In contrast to the situation with a hammock, it’s not gravity that causes the drop to sink in, but the so-called internal capillary pressure,” says Hans-Jürgen Butt. The capillary pressure causes the drop to become rounded at the bottom as well. It can only do this if it penetrates between the pillars. “The capillary pressure increases when the drop shrinks, and the effect of the surface tension becomes larger and larger,” explains the Max Planck Director. Computer simulations undertaken by the research group working with Stephan Herminghaus, a Director at the Max Planck Institute for Complex Systems in Göttingen, confirm these observations.

As soon as the drop spreads out on the bottom of the micro-pillar hall and...
the super-water-repellent state has broken down, the drop is in a state named after Norbert Wenzel. In 1936, the German scientist was the first to describe the principle whereby a drop wets a rough surface.

The Mainz-based researchers’ experiments therefore demonstrate the conditions under which a drop sinks through a porous surface structure. This depends, on the one hand, on the ratio of the drop size to the fineness of the surface structure or the size of the pores. It also depends on how the liquid and surface chemically attract or repel each other. The fluoridated coating of the superamphiphobic structure thus additionally repels the oil droplets. This causes them to lose all interest, so to speak, in settling down properly on the surface that is so unappealing to them.

After this excursion into the theory of the contact between drop and surface, the conversation with Hans-Jürgen Butt turns to possible applications. During his academic career, the physicist has moved from biophysics to the physics and chemistry of surfaces. Correspondingly unconventional are his thoughts on possible applications for the new superamphiphobic surface structure. “We came up with the idea of using this new structure to develop a new technology for hemodialysis,” he recounts. Here, a liquid – blood – is in contact with another liquid, that is, the dialysis solution, via a membrane.

From here, it was but a short mental jump to the exchange of gas between blood and air, as occurs in lungs. In terms of surface technology, intensive contact between a liquid and a gas presents a certain challenge if the liquid is to remain locked in a container. This is the case for blood that comes into contact with pulmonary alveoli. For some time now, artificial lungs have been a well-established feature in heart-lung machines, otherwise known as life-support machines, such as those used in operating rooms. In the modern devices, synthetic membranes with tiny pores ensure that oxygen gets into the blood and carbon dioxide is removed from it.

However, conventional membranes have disadvantages. One consists in the fact that the liquid can penetrate into the membrane pores – in other words, it wets the membrane. This means that the boundary surface between the liquid and air shrinks, resulting in less gas being exchanged. Artificial lungs are thus much less efficient than our real lungs. Moreover, blood is a very special juice, as Goethe’s Mephisto remarked. The blood platelets responsible for coagulation threaten to close the pores, for example. Clots can form, which break off and block the patient’s blood vessels.

THE COMPLETELY NOVEL MEMBRANE WAS A TEAM IDEA

The Mainz-based researchers considered how the membranes could be improved with the aid of their superamphiphobic structures. “I think it’s very important to provide a creative atmo-

Topography of wetting: The Mainz-based researchers use a confocal microscope (bottom) to investigate the conditions under which liquid wets a surface. Some of their model surfaces resemble microscopic halls of pillars without a roof (top left). With the aid of reflection measurements, they reconstruct how the bottom of a drop is curved when it lies on top of the pillars (top right). The false colors in this section show how far the drop sinks in.
sphere for discussions,” emphasizes Hans-Jürgen Butt. The team thus had the idea of developing a completely new type of membrane. The basic skeleton was an extremely fine lattice of stainless steel wire. These wires are around 30 micrometers thick – a human hair is roughly three times as thick.

HEART-LUNG MACHINES FOR PREMATURE BABIES

Equally tiny are the apertures in the steel mesh, which the researchers now coat on both sides with the superamphiphobic layer of glass spheres. This provides the crucial property of the new membrane: blood can no longer wet it. The blood remains on its own side, and the air can get to it almost unhindered through the membrane pores. Conversely, the blood can expel carbon dioxide very efficiently.

The Mainz-based researchers did, however, hit on one difficulty: How do you let your own blood if you don’t have any medical training? “Fortunately, the husband of my colleague Katharina Landfester is a transplant surgeon, and time and again he has donated his own blood,” says Butt, explaining, “a few milliliters are all we need.” The membrane already works very well in the laboratory. “It’s efficient,” continues Butt, “but even more important is that no blood sticks to it.”

The pieces of membrane produced in the laboratory are still small, but in principle they can easily be scaled up.

But the researchers in Mainz still have a long way to go from pure basic research to medical application. “Comprehensive clinical tests will then be necessary,” says the Max Planck Director. Butt is skeptical that the new membrane technology can supersede the well-established heart-lung machines for adult patients, though its much-improved properties mean it could save very small patients, who have very little blood. “For premature babies, such heart-lung machines would be much better,” says the scientist.

The scientist is also thinking about quite different fields of application. In principle, similar membranes could also efficiently separate off carbon dioxide from power station emissions in the future. “Gas exchange is certainly the potentially greatest field of application,” says Butt. In this way, the membranes from Mainz could also help protect the climate.

TO THE POINT

- Superhydrophobic surfaces, such as lotus leaves, can’t be wetted by water; superamphiphobic surfaces repel water, oil, blood and soap solutions.
- A porous structure of connected glass spheres produced with the aid of candle soot has superamphiphobic properties because it has microscopic overhangs. These keep the drop in a metastable state and prevent it from penetrating into the structure.
- Whether a drop wets a surface depends, on the one hand, on whether the liquid and the surface material chemically attract or repel each other. The ratio of the fineness of the surface structure and the pores to the drop size is also crucial. If the structure is too coarse or the drop too small, the capillary pressure in the drop makes it sink through the structure.
- Superamphiphobic layers may be used as the membrane in heart-lung machines or for purifying exhaust emissions.

GLOSSARY

**Capillary pressure:** Due to surface tension, there is increased pressure inside a drop, similar to a balloon. This is known as capillary pressure. It is necessary in order to maintain the curvature of the surface.

**Surface tension:** The forces between the particles of a liquid cause the liquid to try to minimize its surface area. That’s why water forms drops, even on water-repellent surfaces, but not on water-attracting surfaces.
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The hydrological cycle tirelessly distributes water between land, ocean, atmosphere and cryosphere. Stefan Hagemann and his colleagues at the Max Planck Institute for Meteorology in Hamburg study the exact details of how this happens. They investigate the various feedback mechanisms between wetlands, artificial irrigation, permafrost and climate.

TEXT UTE KEHSE
Water molecules are always on the move. They migrate from the ocean into the atmosphere, disperse to all corners of the continents and eventually return to the oceans after days, months or even centuries. They have possibly the most varied life of all substances involved in the cycle of the elements on Earth. A water molecule on Earth can be in a solid, liquid or gaseous state. It can drift along in the sea, rise into the air, dance across the sky as a cloud, crawl slowly along Earth’s surface in a river of ice, or babble quickly along a river bed. It can seep away in the soil, be absorbed by a plant and released again, or gradually find its way through the subsoil as groundwater.

The water cycle, driven by the Sun, is enormous: at any one time, the water molecules contained in the atmosphere would fill a volume of 12,900 cubic kilometers in their liquid state. This quantity is sufficient to cover Earth’s surface to a height of 2.5 centimeters across the entire globe. Altogether, however, the hydrological cycle turns over many times this quantity of liquid. It’s as if the total water content of the atmosphere were exchanged completely around 40 times per year.

Water’s journey plays an important role in Earth’s climate, but this role is a big challenge for climate researchers. It’s not only the fact that water uses so many different travel routes and transport paths, but many hydrological processes also take place in a very small space. Local processes such as heavy rain during a storm, evaporation in wetlands or the runoff from glaciers fall through the usual grid that climate researchers span across the Earth in their models.

Although the scientists’ most important tools, the latest generation of Earth system models, are able to calculate the temperature on Earth quite well, they still have their weaknesses when it comes to estimating the precipitation in any particular region. “The error is sometimes between 50 and 100 percent,” says Stefan Hagemann. A physicist with a German post-doctoral lecturing qualification, Hagemann is working very hard to change this at the Max Planck Institute for Meteorology in Hamburg: he heads the Terrestrial Hydrology research group. His team aims to gain a better understanding of those parts of the water cycle that take place on land – and to investigate how they feed back into the climate.

PRECIPITATION INCREASES WITH GLOBAL WARMING

The most important relationship here is the interaction between precipitation and temperature. Not only do clouds, rain, hail and snow transport a vital substance across the globe, but they also carry along thermal energy in the process – albeit hidden, in latent form, as meteorologists say. Water vapor, for example, releases heat when it condenses into liquid water or freezes to form ice. Conversely, energy input is necessary for ice to melt or sublime, or for liquid water to evaporate. Water acquires this energy from its surroundings. It therefore becomes cooler where a lot of water evaporates. This is also the reason why rain feels cold to the skin, or why sweat cools the body.

So if climate researchers want to project the temperatures for the future correctly, they need to know how the precipitation is changing. “In general, one can say that the water cycle and the precipitation are intensifying due to global warming,” says Stefan Hagemann, because a warmer atmosphere
can store more water. But there are also regions that are getting drier. “If it rains even less in a predominantly dry region, evaporation can decrease there, and with it, also the cooling. It thus becomes even warmer there,” explains the Hamburg-based researcher. Consequently, the decreasing precipitation aggravates the warming even more – a textbook example of positive feedback.

Hagemann and his six colleagues focus on three quite different hydrological processes that are currently not yet represented realistically in the current climate models, but that could possibly create strong feedback loops with the climate. Firstly, they investigate the consequences of artificial irrigation. Where water is released onto fields for agriculture, evaporation increases – an effect that can impact not only temperatures, but also large-scale air currents in the atmosphere.

SEC O NDLY, THE RESEARCHERS IN HAMBURG MODEL THE GROWTH AND SHRINKING OF WETLANDS AS A FUNCTION OF THE CLIMATE. Their third research focus is the permafrost. Quite a number of complicated hydrological processes occur in the permanently frozen regions of the high latitudes, and they determine how much the ground thaws in summer and how much water is stored there. Furthermore, the group wants to find out how large the errors are that different climate models are still making in the simulation of the terrestrial water cycle.

Fahad Saeed investigated a particularly impressive example of how important hydrological processes can be for the regional climate in his doctoral thesis. The physicist, who has since moved from the Hamburg-based Max Planck...
Institute to the Climate Service Center, also in Hamburg, looked into irrigation in India and Pakistan.

“The Indian subcontinent is one of the most intensively irrigated regions on Earth,” says Saeed, who himself originates from northern Pakistan. The climate is shaped by the monsoon: there is hardly any rain in winter, but in summer, humid maritime air is transported from the Arabian Sea and the Gulf of Bengal for several months and falls as rain on the slopes of the Himalayas. In some places, the annual average precipitation is 10,000 millimeters – more than ten times as much as in Germany.

The monsoon has its roots in the large temperature difference between land and sea. During the summer months, the land masses heat up much more than the ocean. The hot air above the subcontinent rises, thus drawing in humid air from the Indian Ocean, which releases its wet load over the land. Dams and reservoirs catch the plentiful summer rain so that the fields can be irrigated year-round.

An ingenious irrigation technique was probably the basis for the early advanced civilization on the Indus river as far back as more than 5,000 years ago. Even today, the waters of the mighty river in the northwest of the subcontinent are utilized intensively: the Indus catchment area is home to the largest continuous irrigated zone in the world, comprising countless reservoirs, dams and a huge network of channels and pipes. The experts estimate that only one-eighth of the precipitation in the Indus catchment area ever reaches the estuary in the Arabian Sea. The rest is first spread over the fields before evaporating again.

Fahad Saeed discovered that the huge amounts of water vapor that rise from the floor of the Indus basin have a great impact on the whole monsoon climate in India. “Without irrigation, the areas of low pressure from the Gulf of Bengal wouldn’t penetrate very deeply into the interior,” says the physicist. Saeed compared two different versions of the regional climate model REMO from the Max Planck Institute for Meteorology. He incorporated the effect of irrigation into one, but not the other. As he found out, a too-strong westerly wind from the Arabian Sea toward the Gulf of Bengal always developed in the model without irrigation, which prevented the monsoon lows from migrating to the east. The interfering wind was less pronounced in the model with irrigation, so that the modeled route of the low pressure areas agreed better with observations.

By taking irrigation into account, it was also possible to remove a further deficit of the regional climate model: a so-called heat low above northwest India and northern Pakistan could be represented more realistically with the changed water balance. In earlier climate models, this heat low, a stationary area of low pressure that forms above the Thar desert on the border between India and Pakistan due to the extreme heat in summer, was too pronounced. The temperatures calculated from models were sometimes 5 degrees Celsius above the actual values here, and the air pressure modeled was also significantly lower than that observed.

**IF GLACIERS MELT, THE INDUS RIVER WILL HOLD LESS WATER**

In Saeed’s model with irrigation, this systematic error disappeared, the heat low was less intense. “Irrigation must obviously be taken into account in order to realistically simulate the monsoon climate,” says Stefan Hagemann. At present, the human impact in the region has an overall positive effect on the climate: without the gigantic irrigation region along the Indus, it wouldn’t only be hotter in large parts of India, but also significantly drier.

But the source that feeds the irrigation installations may well begin gradually to dry up with climate change, because a large part of the Indus water originates from the glaciers of the Himalayas. If the glaciers melt, the
amount of water available for irrigation will decrease. The evaporation in the irrigation region could then decrease, and its positive effect diminish. Future climate models must therefore also take into account changes in land use, says Hagemann.

The impact of wetlands on the climate system is at least as important as that of irrigation. Swamps, moors, riverside meadows and marshlands store not only water, but carbon as well. Since organic material is slow to decay in wetlands, the carbon accumulates over the years and millennia. Moors, for example, are deemed to be the most effective carbon stores on land.

Overall, wetlands contain roughly as much carbon as the atmosphere. The problem is that they also release greenhouse gases: if the organic material decomposes aerobically, they release carbon dioxide. If no oxygen is present, the much more powerful greenhouse gas methane is produced. Whether a marshland stores carbon or releases it, and in which form it does so, depends primarily on the water level. Some researchers suspect that global warming could transform wetlands from carbon sinks into carbon sources, given that the methane bacteria become more active in oxygen-starved sludges at higher temperatures.

In order for Earth system models to be able to compute these relationships in the future, Tobias Stacke from the Hamburg research group developed a model in his doctoral thesis that simulates the growth and shrinking of wetlands. At higher latitudes, for example, relatively small lakes increase in size in spring after the snowmelt, forming entire lakeland areas. If the climate in a region changes in the long term, this also has implications for the wetlands there.

THE MODEL COMPUTES LAKES IN THE RIGHT PLACES

Stacke first integrated these processes into a specific hydrology model developed at the institute, a program called MPI-HM. “This model is relatively simple, but it provides results that are just as good as those of other, significantly more complicated hydrology models,” emphasizes Stefan Hagemann. It is therefore an excellent tool to test new program components such as the wetland module. MPI-HM uses either observed or modeled precipitation data as input. The model then computes the evaporation, the runoff and the soil moisture, for example – either for a specific region or for Earth as a whole.

To find out how realistic the results of his model are, Stacke used it to simulate the distribution of the wetlands during the mid-Holocene, 6,000 years ago. At that time, there was significantly more precipitation in the Sahara than today, and in southern Asia, the climate was also wetter. There were expansive lakes in Africa, such as Lake Chad at the southern edge of the Sahara. The lake covered 400,000 square kilometers – more than the Caspian Sea today. Such mega-lakes also formed in the right places in the model, and it also provided the correct distribution and extent of the wetlands in today’s climate. Since it proved to be correct, Tobias Stacke is currently working on integrating his model into the JSBACH land model developed by the Max Planck Institute in Hamburg. This model, in turn, is part of the current Earth system model. He collaborates closely with researchers from Victor Brovkin’s Climate-Biogeosphere Interactions research group, which is interested mainly in the methane production of the wetlands.

The most northern terrestrial regions on Earth are also feared to be sources of the greenhouse gas methane – those regions in North America or Siberia where the ground is permanently frozen. Permafrost regions store
large quantities of carbon in organic matter, just like wetlands; they are deep-frozen swamps, as it were. If the ground thaws there, the accumulated carbon could be released rapidly. Additional quantities of methane and carbon dioxide would get into the atmosphere and aggravate the warming effect. Climate researchers have therefore long been asking themselves how the permafrost will react to global warming – where, how rapidly, and to what depth the ground will thaw.

However, these questions aren’t so easy to answer, because the hydrology of the permafrost is much more complicated than that of normal soil. This is due to the thin, active layer that thaws in summer and then lies on top of the largely water-impermeable frozen layer. The top layer is often quite swampy, even in areas of low precipitation. Only extremely small quantities of water run off in winter, but in spring, during snowmelt, there is significantly greater runoff.

Since the melt water can’t penetrate very deeply into the ground, it runs off much more rapidly than at moderate latitudes. In addition, meter-high ice wedges often form in permafrost soils, which can suddenly collapse after heavy rain, for example. This gives rise to so-called thermokarst lakes, which, in turn, aggravate the soil erosion.

**THE SOIL ACTS LIKE A MEMORY**

As comparative tests show, the current Earth system models still fail to correctly reproduce the specific hydrological behavior of permafrost soils in today’s climate. “Most Earth system models don’t take into account even the simplest processes that take place in the permafrost, such as the freezing or thawing of the soil water,” criticizes Stefan Hagemann. His group wants to change this: the researchers are involved in the PAGE21 EU project, which is investigating the vulnerability of the permafrost regions due to climate change.
Tanja Blome is currently working on the hydrological processes typical of permafrost areas. During this project, she is cooperating closely with colleagues from the Max Planck Institute for Biogeochemistry in Jena, who have incorporated these processes into the Max Planck land surface model JSBACH in order to simulate the methane production of the permafrost soils more reliably.

Be it in permafrost soils, in wetlands or in the artificially irrigated agricultural landscapes of the Indian subcontinent, the water balance on land, and thus the soil moisture, can play a key role regionally in medium-term forecasts. Stefan Hagemann’s group is therefore also working in the BMBF project known as MiKlip (medium-term climate forecasts). This involves improving climate forecasts for the next years through to the next decade.

A detailed understanding of the hydrological processes on land could help here: since the soil can store water for a long time, it acts like a memory. A dry period or a flood can affect temperatures and precipitation for months. How strongly plants grow and how much water they release from their pores also depends on the soil moisture.

To date, soil moisture has gone into the Earth system model of the Max Planck Institute for Meteorology only in a greatly simplified form: “The soil was represented as a single layer,” reports Hagemann. Model plants and evaporation gradually extracted the rain water from the soil. During dry pe-
Gigantic amounts of moisture are constantly being moved between land, oceans, atmosphere and cryosphere – as much as if the total water in the atmosphere were exchanged 40 times per year. The water cycle on land is closely coupled with the regional and global climate.

As simulations done by the researchers at the Max Planck Institute for Meteorology show, the massive extent of irrigation on the Indian subcontinent causes it to be less hot and dry in the region than in a climate without irrigation. Global warming could reduce the amount of water available for this process.

Whether wetlands release carbon dioxide or methane depends on the water level in the ecosystems. Simulations of the water balance of swamps, moors, river meadows and marshlands thus help provide a more accurate determination of their role in the climate system.

Forecasts of whether permafrost soils release more greenhouse gases during climate change also require knowledge of the water balance in these regions. The reason is that the soils that have so far been frozen all year round could emit more carbon dioxide and methane the more they thaw.

TO THE POINT

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The Art and Artists of Numbers

For many, mathematics is nothing more than an accumulation of abstract formulas and dry recipes for calculating. Not so for Friedrich Hirzebruch, Founding Director of the Max Planck Institute for Mathematics in Bonn, Germany. He had already succumbed to the beauty of the subject in his youth. As the "doyen of German post-war mathematics," Hirzebruch made this city on the Rhine an attractor for researchers the world over.

TEXT ELKE MAIER

"In principle, the functioning of a mathematical institute is extremely simple," wrote the Dutch mathematician Hendrik W. Lenstra Jr. in 1984: "A large stack of paper, blank on both sides, goes in the front. A specialized staff of typists, university lecturers and exercise group leaders have the task of making all of the sheets unusable on one side. The stock of paper processed in this manner is then distributed equally among the mailboxes of the mathematicians, who then have a go at the other side. The paper, now completely unusable, leaves the building at the rear."

The Max Planck Institute for Mathematics is accommodated in an historic palace in the center of Bonn, just a five-minute stroll from the main train station. The scientists here still like to work with paper and pencil even today, mostly by themselves in their offices. However, promptly at 4 p.m. each day, they leave their desks in order to meet for a traditional cup of tea and chat about mathematical problems. The originator of this social ritual was Friedrich Hirzebruch. With his persistent effort to promote scientific exchange, he instituted not only the tea tradition, but also the institute itself.

Friedrich Hirzebruch was born October 17, 1927 in Hamm, in the German province of Westphalia. As the son of a mathematics teacher, he came into contact with the world of numbers very early. At age 9, he was already concerning himself with the question of why the square root of two is an irrational number. At 16, Hirzebruch was drafted into the Air Force auxiliary. While he kept a lookout for enemy aircraft in the sky above, he observed spherical triangles in the nocturnal firmament and other figures in the stars, and performed calculations in his head about their geometry. He used his time in an Allied prisoner of war camp to derive mathematical proofs – on toilet paper.

After the war ended, Hirzebruch was ordered to a work detail in a British barracks. Shortly thereafter, he was released: "A British officer who spoke fluent German spoke with me about my intention to study at university and was so taken with the idea that he declared my work time over, brought me home in his Jeep and encouraged me to do nothing other than mathematics ...," he recalled later.

Following this good advice, Friedrich Hirzebruch began his university studies in mathematics in Munster, Germany, in December 1945. There, he made the acquaintance of Heinrich Behnke, who introduced him to complex analysis and geometry. Another influential instructor was Heinz Hopf from ETH Zurich, from whom he got to know topology. This discipline is concerned with the particular properties of geometric shapes that remain invariant under transformation – for instance, the surface area of a cube made of modeling clay that can very easily be transformed into a sphere.

In 1950, Hirzebruch eventually received his doctoral degree with his dissertation on four-dimensional Riemann surfaces. The brilliant mathematician Bernhard Riemann had founded an entire branch of geometry in the 19th century. Up until then, the 2,000-year-old teachings of Euclid were customary. However, these teachings are inadequate when curved objects, such as bent surfaces, are involved.

Riemann was the first to learn how the angles, lengths, intervals and volumes of spaces in any dimension whatsoever can be determined. That became the framework for the theory of rel-

Science on the blackboard: In his lectures, Friedrich Hirzebruch knew how to instill his fascination with mathematics in his listeners.
At the harbor by Donald Spencer on August 18, 1952. He was to work closely with him at Princeton over the coming two years, as well as with the other eminent mathematical authorities Armand Borel and Kunihiko Kodaira, who would be awarded the Fields Medal a short time later.

The atmosphere at the institute captivated Hirzebruch right from the beginning. Spencer, Borel and Kodaira introduced him to methods that were as yet unknown in Germany, and that had experienced as a forge for new ideas and was a magnet for the international research elite. While the sciences lay fallow in Germany after the war, Albert Einstein and logician Kurt Gödel, as well as respected German mathematician Hermann Weyl, who had emigrated to the US in 1933, were all there.

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A Prize That Benefits Young Scientific Researchers

Max Planck Society doubles the award money to provide scholarships to 15 Spanish scientists

At a festive gala in Oviedo, Spain, the Max Planck Society received the Prince of Asturias Award for International Co-operation and sent a clear signal in support of science in the light of austerity measures in Spain.

Do you know Oviedo? The capital of Asturias is not one of the “hot spots” for travellers in Spain, although it has a few UNESCO World Cultural Heritage monuments. But once a year, in October, international attention is focused on Oviedo – when the Prince of Asturias Awards are presented by the Spanish Crown Prince. Outside the entrance of the venerable Hotel de La Reconquista – the building dates from the 18th century – a “red” carpet is rolled out for the winners. In this case, the red carpet is actually blue, the color of the Prince of Asturias Foundation. The Director of the Foundation welcomes each prize-winner in person, to the sounds of traditional bagpipe music. The reception is followed by a press conference.

The Max Planck President is at the center of a flurry of photographers’ flashlights – and with him the four young researchers Ali Shahmoradi, Soojin Ryu, Damian Refojo and Matthias Weißenbacher, who accompanied the President on his journey as representatives for the approximately 400 junior scientists within the Max Planck Society.

At the press conference, the President called for more political commitment to research. In numerous letters, Spanish colleagues had asked Peter Gruss to champion basic research during his visit. “La Max Planck dedicará el premio a enlazar con Investigadores españoles” was the headline of the local newspaper La NUEVA ESPAÑA on the following day, emphasizing the Max Planck Society’s dedication to fostering young researchers. The Max Planck Society has doubled the prize money from its own resources to provide 15 young Spanish doctoral students and postdocs with the opportunity to spend a research residency at a Max Planck Institute.

The roundtable discussion that took place in the evening in Gijon with the CEO of ThyssenKrupp Elevator, Ramón Sotomayor, also focused on the next generation of scientists, in the light of the alarmingly high youth unemployment in Spain. The discussions were held in the buildings of the University of Oviedo, which was founded in Spain 1608 and is thus the third oldest university in Spain. Currently with 30,000 students, it is the scientific and cultural center of Asturias. Under the headline “En defensa del talento,” the Spanish regional newspaper El COMERCIO quoted Peter Gruss’s statement that Spain should keep its talents in the country.

In any case, the media coverage surrounding the award ceremony was huge. The local newspapers printed extensive supplements in which they reported in detail on the individual winners of this year, including U.S. star photographer Annie Leibovitz, Oscar-
winning Austrian filmmaker Michael Haneke and Nobel Prize winners Peter Higgs and François Englert. The Max Planck Society was also presented with its “Images of Science” exhibition. The pictures were prominently displayed alongside the path through the city’s park – everyone making their way to the Teatro Campoamor, the venue of the award ceremony, walked past it. Thousands of people lined the streets to watch the motorcade of the Queen of Spain, the Crown Prince and the Crown Princess, as well as the winners, making their way to the theater.

The actual award ceremony, attended by 2,000 guests, made it to the front page of El País. And by that time, at the latest, it became clear why the Prince of Asturias Award is also called the “Spanish Nobel Prize.” The ceremony is as impressive as that presided over by the Swedish Royal Family during the Nobel Prize ceremony.

Before the presentation of the Prince of Asturias Awards, there is a Cultural Week, where the prize winners – artists, scientists, charities and athletes – take some time out to attend readings or exhibitions.

“During those five days, I was most amazed by how genuinely warm and friendly the people of Oviedo and the prize-winners were,” says Ali Shahmoradi, Ph.D. student from Göttingen. With three fellow junior scientists, he was directly involved in the proceedings. “At a panel discussion with the Spanish Max Planck Director Ignacio Cirac, we presented the Max Planck Society and answered questions about our institutes and the application procedures.”

The program wasn’t only about recreation, of course. Together with three junior scientists from Spain, Austria and South Korea, Ali was directly involved in the official events of “Award Week” – a week of cultural activities preceding the presentation of the Prince of Asturias award – for example, during a panel debate with students in the crowded auditorium of Oviedo University.

Since everyone stayed at the same hotel, not only did Ali meet the Crown Prince at the reception, but he also spotted him when “he cheerfully paced through the halls.” It was practically impossible not to come into contact with him or the other laureates. Other celebrities were also relaxed. “On a hike in the mountains of Asturias, we talked to Michael Hanecke about the film industry, and Peter Higgs even had a few minutes’ time for a chat at the conveyor belt of the airport baggage claim.” The highlight, however, was no doubt the awards ceremony. “Every time I am asked what I liked best, I think, Ali says. “But to walk into the Teatro while traditional Asturian music was playing in the background was sure-ly one of the highlights.”

Maybe it was also the morning after the gala, when the Max Planck researchers had gotten comfortable in the hotel lobby. Early bird and star photographer Annie Leibovitz asked them, quite surprised: “Wow, did you guys work through the night?” “That’s just how it is in the Max Planck Society,” Ali replied.

Culture Fair

Young Max Planck researchers at the “Cultural Week” in Oviedo, the capital of Asturias

Fascinated by research: In connection with the presentation of the Prince of Asturias Award, the Max Planck “Images of Sciences” exhibition was displayed in the inner city of Oviedo. The most striking images by Max Planck scientists were presented in large copper frames.
The Future on the Big Screen

Doctoral students and professors “slam” and debate at the 2nd Visions in Science conference

This interdisciplinary science event, organized by members of PhDnet, showed that the next generation of scientists produce ideas far beyond the topics of their own doctoral theses. This year, the presentations were more engaging than ever.

Explaining my research – in an exciting way in five minutes. That may seem a difficult challenge, but not to the eleven “science slammers” at the 2013 Visions in Science conference in Dresden. Armed with a watering can, chalk and rap lyrics, they battled for triumph. The audience – more than 70 doctoral students – generously rewarded not only the props but also the technical glitches with thunderous applause, especially in the case of winner Dong-Seon Chang. He gave a very impressive presentation of his thesis topic: willingness to cooperate. But it was the lack of cooperativeness on the part of his computer that forced him to reboot three times – and that made the crowd go wild.

His equally talented fellow competitors also benefited from the great atmosphere at the “slam”; for example, Shradha Das, who secured second place with her rap song about molecules involved in tissue formation. Physics student Filippo Guarnieri, who came in third place, chose to insert a written disclaimer in his presentation: “No cats or god particles were harmed during the making of this science slam.”

Quite apart from the care taken not to harm cats or god particles, the central discussion topic at Visions in Science was whether such laid-back scientific presentations actually work. The organizers Dong-Seon Chang (MPI for Biological Cybernetics, Tübingen), Ilka Vosteen (MPI for Chemical Ecology, Jena) and Sabine Keiber (MPI of Quantum Optics, Garching), as well as team leader Norman Gerstner (MPI of Molecular Cell Biology and Genetics, Dresden), are now convinced that the Science Slam complements the main program nicely.

The program involved renowned scientists offering prospects in their respective fields. This year, Dirk Helbing, Thomas Hamacher and Anja Feldmann talked about the

Winner and co-organizer of the Science Slam Dong-Seon Chang.
role of networks in economics, energy supply and digital communication. Environmental scientists Felix Eckardt and Victor Smetacek, as well as neuroscientist Rainer Goebel, testified to the ever-increasing interest in sustainable solutions in environmental and medical science.

“Besides the talks, I particularly enjoyed the panel discussions, in which interdisciplinary cooperation in science and industry was debated,” said Ph.D. student Daniela Popescu. Another highlight was the talk by Max Planck Director Reinhard Jahn and his account of the work of the Presidential Committee on “next-generation scientists.”

Since the first conference in 2012, Visions in Science has gained impetus, notably thanks to funding by the MPG and the steadily growing support from sponsors including BASF, McKinsey, Lanxess and TÜV Süd. “If next year's conference can maintain the same degree of professionalism, it will establish itself as a recurring event,” said Daniel Kalthoff, former PhDnet spokesperson. To ensure that this is indeed the case, the organizational team for the third conference is already in place. Recordings from the second conference – Science Slam, talks and panel debates – are available online at maxNet.tv and YouTube.
Ahmed El Hady, a postdoc from Egypt, speaks about the period of transition in his homeland and says that the Arab Spring must not give way to a new winter.

Change through Education

Ahmed El Hady, a postdoc from Egypt, speaks about the period of transition in his homeland and says that the Arab Spring must not give way to a new winter.

“If I had the opportunity to carry out research at home in experimental neurosciences, I would do so immediately,” says Ahmed El Hady. “But this is still a daydream.” Germany has been the scientist’s home for the past six years: initially as one of the doctoral students at the MPI for Dynamics and Self-Organization who moved directly on to doctoral studies from a bachelor’s degree, without completing a master’s degree.

In the meantime, this phase of his life has come to a close and Ahmed is now furthering his knowledge as a postdoc at the same institute. “It was a friend and Max Planck alumnus in Egypt who suggested that the MPI in Göttingen could be the right place for me – and my subsequent application for an IMPRS grant was successful,” says Ahmed. Something he found particularly appealing was the scientific freedom offered by the institute to carry out experiments for the purposes of proving theoretical principles of neuroscientific research. Ahmed is also grateful for the facilities and the comparatively low teaching commitment. For many researchers around the world, such privileges are still a distant reality, including in Ahmed’s native Egypt.

Like many young people, Ahmed had a primary concern in Egypt: “Since 2001, I thought a lot as a student about the problems with the strict security system. But political activities at the university were, of course, strictly prohibited in the Mubarak regime.” Nevertheless, in 2004, Ahmed and some other students founded a “Pugwash” for young Egyptian students.

Inspiration for the idea came from the fishing village of the same name in Nova Scotia, Canada, where scientists and intellectuals met and drafted a declaration against nuclear energy in 1957; the resulting international “Pugwash” groups won the Nobel Peace Prize in 1995. “Our main concern is the Middle East – in particular its security policy and how it affects Egypt. I also raised issues that were rather unconventional to date, such as equality between men and women, but also the security risks arising from modern warfare technologies,” says Ahmed. Although his political work underwent setbacks, it may well have been the small seed that would bear fruit much later, long after Ahmed left Egypt for Germany.

From January 2011, Ahmed followed the events surrounding the Egyptian revolution from Germany. For him, it was a time of “elation, inspiration, and yes: for the first time in my life, I was proud of my country.” From colleagues at the institute to his family in Cairo – once the discussion had started, nothing could stop it. “In this difficult and emotional time, I received tremendous support here in Germany, primarily from the institute. I even managed to be at Tahrir Square a few times during my visits to Cairo.”

From Göttingen, Ahmed is also following the ongoing transformation of the political landscape. To “meet the objectives of the revolutionary movement with freedom, transparency and equality,” the education system also has to change. “We need an education system that helps future generations to be more critical and more informed. I hope that this will be the case some day, and I would love to play my part in this.”
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