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Max Planck RESEARCH

The Science Magazine of the Max Planck Society 3.2019

Freedom

ECONOMIC POLICY
On the urge to regulate freedom

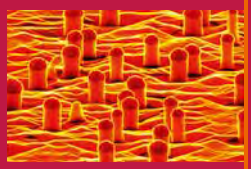
GAIA MISSION
Inventory of the Universe

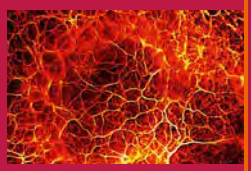
VIRUSES
Tiny giants

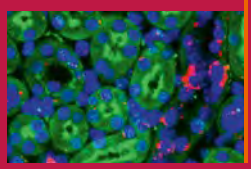
METHANE DEGRADATION
Partners in the deep

Max-Planck-**Innovation**

Connecting **Science and Business.**







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 inter-disciplinary 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.

Connecting Science and Business

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In full swing

Up, down, backwards, forwards, upside down, the right way up – with seven independently controllable swivel joints, a twelve-meter linear axis and a cabin that can rotate 360 degrees while being maneuvered in six different directions, the CyberMotion Simulator (CMS) in Tuebingen offers an almost infinite range of possibilities for motion simulation. Although you wouldn't be blamed for thinking it, the purpose of this worldwide unique instrument is not to serve the development of the latest attraction at the Oktoberfest in Munich. Instead, the research team led by Heinrich Bülthoff at the Max Planck Institute for Biological Cybernetics is using it to investigate the complex interactions between vision and balance in the human brain.

Constructed on the basis of an industrial robot arm, the CMS can move test subjects in almost every position imaginable. The person in the cabin can be guided passively along predefined tracks or control the motion themselves using a steering wheel or joystick. Even real helicopter flights can be simulated. The large, high-resolution display on the interior wall of the cabin provides the appropriate virtual reality scenario.

The scientists are particularly interested in the possibility of individually stimulating each of the sensory organs responsible for spatial orientation. In this way, they can for example investigate what causes the dizziness that not seldom occurs when people are moving in virtual spaces, for example when playing computer games that require VR glasses. This is also highly significant for the development of autonomous vehicles. By the time that passengers have developed enough trust in the self-driving car to occupy themselves with completely different activities during the journey, their physical self-awareness will not coincide with the information delivered by the eyes to the cerebral cortex in the brain. And quite a few people react to this with nausea.

Photo: Berthold Steinhilber/MPI for Biological Cybernetics

18 FREEDOM

ON THE COVER Freedom is a fundamental requirement for academic work. That's the reason why it is an area of interest for all fields of research. In the fields of legal, social and historical studies in particular, freedom is also a topic of research. Academics examine the development of academic freedom and query the status of judicial independence or how people experienced the transition in the GDR to a liberal, western system.

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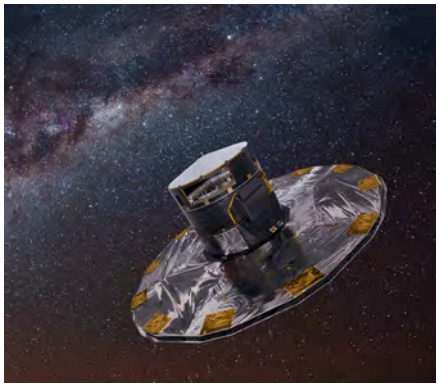
Internet users demonstrate against losing access to online content.

Cover: Alessandro Gottardo; photo and illustration on this page: Alessandro Gottardo (big picture), dpa/picture-alliance/xim.gs



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a space telescope focuses on the stars of our galaxy.

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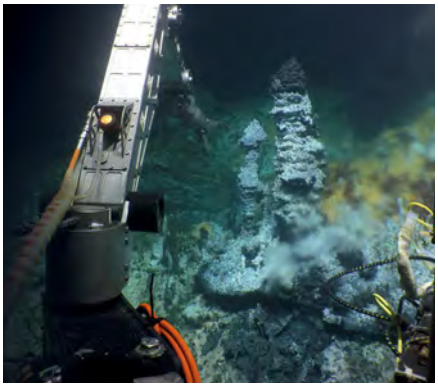

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SPECTRUM

PHYSICS & ASTRONOMY

BIOLOGY & MEDICINE

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ENVIRONMENT & CLIMATE

REGULAR FEATURES

Plenary Assembly with a European theme

The Max Planck Society came together in Hamburg to mark its 70th anniversary

"The European Research Area is a beacon of hope for the future," said Martin Stratmann in his closing speech at the 70th Annual Meeting in Hamburg at the end of June. Helping to shape this community of responsibility was, he said, a central task of the Max Planck Society. For example, Stratmann champions the Dioscuri program, which was launched in 2018 with the aim of establishing scientific lighthouses in Central, Eastern and Southern Europe. The talk by Kiran Klaus Patel, a historian at the University of Maastricht, centered around lessons learned from the history of European integration.

At the start of the Annual Meeting, the Wissenschaftspreis des Stifterverbands (Science Award of the Donors' Association) was awarded to Wolfgang Baumeister, Director at the Max Planck Institute of Biochemistry. Baumeister received this 50,000 prize for developing the technique of cryo-electron tomography. A total of 32 junior scientists also received prizes, including the Otto Hahn Medal, which is awarded in recognition of outstanding doctoral theses.

Plenary Assembly at the Fish Auction Hall in Altona: having just been confirmed for a new term of office, Max Planck President Martin Stratmann called for a strengthening of the European Research Area.

Max Planck President to continue in his post

At its session at the Annual Meeting, the Senate of the Max Planck Society confirmed Martin Stratmann as head of the Max Planck Society. "The office of President is a fantastic opportunity to shape the Max Planck Society in collaboration with its governing bodies. And the next few years will be a particularly exciting time," said Stratmann with regard to his second term in office, which will begin in June 2020.

Growth in Bochum and Konstanz

With two new additions, the number of Max Planck Institutes grows to 86

By May 2019, everything was in place: the Joint Science Conference (GWK) of the federal administration and its federal states gave the green light for the establishment of two new Max Planck Institutes in the fields of "Cyber Security and Privacy" and "Animal Behavior". The Max Planck Institute for Cyber Security and Privacy in Bochum will focus on the growing challenges in relation to data protection and already has two founding Directors: Gilles Barthe, who previously conducted research at the Institute for Advanced Studies in Software Development Technologies in Madrid, and Christof Paar, a Professor at the Ruhr-University Bochum. The second new Institute to be established, the Max Planck Institute of Animal Behavior, emerged from a part of the Max Planck Institute for Ornithology that was formerly based in Radolfzell. In addition to the existing Departments led by Directors Martin Wikelski and Iain Couzin, Margaret Crofoot from the University of California, Davis, is also coming on board as a Director. Established in Konstanz, the new Institute will form part of a world-leading interdisciplinary research association that uses the latest technologies to investigate the group behavior of various species of animals.

Photo: David Ausserhofer

"The telescope offers enormous potential"

Peter Predehl from the Max Planck Institute for Extraterrestrial Physics on the *eRosita* mission

The largest joint German-Russian project in the field of science to date was launched from Baikonur on 13th July, when a rocket carried the Spektrum-RG observatory into space. The platform is equipped with two X-ray telescopes, one of which is *eRosita*. Developed under the leadership of the Max Planck Institute for Extraterrestrial Physics, this is intended to survey the entire sky in previously unattained spectral and spatial resolution. We spoke with Peter Predehl, the scientific Director of *eRosita*, about the mission.

Mr. Predehl, what's so special about eRosita?
Peter Predehl: First, our telescope will scan the entire sky in X-ray light without focusing on individual sources. An "all-sky survey" of this kind offers huge potential for discovery, because you're not searching for a specific object but rather keeping an eye out for something new and unexpected. Second, *eRosita* has an unlimited field of view and can therefore observe even very large X-ray sources extending over a large area on the sky. These include supernova remnants – that is, the ejected gas shells of exploded stars.

What are the goals of the mission?
Simulations have shown that with *eRosita*, we'll observe around 100,000 galaxy clusters. Investigating these, the largest structures in space, is our primary goal. A cluster of this kind contains up to several thousand galaxies – Milky Way systems like ours – that are bound to one another by gravity. In X-ray light, these galaxy clusters appear as compact objects. However, rather than measuring the light from individual galaxies, we measure the radiation emitted by the gas between them. This radiation surrounds the galaxies like a cocoon. All in all, galaxy clusters form a large-scale structure that resembles a cosmic web. By observing the galaxy clusters, we are pushing ahead in the field of cosmology.

What do you mean by that exactly?
The galaxy clusters reflect the distribution of matter in the universe. They form the threads and nodes of the cosmic web, between which there are huge voids containing virtually no matter. Space has evolved since the time of the Big Bang. With *eRosita*, we can see great distances as well as looking back in time, because the light from distant objects takes a long time to reach us. Imagine we're observing a galaxy cluster in X-ray light. We already know the direction and the brightness. If we measure the distance by making follow-up observations with optical telescopes, we can finally determine the mass. We therefore know what specific density the universe had at a certain time. From a large number of these measurements, we can ultimately derive a range of cosmological parameters.

Can you also find out anything about the expansion of space?
Yes, because space is expanding at an accelerated rate. The reason for this appears to be dark energy. We're therefore dealing with a hot topic in current research. I'm not saying we're going to solve the mystery of this dark energy. But we're at least on the right track.

And is dark matter also an issue for eRosita?
As I already mentioned, there are large quantities of hot gas between the galaxies in a cluster. This intergalactic plasma collected inside a gravitational well, which was probably generated by dark matter. It's interesting to follow how galaxy clusters have evolved under the influence of dark matter and over time.

Why will eRosita not follow an orbit around Earth but rather be stationed far away in space?
There are three main reasons for this: at a location around libration or Lagrange point 2, which is about 1.5 million kilometers from Earth, our planet doesn't get in the way. There's also a constant temperature out there because the instruments are not exposed to the perpetual cycle of day and night. Thirdly, the location allows constant observation of the sky.

What was it like to work with the Russian colleagues?

Peter Predehl

At the working level, this was generally not a problem. Of course, there are always some conflicts in collaborations. That's only normal. But we also had a lot of learning to do, because the Russians follow slightly different procedures in a space project than those of western agencies such as ESA or NASA.

Were you nervous before the launch?
No. I wouldn't say nervous. I was tense, if anything. But we'd done everything that had to be done. And I was well aware that if the launch went wrong, the telescope was gone. There was no plan B. Incidentally, we've been working on the project for ten years, which is a reasonable length of time for a mission of this magnitude.

When did you get the first results?
About three months after launch, *eRosita* arrived at the Lagrange point 2 and entered an elliptical orbit with a semimajor axis of up to 800,000 kilometers. In October the telescope entered into full science observations with all even modules and we obtained the first images.

Interview: Helmut Hornung

Photo: MPI for Extraterrestrial Physics

Top women scientists

First Lise Meitner Group Leaders selected

Whether it's astrophysical spectroscopy, neuroplasticity or pan-African evolution: however diverse the research fields of the first Lise Meitner Group Leaders may be, these women have one thing in common – like the program's namesake, they are some of the most exceptional talents in a world often dominated by men. As part of the Lise Meitner Excellence Program, launched by the Max Planck Society in 2018, twelve female junior researchers have now been appointed as Group Leaders at a Max Planck Institute. The aim of the program is to identify highly motivated and committed female scientists in the breakthrough phase of their career. They are then given the opportunity to train for leadership positions in science and in particular at the Max Planck Society.

Almost 300 candidates from 42 countries applied for group leadership positions. The twelve successful applicants were chosen primarily based on their impressive research accomplishments to date and evidence of strong potential. Nine of them have since accepted their appointments.

https://www.mpg.de/lise-meitner-excellence-program

Flight simulation for flying disks

Max Planck Society congratulates "Jugend forscht" prizewinner in the physics category

At the 54th nationwide final of the "Jugend forscht" competition for young researchers in Chemnitz, Nils Wagner won the jury over with his creative approach and methodological breadth to scoop first place in the physics category. In his project, the 20-year-old, who is studying at the Technical University of Munich, worked on a special type of projectile: the X-Zylo is a thin-walled, hollow cylinder that is thrown like a football and can fly in an astonishingly straight line. To understand this behavior in greater detail, Wagner wrote a computer program that can simulate the X-Zylo's trajectory. He then verified the results in experiments using a self-built, catapult-like firing mechanism. The result: the calculated and actual trajectories were very similar, even though the software didn't yet take account of all of the factors affecting the projectile's flight.

The Max Planck Society was also delighted at the young researcher's success: since 2012, it has been sponsoring the prizes in the physics category of "Jugend forscht". The award was presented by Jan-Michael Rost from the Max Planck Institute for the Physics of Complex Systems.

Cause for celebration in Chemnitz: Nils Wagner (left), winner of the 2019 national competition in the category of physics, with Max Planck Director Jan-Michael Rost.

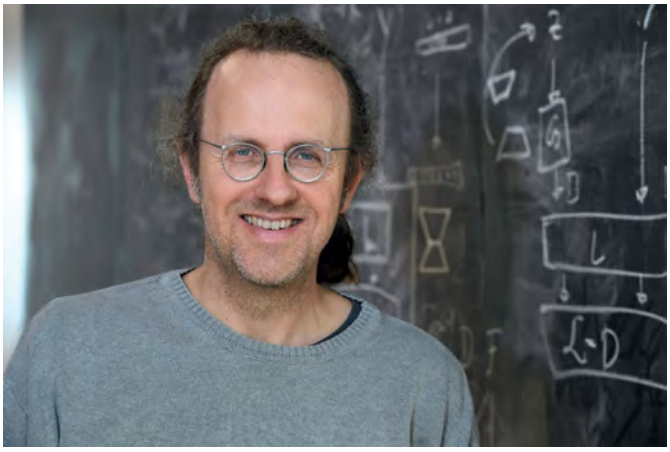
Photos: Jugend forscht (below); MPG (above)

A prize for the pioneer of Artificial Intelligence

Max Planck Director Bernhard Schölkopf receives the Körber Prize 2019

His mathematical methods have played a key role in the latest triumphs in the development of artificial intelligence (AI). In recognition of these pioneering achievements, Bernhard Schölkopf, Director at the Max Planck Institute for Intelligent Systems in Tuebingen, has now received the Körber European Science Prize – which, with prize money of 1 million, is one of the world's most valuable research prizes.

"AI is at work when a smartphone automatically groups stored photos according to faces and topics such as vacations," explains the physicist, mathematician and computer scientist. "Or when it translates texts from one language into another." Together with his team, Schölkopf researches algorithms that allow computer programs to react flexibly to situations – in driverless cars, for example. "If, in a built-up area, a 30 km/h speed limit sign has been pasted over in such a way that it looks like a 120 km/h sign, then the AI system of a driverless car must be able to infer from the context that this sign is to be ignored," says Schölkopf. He has established key methods for machine learning whose applications are beneficial to the worlds of biology, medicine, economics and social sciences as well as many other fields. Schölkopf is also a co-founder of the Stuttgart/Tuebingen region's "Cyber Valley", an association of academic and industrial research facilities that is funded by the state of Baden-Wuerttemberg. The association aims to help Germany take a leading international role in the field of AI.



Providing computers with flexibility: Bernhard Schölkopf, Director at the Max Planck Institute for Intelligent Systems and winner of the Körber Prize 2019.

Photo: David Ausserhofer

On the net

MRI of a French horn quartet
Strange sounds in the laboratory: in July, the professional musicians of german hornsound visited the Max Planck Institute for Biophysical Chemistry to be filmed – while playing the horn – using real-time magnetic resonance imaging (MRI). With their performances, the horn players lent a helping hand to a project by Jens Frahm, who is conducting research into a treatment for focal dystonia. This occupational illness leads to cramps in the tongue and lips, to the extent that brass-band musicians can no longer play their instruments with the same virtuosity. You can find a video and further information on this topic at
https://www.mpibpc.mpg.de/hornists-in-real-time-MRI

Prestigious prize for two US researchers
This year's Max Planck-Humboldt Research Award 2019 goes to Ufuk Akcigit, Professor of Economics at the University of Chicago. The economist is recognized for his outstanding achievements in the field of macroeconomics. During his research stay in Germany he will use the prize money of 1.5 million euros to investigate an issue that continues why there still is an economic gap between East and West Germany. The Max Planck-Humboldt Research Medal 2019 is awarded to Professor Elliot M. Tucker-Drob from the University of Austin Texas for his research into life span development.
https://youtu.be/IO5YMDBUpKY
https://youtu.be/lXct9odnt_M

The variety of life
Almost everywhere on Earth, we're witnessing a decline not only in biodiversity but also in the abundance of organisms. This special topic on the Max Planck website clearly shows how dramatically this decline is affecting populations worldwide, why biological diversity is important, and why high biodiversity has a positive effect not only on agriculture but also on global climate.
https://www.mpg.de/biodiversity

On the urge **to regulate freedom**

Digitization is transforming the economy, society, and every individual's life. With it, the need is growing for clear legal framework conditions. These should leave sufficient freedom for the data economy, while preventing too much market power from being concentrated in a single place. Our authors examine the ways in which politics have approached these challenges in the recent past. They also warn against protectionist regulation and rushed decisions – not only in the digital sphere.

TEXT **RETO M. HILTY** AND **HEIKO RICHTER**

The German Basic Law entered into force in the night of May 23rd to 24th, 1949. This freedom-based system was the foundation on which a democratic and constitutional society formed in Germany, while a level of prosperity that was barely conceivable at the time emerged. The drafters of the Basic Law deliberately avoided defining a particular economic system. Nevertheless, the cornerstones of a liberal economic order were already laid: the right to own property, free choice of profession, and general freedom of action.

> The weathervane of economic policy is turning in the wind of national phantasms

Now, 70 years later, a market-based system seems like a matter of course, especially since this was agreed upon by the European Economic Community that was established in 1957. The development of a "common market" is in turn based on the principles of freedom of movement for people, goods, services, and capital. What began with the Franco-German reconciliation has meanwhile culminated in the form of a single market that is available to half a billion people. This European market is driven by the principle of competition. Its functionality is guaranteed through protection against distortions of competition. It is through effective competition that market participants are constantly encouraged to create innovations, and which keeps providing new solutions to problems.

The specific design of a liberal economic system is, of course, a matter of controversy: what conditions are suitable for supporting innovative economic players? What degree of freedom do they need – and what role should the state play? Which aspects should a state focus on when designing market-relevant regulation? Questions like these are an ongoing theme of economic policy discussions. In the context of increasing digitization, however, they have become particularly acute issues. Why is it, for example, that Germany has recently dropped to rank 17 in the IMD World Competitiveness Ranking, and appears to be at risk of being left behind in the course of a global power shift? >

Photo: dpa/picture-alliance/xim.gs

Protests against the proposed Article 13 of the EU copyright reform took place across Europe in spring 2019. Legal scholars share the concern that the new regulation may lead to a general use of upload filters. The EU Parliament adopted the Directive nevertheless.

In the midst of the current global political climate there is a virulent risk of legislators trying to trace any failings back to simple causalities, and to "fix" supposedly undesirable developments through specific regulation. A better approach would be to focus on improving general conditions and thus to create open-ended incentives for investment. Instead, the weathervane of economic policy is increasingly being tuned by national phantasms, which disregard basic economic principles. A symptomatic example of this development is the German-French "Manifesto for Industrial Policy" and the "Industry Strategy 2030" issued by the German Minister of Economics Peter Altmaier in spring 2019.

The strategy paper propagates a more active federal industrial policy, designed to help German enterprises to compete successfully on a global level. The paper sets a target of 25 percent of German gross value creation to be reached by the industrial sector by 2030. To be able to compete on the world market, the strategy provides that particular industries and specifically also major German corporations should be strengthened. Furthermore, the paper recommends that a federal equity fund should be established in order to be able to prevent companies from being bought by non-European investors in certain important cases. These ideas were inspired by the proposed merger of rail assets of Siemens and Alstom that was prevented on grounds of competition law, and the successful takeover of the Augsburg-based robot manufacturer Kuka by the Chinese Midea group.

Structural change is being delayed to protect traditional business models

Unanimous criticism from the business world, which strongly opposed the suggestion, was not long in coming. Also, the Scientific Advisory Board of the Federal Ministry for Economic Affairs firmly rejected this approach. The ministerial perception that political decision-makers were more capable of predicting future developments than decentrally organized market actors was indeed disconcerting. Not only does this approach reveal the policymakers' lack of confidence in the fundamental principle that everybody will ultimately benefit from entrepreneurial freedom. It also questions a crucial determining factor for innovation: the decisive information required for mastering future challenges is provided by the market. This is why the active players on the market are much better equipped than the government to analyze the ongoing technological developments and to adequately address new demand.

By instead designating national champions and specifically directing the production of particular goods and services, the state encroaches on a sensitive core area of entrepreneurial decision-making. A similar route is taken when particular industries are promoted in order to supposedly catch up with the global market or to remove dependencies. The EU Commission and the Member States did just this in October 2017, by launching the so-called Battery Alliance, which plans to use considerable amounts of public funds to promote the development of a battery cell manufacturing industry for electric mobility. Industry consortia are to be subsidized with funds of the EU and the Member States. According to the French Minister for Economics, Le Maire, several billion euros are to be invested for this purpose over the next few years. Meanwhile, his counterpart from Berlin calls for one-third of the worldwide demand for batteries to be covered by European producers by 2030 (the current figure stands at around four percent).

However, the more long-term the strategic timeline for this type of development scenarios, the greater the risk of their failure. It is therefore quite justified that the EU Court of Auditors criticized the focus of the EU funding of the Battery Alliance mostly on existing (in particular lithium-ion batteries) rather than on innovative and pioneering technologies. Even at an early stage, according to the Court of Auditors, there are signs that the wrong route is being taken: the competitive disadvantage is not being reduced – quite the contrary, it is even being reinforced, as state intervention removes the pressure to provide real innovations. This gives rise to industries that are unable to survive upon expiration of the subsidies.

Naturally, this caution regarding state intervention does not mean that the state should not play a role at all. On the contrary, if business practices might cause harm to the society, there is a reason to draw

clear legal lines. It is among the state's core duties to decisively promote the public interest in such cases. Intervention designed to protect individual market actors against those trying to stimulate competition with innovative products, services, sales channels, and business models, on the other hand, is not part of the state's role. This necessary delineation is often overlooked, and as a result, innovative players are frequently presented with obstacles in the form of specific market regulations. This applies equally to pharmacies as to book retailing or the taxi business.

There are, of course, cases in which public welfare considerations justify specific regulation; for example, with respect to health protection, a diversity of opinions, or the establishment of ethical principles. It is alarming, however, if such reasons are merely a pretext for measures intended to safeguard traditional business models. In a global competitive environment, this approach will cause the affected industries to fall behind even more quickly. It would merely delay the structural change that is inevitably brought about by technological progress. This is why farsighted policies tend to focus on the exact opposite: on identifying necessary structural changes in good time and on creating the kind of room for maneuver that facilitates the steps that must be taken. At the same time, it is a central task of the state to provide a socially acceptable design for significant changes and to determine framework conditions that allow for the stakeholders' activities to also be beneficial to the general public in the long run.

A particularly complex task in this context is to draw up a "regulatory framework for the digital sphere". Policymakers must beware of hastily introduced and dysfunctional rules. The political approach to the data economy that has been pursued to date can on the whole be considered a positive example. Its origin was the idea that a kind of "data property right" had to be established. This discourse was initiated by legal scholars from Germany. The EU Commissioner Günther Oettinger promptly added the issue of data property to the Commission's agenda. The situation seems perfectly clear at first glance: companies should exchange and trade more data. This applies in particular to machine-generated data such as soil measurements taken by tractors while working the fields, information about traffic density gathered by moving vehicles, or real-time sensor data from industrial manufacturing. From an innovation policy point of view, it appears sensible to share data, as it can be used and recombined in many different ways. Modern methods for data analysis provide for new findings and are therefore beneficial to the most diverse areas of society.

It seems obvious to grant a data property right to whoever "produces" the data. However, such considerations do not withstand closer inspection. Rather than promoting exchange, property in data would make transactions more complicated. Third parties might be excluded from access, and dominant market positions might be reinforced; new legal uncertainties would occur. The EU Commission has carefully pieced together these interrelations. Based on a successful combination of analyses of real-life circumstances and theory, it was found that there is simply no need to establish a new exclusive right. The introduction of data property would therefore have become a battle with a hydra: rather than solving one supposed problem, it would have given rise to a multitude of new ones.

> Google has enough market power to enforce licenses being granted for free

To abandon the issue of data property was a daring step from a political point of view; however, it was a step that is likely to be forgotten much sooner than would a new regulation. Meanwhile, the path was paved for another, much more important debate: at its core is the availability of data as a decisive innovation factor. The central issue in this context, which needs to be addressed in view of macrosocial benefits, is who should be granted access to particular sets of data, for which purposes, and under which conditions. It should be considered a success that industry stakeholders, the academia and politics are cooperating in this matter in order to determine regulatory requirements and to avoid any rash legislative activism.

A very different approach was used in the most recent EU copyright reform. Across the European Union, people took to the streets to protest against

Photo: dpa/picture-alliance/xim.gs

the notorious "Article 13". These protests were based on the justified concern that the reform might give rise to a general use of upload filters on online platforms. Nevertheless, the EU has now formalized the rule as Article 17 of the new "Digital Single Market Directive". Another provision with far-reaching consequences was determined at the same time: ancillary copyright for press publishers is now to be established across Europe, aiming primarily at enabling publishers to participate in the profits generated by "news aggregators". Such services are designed to take users who are searching the Internet directly to the publishing websites via links. Along with these links, they post small extracts (snippets) of the articles in question, which are not protected by copyright. This is where the new ancillary copyright comes in, as it provides for this use of snippets to be subject to the respective press publisher's approval. From a superficial perspective, this arrangement may make sense. What is overlooked, however, is the central function of such aggregators: all in all, they direct far more users to the publishers' pages than could possibly be achieved by the publishers themselves.

The issue of the press publishing law was taken to EU level despite its obvious deficits

Nevertheless, German press publishers initially campaigned for this type of ancillary copyright on a national level. The legislature was promptly willing to support their case. As a result, ever since 2013, aggregators in Germany have needed a license to use snippets. Unfortunately, the biggest player was not taken into account. Google, the very stakeholder that the regulation was intended to hit the hardest, has sufficient market power to enforce that licenses are granted for free. Smaller – i.e. specialized national – aggregators find it almost impossible to follow suit. If they are unable or unwilling to pay, certain content may no longer be linked at all. This is detrimental not only to the affected publishers, but especially to users, as access to information is made significantly more complicated.

Despite its obvious deficits, the German press publishing law was never evaluated, contrary to the agreement included in the coalition contract that was in place at the time. Instead, the issue was addressed at the EU level. There is a particular reason why this approach is so alarming. Influential media companies have significant potential to exert pressure on political decision-makers. If politicians give in to such pressure, they do a disservice to the free democratic society. This causes a threat not only to entrepreneurial freedom, but in fact also to freedom of opinion.

This example ultimately illustrates that there are two sides to the issue of digital transformation: while digitization initially promotes the distribution of and access to information and thus also promotes free opinion forming, the essence of a liberal system is at risk of being undermined if market power, opinion-making power and political power coincide. Particular caution is necessary, especially with regard to the information markets, to ensure that a suitable economic regulatory framework is established with the help of competition law. It is for good reason that the EU Commission's Directorate-General for Competition is endowed with broad enforcement powers.

The responsible Commissioner, Margarethe Vestager, recently raised awareness of the important role of competition law, as record-level fines were imposed on Google: anybody who has enough market power to influence the rules of the market in their favor holds special responsibility to not abuse this power. This is particularly true for data-driven business models and value chains, as network effects and the de facto concentration of data held by individual players give rise to an increase in the risk of economic influence being exerted in the private sphere to an extent that is almost inconceivable at this point. What is currently primarily a cause of concern in relation to search engines, social networks, and trading platforms is increasingly expanding. In view of the great importance of the availability of data, there is an imminent threat of new concentrations of power and predominance forming in the field of technology, especially in the area of machine learning. The fact that the EU Commission and the German government are paying particular attention to such developments should be welcomed.

Photo: dpa/picture-alliance/xim.gs

Even beyond this particular problem, it is within the state's responsibility to provide for framework conditions that promote innovation. This includes – as pointed out by the Scientific Advisory Board of the Federal Ministry for Economic Affairs – an internationally competitive tax system, for example, but also sufficient availability of energy, venture capital, and most of all, human resources. The latter aspect is of greatest relevance to the education and research system. There is no easy solution to this issue. If the federal government announces, for example, that as part of the artificial intelligence (AI) strategy, 100 additional professorships will be awarded to allow for a broader-based anchoring of AI in the university landscape, this is going to raise fundamental questions about the attractiveness of Germany as a research location. Even filling the currently vacant positions is a challenge, as public institutions are facing fierce global competition from the private sector. Such planned economy targets attract attention, especially in a country in which just a few years ago, a wake-up call from the Federal Constitutional Court was required in order to increase basic W2 salaries that were so low that they violated the Basic Law. Would prospects of freedom not be a better way to attract the brightest minds to Germany, rather than setting target values?

The Basic Law, with its freedom-oriented emphasis, points the way in this respect, as does an integration of the EU Single Market based on fundamental freedoms. Compared to the conditions in 1949, it is a groundbreaking development that it now appears perfectly natural for France and Germany to join forces to think about such matters. It would not be expedient, however, if attempts to master digital challenges led to a foot race, or even to the coordination of short-sighted state interventions. Legislators should instead focus on establishing freedom-based framework conditions from which private-sector stakeholders will benefit. It goes without saying that there are limits, especially where central societal goals and moral concepts do not develop naturally on the breeding ground of freedom, but must be realized by the state as part of its fundamental duties. It would also be disadvantageous for politics to squander people's trust in the great benefits of individual freedom. Personal freedom is the best way to facilitate innovation and progress. After all, freedom ultimately serves the wellbeing of all people. ◀

ABOUT THE AUTHORS

Reto M. Hilty has been the Director of the Max Planck Institute for Innovation and Competition since 2002. He is also a full professor at the University of Zurich, and he teaches at Ludwig-Maximilians-Universität in Munich as an honorary professor. His areas of research include contract law, in particular for intellectual property, fundamental issues concerning new technologies and business models on intellectual property rights, and the European and international harmonization of intellectual property law.

Heiko Richter has been a research fellow at the Max Planck Institute for Innovation and Competition in Munich since 2015. He obtained his law degrees in Berlin and New York and a business administration degree in Mannheim. In his research, he focuses on competition law and copyright, in particular on arrangements for the data-driven economy and concerning the use of public-sector information.

Photos: MPI for Innovation and Competition

Living side by side with chimpanzees

Max Planck scientists travel to all the continents in the world to conduct research. Here they write about their personal experiences and impressions. Lou Marie Haux from the Max Planck Institute for Human Development in Berlin spent three months on Ngamba Island in Uganda studying the risk-taking behavior of chimpanzees. In this article, she reports on her behavioral studies, everyday life on a small island and her most cherished moments.

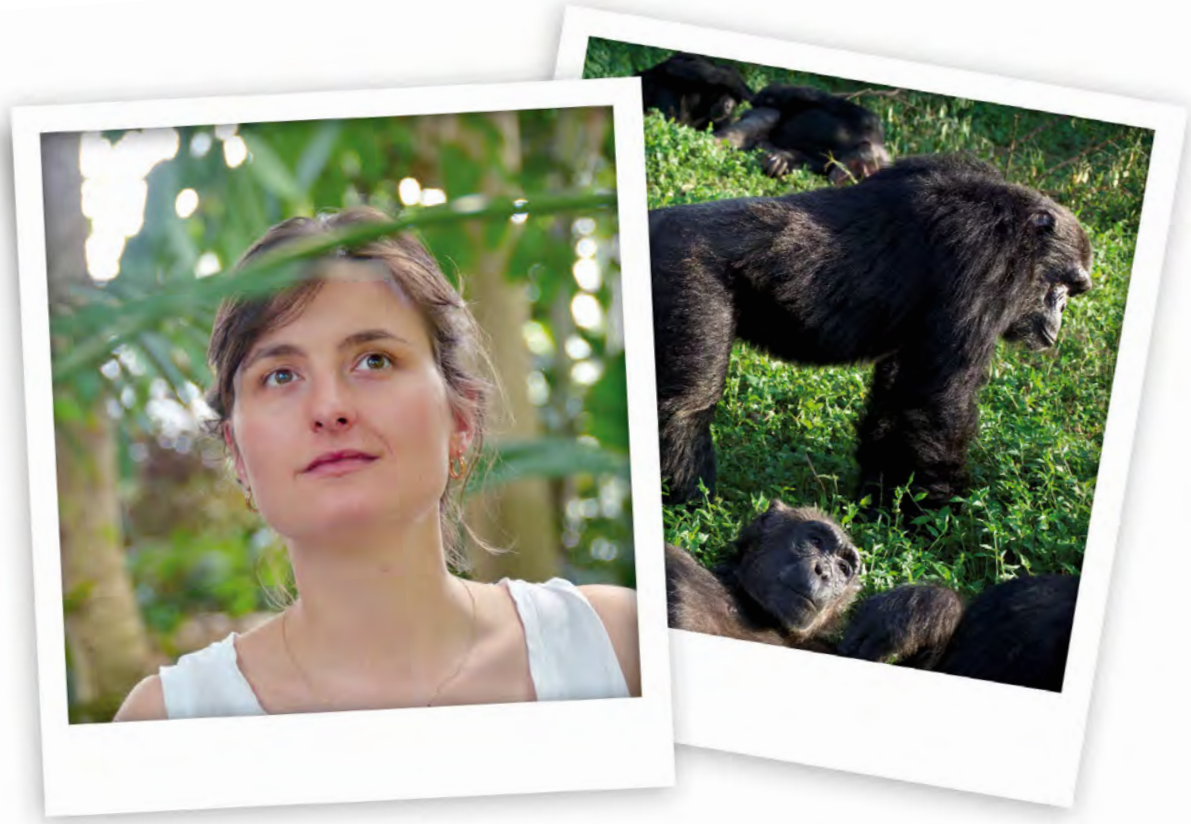
Ngamba Island is situated in the middle of Lake Victoria, and covers an area of around 40 hectares. It is accessible only by boat. The island has been home to a sanctuary for orphaned chimpanzees since 1998. Some of the animals were saved from the bushmeat trade and brought to the forested island. To reach the chimpanzees, I fly to Entebbe from Berlin. From there, a two-hour boat trip across Lake Victoria takes me to Ngamba Island.

Most of the island is inhabited by the chimpanzees – one of our closest living relatives. Apart from myself and my research colleague from Warwick University in England, there are a few animal caretakers and cooks on the island. Our accommodation is limited to eight small houses that are located directly next to the places where the chimpanzees sleep.

For the 49 chimpanzees, secure sleeping places and regular feeding times are necessary for survival, since the forest, which grows on most of the island, offers only enough food for a small number of chimpanzees. If they were to sleep in the forest, then it would be completely devastated within a very short space of time, since chimpanzees usually build a new nest to sleep in every night.

The chimpanzees dictate our daily rhythm. They are fed early in the morning, and are then most amenable for our behavioral studies. It is fascinating to watch how the animals think, reflect and make decisions. In one study, for example, the chimpanzees can either secure a peanut for themselves or take a risk; in so doing, they could double their win or end up empty-handed. I am main-

Graphic: iStockphoto



Lou Marie Haux, 30, studied psychology in Strasbourg, Magdeburg and Berlin. She wrote her bachelor and masters theses under Michael Tomasello at the Max Planck Institute for Evolutionary Anthropology. Since February 2018, she has been a doctoral student at the Max Planck Institute for Human Development, focusing on the evolutionary bases for human risk-taking behavior.

ly interested in whether the risk preferences of chimpanzees and humans differ, or where any common features can be observed. The goal of my research is to find out more about the evolutionary origins of human risk-taking behavior.

As soon as the studies have been completed, the chimpanzees fan out into the rainforest. There, they disappear into the trees and are not bothered by us humans. During that time, I focus on other aspects of my research work: data input, video coding, or initial study analyses. Even though there are few people here, and the activities are repetitive, everyday life on the island is anything but boring. Countless plants, birds, bats and monitor lizards make every day unique – and anyway, with the chimpanzees, no one day is like another. Sometimes we travel to Entebbe to buy necessities, although we spend most of our time on Ngamba. Whenever I leave the boat, I'm really excited to be back on the island.

When darkness falls, the chimpanzees return "home", are fed and get ready for the night. I also go to bed relatively early, just a few meters away from their sleeping places. Often, after a long and arduous day researching, I lie exhausted on my bed and can clearly hear how these animals that I have come to love so much build their nests, make themselves comfortable in their hammocks and communicate with each other. Then I feel connected to them in a very special way. For me, these are the moments on Ngamba Island that I cherish the most.

Photos: private

Academic freedom – a never-ending story

To a very large degree, academic freedom as we know it today is based on the way it was conceived in Germany during the 19th century. At that time, it was not only professors who were in a position to make independent decisions about their research topics; students, too, enjoyed freedoms that seem incredible from today's perspective. **Lorraine Daston** from the **Max Planck Institute for the History of Science** in Berlin has studied the development of academic freedom and its limitations.

TEXT **LORRAINE DASTON**

Three facts must be kept in mind in any discussion of academic freedom as both ideal and practice. *First*, in long-term historical and cross-cultural perspective, there have been relatively few societies that have recognized intellectual inquiry for its own sake as either a value or as an activity worthy of sustained support. And among those exceptional societies that have made such normative, institutional, and financial commitments, all have set boundaries to unfettered curiosity. In the medieval European university, those boundaries invoked religious orthodoxy (as in the case of the 1277 Paris condemnation of certain Aristotelian doctrines such as the eternity of the world); in many modern societies, limits are drawn with respect to experiments on humans (and increasingly also some animal species) that inflict extreme pain or risk life and limb. Calls for imposing limits can also come from within the research community, as in the case of the recent appeal for a temporary moratorium on heritable genome editing by prominent scientists in that field. Academic freedom is both a rare and restricted value.

ECONOMISTS REFUSED TO DOCTOR STATISTICS

Second, both the meanings and justifications of academic freedom have varied not only by time and place but even in the same time and place. Much depends on what the defenders of academic freedom perceive to be the greatest threat to its exercise in a particular context. Even if we restrict ourselves to the present and to societies with roughly similar academic institutions, there is considerable variability on this point. Many Indian scholars and scientists protest censorship, legal suits, and threats of violence by Hindu activists against historians who cite archaeological evidence that Hindus once ate beef or who dispute claims (made by, among others, the Prime Minister Narendra Modi) that in Vedic times genetic science and airplanes already existed in India. In this context, religious extremism tinged with chauvinism poses the clear-and-present danger to academic freedom.

In contrast, economists and statisticians in Argentina who refused to massage official inflation statistics to match the ruling party's rosy election

Illustration: Alessandro Gottardo

History in view: Lorraine Daston has spent 24 years as the Director of the Max Planck Institute for the History of Science, with her research focusing on the development of probability and statistics, the history of objectivity in science and the moral authority of nature, among other areas.

prognoses lost their jobs and risked punitive fines if they persisted in publishing accurate information in academic journals For them, corrupt government was Enemy Number One. In the United States, opinion is divided as to whether academic freedom is most endangered by moralizing and political correctness (in which case a civil libertarian justification would offer the most robust defense), the willed ignorance of a belligerent government (best countered by a public appeal to citizens to demand accurate information about climate change or vaccines), or by rampant commercialization (to be combatted by stiffening university regulations and professional standards, especially in the biomedical and computer sciences). Academic freedom has chameleon qualities, taking on the color of its surroundings.

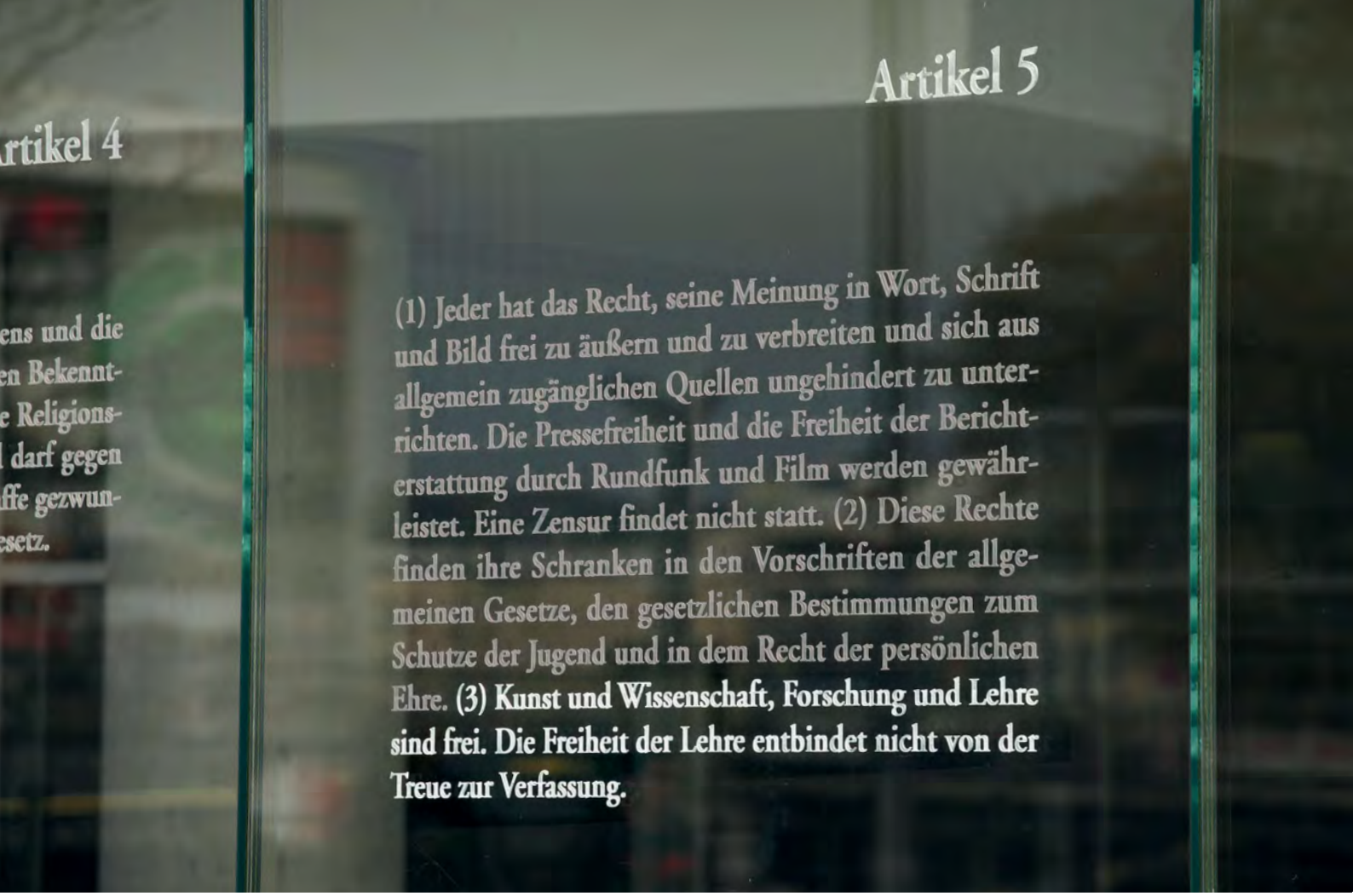
RESEARCH IS HARDLY EVER INDEPENDENT

Third, there is an important distinction between independence and autonomy that is often overlooked in debates about academic freedom. Intellectual inquiry, particularly but not exclusively in the modern empirical sciences, is almost never independent. Scholars and scientists have depended (and still depend) on the support of organized religion, governments, universities, industry, private patrons, and above all the culture at-large to do research, whether in the library or the laboratory or the field. This support is both financial and moral. The financial part is obvious, especially in an age of hugely expensive instruments such as the Large Hadron Collider in Geneva or the European Southern Observatory in the Chilean desert. But moral support is even more important: unless a society subscribes to the intrinsic value of free intellectual inquiry, there will be little motivation for its best and brightest members to devote their talents and energies to such demanding, uncertain, and comparatively ill-paid pursuits. In this sense, even those few researchers bankrolled by their own private fortunes are dependent.

However, dependence need not imply the absence of autonomy, defined in this context as the freedom of an academic body to decide on membership, governance, and, above all, the quality of scholarship and science. Autonomy as self-governance can apply to individuals (e.g. with respect to the choice of a topic of research), but its primary focus is institutional. From the *libertas scholastica* of the medieval university to the 2004 declaration on academic freedom and the research university by the University of California system, the ideal of academic autonomy as self-governance, however often it has been violated by the powers-that-be in practice, runs like a scarlet thread through the long and labyrinthine history of academic freedom.

Restrictions, diversity, and autonomy still characterize modern ideals and practices of academic freedom, especially if viewed from a global perspec-

Photo: Skuli Sigurdsson



Free, but not unlimited: Article 5 of German Basic Law safeguards academic freedom but also obligates the scientific community to abide by the constitution and therefore also to uphold human dignity.

Photo: dpa / Wolfram Steinberg

tive. Nonetheless, certain models of how to articulate, realize, and defend academic freedom have exercised wide and enduring influence, probably none more than those of the nineteenth-century German university. The international prominence of the German model has no doubt been reinforced by the fact that some guarantee of artistic and scientific/scholarly freedom has appeared in almost every proposed and actual version of a German constitution since the 1849 Paulskirche declaration and is enshrined (along with an explicit restriction) in the current German constitution, Article 5, Section 3: "Arts and sciences, research and teaching shall be free. The freedom of teaching shall not release any person from allegiance to the constitution."

The fame that drew students from many countries to study at German universities in the late nineteenth century also endowed the German model of academic freedom with enough prestige to allow foreign graduates of Berlin, Leipzig, Heidelberg, and elsewhere to campaign for similar freedoms when they returned to their home countries. Almost half of the members of the committee of the American Association of University Professors that drafted the United States' first declaration of academic freedom in 1915 were graduates of German universities.

STUDENTS COULD CHANGE THEIR UNIVERSITY

Because the German model of academic freedom is so intimately associated with the Humboldtian university, particularly its aspiration to combine teaching and research, Wilhelm von Humboldt's own statements concerning academic freedom are often cited as the crystallization of this ideal, although his fragmentary writings on this topic were not published until long after his death and therefore played little role in practice. More representative of how these ideals were actually realized in German universities during the late nineteenth century is Hermann von Helmholtz's 1877 inaugural lecture as rector of the Friedrich-Wilhelm Uni-

A protest in vain: in February 2019, demonstrators gathered in Budapest to protest against the planned restructuring of the Hungarian Academy of Sciences. The government has now taken control of the Academy.

versity in Berlin, "On the Academic Freedom of German Universities."

Helmholtz, whose worldwide eminence as both physiologist and physicist lent him the authority to speak for German science as a whole, laid out a vision that was certainly remote from the *libertas scholastica* of the medieval universities but also divergent in key points from late 20th and early 21st century views of academic freedom. The *libertas scholastica* had been primarily concerned with the legal privileges of members of the university, both students and teachers, e.g. the right to be tried in special courts, to adjudicate academic disputes, to move freely from one university to another, to work on Sundays and holidays, and even to evict noisy neighbors who disturbed a professor's peace and quiet. Current notions of academic freedom focus almost entirely on the rights of professors to teach and research whatever they (or their disciplinary community) deem to promote the growth of knowledge, even on controversial topics, and seldom discuss the rights of students. In contrast, Helmholtz upheld the freedom of both students and docents in almost equal measure, *Lern- und Lehrfreiheit*.

MORE FREEDOM THAN PARLIAMENTARIANS

Helmholtz's understanding of the freedom to learn would surprise a good many students at European, North American, and Asian universities nowadays, who are subject to increasingly strict and demanding curricular requirements. Aside from the exceptional case of students intending to make a career in a particular profession, such as law or medicine, and therefore subject to official requirements and examinations, students were and ought to be completely free to visit whatever lectures they pleased – or none at all. Helmholtz explained that students may "seek their instruction to any extent they wish from books; it is indeed highly desirable that the works of the great men of the past constitute an essential part of their studies."

Moreover, students were free to wander among all Germanophone universities, admittedly a contraction of the ambit of the Latinate medieval student, who could travel from Paris to Bologna to Oxford to Prague, if he so wished, but still permitting considerable geographic mobility in comparison to current regulations. Much to the astonishment of foreign visitors, who could not conceive of how one could "leave young men to themselves without the greatest damage," – as Helmholtz noted – students were also free to comport themselves as they wished outside the university, short of outright criminality.

It was this training in responsibility and independence that Helmholtz praised as one of the university's greatest gifts to the society that supported it: students who survived this test of character would be able to think for themselves. It was also the most difficult aspect of the German model of academic freedom to export, particularly to Anglophone countries with a collegiate model of student life (Great Britain) or a commitment to moral and religious education as well as to the doctrine of in loco parentis (the United States).

Helmholtz's conception of the freedom of teaching, in contrast, makes for more familiar reading. Despite the name, freedom of teaching had already become freedom of research. University instructors were to be chosen chiefly on the basis of their ability to advance their branches of science and scholarship, not pedagogical talent (another aspect of the German university that took foreign visitors aback). In contrast to the limited political freedom en-

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Photo: dpa/picture alliance / AP Photo

joyed even by parliamentarians, the freedom of the German professor to debate even the most extreme forms of materialism or Darwinian evolutionary theory or the most uncompromising defense of papal infallibility knew no bounds – so long as a controversial scientific question was discussed in a scientific manner.

Helmholtz acknowledged that such no-holds-barred disagreements among professors could lead to schisms in faculties but thought that the end effect would be to attract more, not fewer students. In any case, a certain amount of internecine strife among professors served as a healthy corrective to tendencies toward dogmatism and the establishment of scientific schools. What Helmholtz did not promise was the eventual convergence of scientific and scholarly views toward some single truth, much less a useful truth. His defense of academic freedom as the professor's "free conviction" rather than doctrinal loyalty had an unmistakably Protestant ring to it: "In their innermost hearts our founders did not lose their trust in the power of freedom to correct the missteps of freedom and of more mature knowledge to correct the errors of the less mature. The same sensibility that threw off the yoke of the Roman church also organized the German university."

Whatever the inspirational role of the German model of academic freedom, the variations on its themes imported to other countries were always adjusted to local circumstances. Cambridge and Oxford, Johns Hopkins University and the University of Chicago, all embraced the advanced seminar and the doctoral degree as qualifications to pursue independent research but never wholly abandoned moral missions or collegiate living or in loco parentis responsibilities, at least not at the undergraduate level. France managed to graft many of the German innovations onto its own distinctive system of universities and Grandes Ecoles, simply adding a few more of the latter (e.g. the Ecole Pratique des Hautes Etudes) to accommodate the new research imperatives.

COMMERCIALIZATION IS AGAIN CHANGING THE IDEAL

Even more significantly, each local ideal of academic freedom joined battle against a different adversary: in the French Troisième République, against Catholic orthodoxy; in the American Gilded Age, against the millionaire capitalists who served on the boards of trustees of private universities and the state legislatures that watched over public universities with a gimlet eye. In countries that have included guarantees of academic freedom in their statutes or constitutions, jurists and judges have in practice further modified the ideal and sharpened its limits. It is therefore not surprising to find a plethora of defenses of these different variants of academic freedom, from the instrumental (in the long run, academic freedom produces a useful pay-off for society, whether in the form of well-informed citizens or life-saving scientific breakthroughs or lucrative technology) to the ethical (academic freedom fosters "the culture of independence that we need in order to lead the kind of lives we should", according to the legal philosopher Ronald Dworkin).

There is every reason to expect that the challenges of the twenty-first century, from steep increases in government regulation, commercialization, and the sheer number of researchers worldwide, will generate new versions and justifications of academic freedom, as well as new restrictions in tune with the times. The unfinished, adaptive, and exploratory nature of academic freedom chimes with what Wilhelm von Humboldt believed to be the fundamental value of scientific research to progressive societies: "[I]n the organization of higher scientific institutions, everything is based on holding fast to the principle that science and scholarship must be considered as not yet entirely discovered and never entirely to be discovered and always ceaselessly to be sought." ◂

www.mpg.de/podcasts/freiheit (in German)

SUMMARY

- Academic freedom is always subject to limitations such as those defined by religious or legal principles. Currently, however, it is also being restricted by religious extremism, new ideologies, ignorance and commercialization.
- Science is also dependent on the financial support and moral backing of the state and society.
- The German model of academic freedom, which was designed by Wilhelm von Humboldt during the 19th century, has been adopted by many other countries, albeit in a modified form.


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Cracks in the justice system

For the past 70 years, the German Basic Law has guaranteed the independence of judges, whose decisions are "subject only to the law." But aren't there other influences at play? Legal scholars **Konrad Duden** from the **Max Planck Institute for Comparative and International Private Law** in Hamburg and **Jasper Kunstreich** from the **Max Planck Institute for European Legal History** in Frankfurt am Main have researched this question and come up with some astonishing answers.

TEXT **MICHAELA HUTTERER**

Every birthday celebration raises the question of the celebrant's state of health. This also applies to the Basic Law, which has guaranteed both the fundamental rights of the individual and an independent judiciary for 70 years. But how is the justice system faring now, when autocratic tendencies throughout Europe and political attacks on the rule of law are on the increase, and respect for state institutions and the judiciary seems to be waning?

The rule of law has already come under fire in certain EU member states, so much so, in fact, that the EU Commission now wants to introduce an annual rule of law check in member states to ensure that those which have already departed furthest from the binding maxim of maintaining a free and independent judiciary are not the sole focus.

The most striking development has occurred in Poland, where, thanks to its parliamentary majority, the ruling party – PiS (Prawo i Sprawiedliwo = Law and Justice) – has transformed the legal system in less than four years to give itself almost unfettered access to the courts and public prosecutor's office. As Konrad Duden from the Max Planck Institute for Comparative and International Private Law in Hamburg and Jasper Kunstreich from the Max Planck Institute for European Legal History in Frankfurt am Main observe: "the Polish experience adds to the list of states that are moving away from the separation of powers and judicial independence at varying speeds." Together the researchers set out to explore the underlying issues. How independent are the judges? To what extent is the judiciary subject to political influence? How free is the legislature?

"We wanted a broad discourse, a discussion conducted in and with the involvement of the public," the researchers explain. Together with Astrid Séville, a political scientist from the Ludwig-Maximilians-Universität in Munich, they organized a symposium in Mainz and invited constitutional judges and lawyers, political scientists, legal historians, politicians and media representatives to join them at the Academy of Sciences and Literature to discuss the following questions in front of and with 150 guests: how much juridical influence over the political system and how much politicization of the judiciary can a constitutional democracy based on the division of powers tolerate, and how much does it require? They concluded that the gains achieved on the basis of constitutional democracy are by no means to be taken for granted and must always be defended in the face of populist propaganda and newly emerging autocratic systems.

AUTHORITARIAN REGIMES VIEW JUDGES AS ADVERSARIES

Constitutional democracies rarely collapse loudly under the chaos of coups and riots. Instead, they are eroded – insidiously, quietly, often unnoticed. The law is dismantled by means of the law. "There can be isolated directives, decrees and seemingly harmless regulations introduced in new legislation," explains Konrad Duden: "multiple tiny pinpricks rather than one fell swoop of the axe – yet, the consequences are comparable." >

Illustration: Alessandro Gottardo

Critical scrutiny: Jasper Kunstreich from the Max Planck Institute for European Legal History (left) and Konrad Duden from the Max Planck Institute for Comparative and International Private Law have been looking into the difficult relationship between the justice system and politics and have organized a symposium at the Academy of Sciences and Literature in Mainz.

Why? "Autocratically oriented governments," says legal historian Jasper Kunstreich, "adhere to a familiar script designed to secure their power without causing too much drama." This includes everything from fostering resentments among the general public to evoking a common "will of the people" and arrogating to themselves the right to sole representation, right up to the consolidation of institutional powers. Their opponents, such as the judiciary, the press and representatives of the arts and sciences are gradually eliminated.

THE CONTROL OF RESOURCES GIVES THE POLITICIANS A WAY IN

The constitutional courts are often the first targets: judges are discredited in a targeted manner, their authority is undermined, their verdicts questioned, resources are withheld and successor appointments refused. There is political intervention in the court administration system and decision making process, reshuffles and, finally, judicial verdicts are simply ignored.

Much of this can be observed in Poland, for example: elected constitutional judges have not been sworn in, and the voting procedure for judges of the Supreme Court has been changed. "Constitutional courts," as Duden explains, "have no armed forces or bailiffs at their disposal – all they have is the force of their words." And in Poland, their words no longer even make it into the public domain, as it is the government, not the constitutional judges, that decides which verdicts of the court are published. Since the new appointments, the court is no longer

Photo: Michaela Hutterer

» Constitutional courts have no armed forces or bailiffs at their disposal – all they have is the force of their words.

seen as an impartial check on the government's actions.

For the past 70 years, it has been enshrined in Article 97 of the Basic Law that German judges are "independent and subject only to the law". The progenitors of the Basic Law were clear from the outset that an independent judiciary would be essential for the construction of a new, democratic Germany. The powerlessness of the judiciary and its solidarity with the National Socialist regime had been too obvious and the consequences too devastating. Therefore, they wrote the division of powers between the judiciary, the executive (government, ministries, administration) and the legislature (Bundestag, Bundesrat) into several clauses of the Basic Law, the idea being that nobody would be able to rule alone, the powers of the state would be divided, and each of the three powers would exercise mutual control over each other. The Federal Constitutional Court has the power to put a halt to the plans of the Federal Chancellor or the Bundestag if they violate the Basic Law.

Political attacks on the judiciary, such as those taking place in Poland or Turkey, are not evident in this country. But are there cracks beginning to appear? Small incidents, initiatives or even everyday occurrences that run counter to the guiding principles of the Basic Law?

Clearly, direct orders from above are strictly prohibited: no court president or minister of justice has the right to tell judges how to decide in any given case. The cracks are beginning to appear elsewhere. Workload, career prospects and prestige are just three of the many areas in which political pressure is being felt. The selection and appointment of judges, the allocation of resources and reputation present obvious routes of attack.

This influence is most obvious when it comes to selecting the judges for the highest courts. "This decision involves both a technical and a political aspect," as Duden explains. It is not the judges nor the courts who select and appoint their colleagues for positions in the highest German courts. This is the task of the MPs and ministers. It is the politicians themselves who determine who can establish the guidelines in German jurisprudence.

"In the case of federal judges," Duden explains, "the relevant decision is taken by the responsible federal minister together with a committee consisting of 16 corresponding state ministers and 16 members of the Bundestag. This involves selecting the best candidate in terms of qualification, professional achievements and ability, but the choice is also influenced by the proportional representation of each state and by arrangements between the major parties."

Put bluntly, this means that hardly any candidate stands a chance of donning the red judge's gown in Kassel, Munich or Leipzig without the support of

A conscious choice: the independence of the judiciary was an important concern for the progenitors of the Basic Law, who enshrined judicial freedom and the protection of judges against arbitrary dismissal in Article 97. The image below shows the relevant article in the 1953 edition.

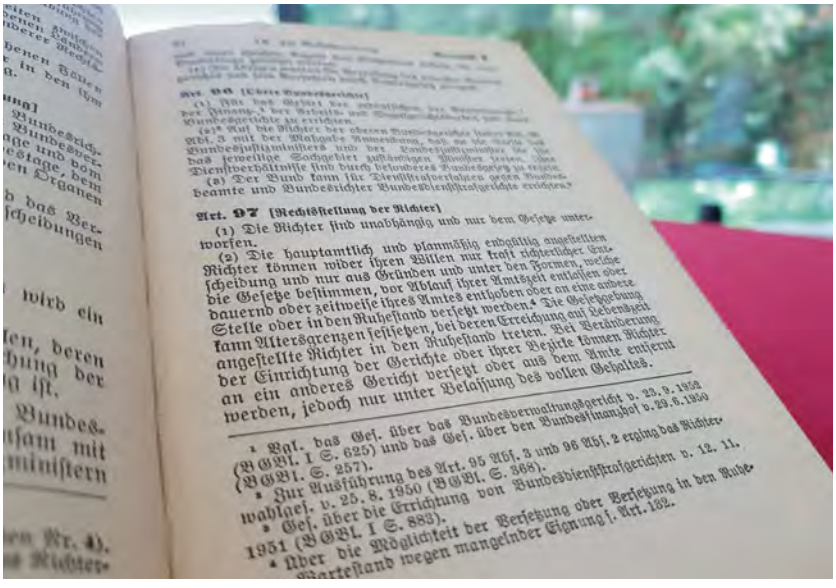
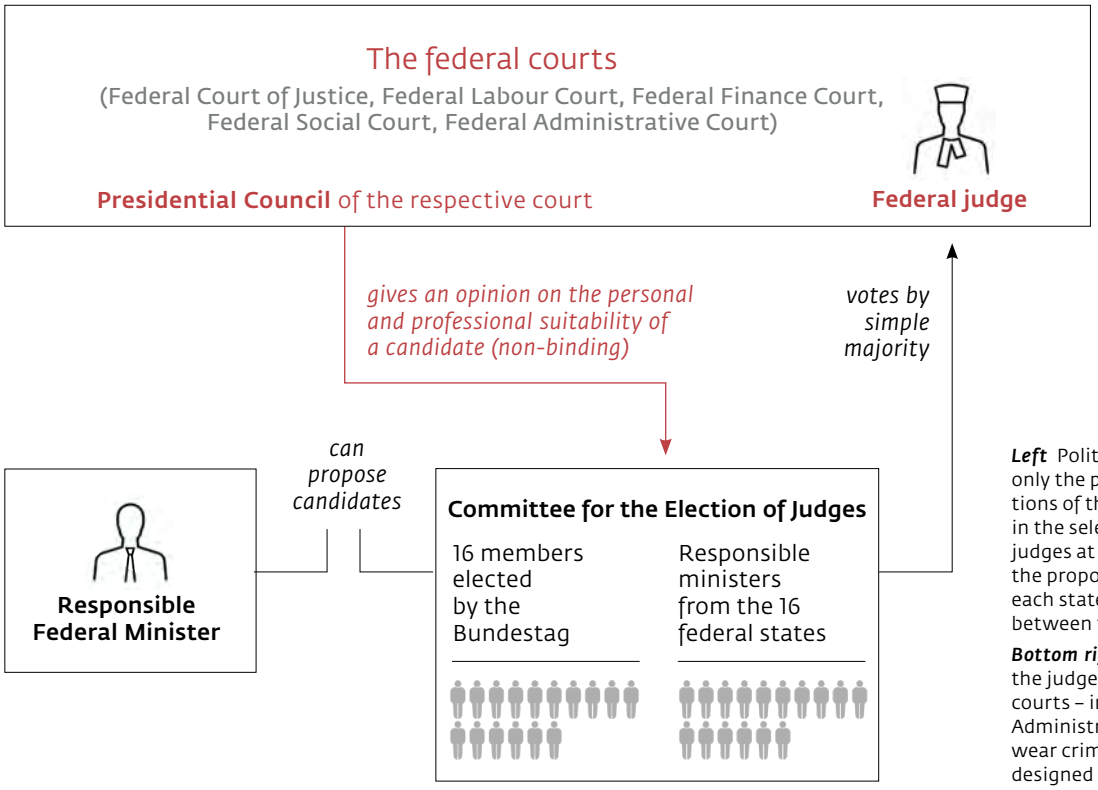


Photo: Michaela Hutterer

Election of federal judges



Left Politically influenced: it is not only the performance and qualifications of the candidates that play a role in the selection of the most senior judges at the federal courts, but also the proportional representation of each state and agreements reached between the major parties.

Bottom right Dressed to impress: the judges at the highest federal courts – in this case at the Federal Administrative Court in Leipzig – wear crimson robes, which are designed to underpin their authority.

contacts in the CDU/CSU and SPD. The judges are elected by simple majority, in secret and without public scrutiny. According to legal experts, the procedure would benefit from greater transparency. As Jasper Kunstreich reports: "the details of the job specification and selection criteria are unclear and the vacancies are not advertised."

Political considerations also play a role in the election of judges to the Federal Constitutional Court. If a judge retires or resigns, the Bundestag or Bundesrat appoint the successor by a two-thirds majority. Usually, federal judges and professors are elected, but sometimes, active politicians are also appointed. "In this case, too, the selection of candidates is subject to political agreements," says Duden.

The high hurdle of the two-thirds majority presupposes a broad consensus in respect of the candidates. "There is a conscious policy in this country not to hold public hearings – such as those held in the U.S.," Duden explains and recalls the politicized confirmation hearings that take place in the U.S. in connection with Supreme Court appointments. "Objectivity should not be compromised for the sake of transparency."

However, courts are not only dependent when it comes to the appointment of judges, but also on the resources made available to them. The federal and state governments provide the relevant funding from their own budgets, which means that it is ultimately the executive that decides how well equipped the courts are – from computers to employees to the security guards. According to a recent survey of 988 judges and prosecutors by the Allensbach Institute, the respondents primarily complained about insufficient personnel and technical equipment. The majority of them have observed a deterioration in the working conditions over the past few years. At the same time, as a further survey reveals, public criticism of excessively protracted proceedings and overworked courts is increasing.

THE AUTHORITIES DO NOT ABIDE BY COURT RULINGS

It was against this background that the federal and state governments concluded the "Pact for the Rule of Law" in January 2019. Together they want to create 2000 new jobs for judges, prosecutors and court employees around the country by 2021, including two new senates for the Federal Court of Justice. Yet this does not go far enough according to insiders.

However, politicians can also influence the courts in another way – and one with a profound effect: they simply ignore them. The bans on diesel-powered vehicles offer an example: the state of Baden-Wuerttemberg ignored a judgement issued by its administrative court and accepted a fine, because the

Graphic: designergold based on an image by Andreas Wetzel

state did not include a ban on diesel-powered vehicles with Euro 5 compliant engines in their clean air plan. Bavaria refused to even develop a concept for "proportional" bans on diesel-powered vehicles in Munich.

As the journalist and lawyer Heribert Prantl comments in the Sueddeutsche Zeitung with reference to the case of the Islamist Sami A. from North Rhine-Westphalia, who was deported to Tunisia last year, despite the fact that the administrative judges in Gelsenkirchen had forbidden this due to formal procedural mistakes and ordered his return: "If the authorities refuse to comply with a court order, then the second power is simply sabotaging the third." In a press interview, the Interior Minister responsible, Herbert Reul (CDU), roundly criticized the decision by the Higher Administrative Court of North Rhine-Westphalia to uphold the verdict: "The independence of the courts is a great good. But judges should always ensure that their decisions reflect the sense of justice felt by the general public."

In Jasper Kunstreich's view, this is an extremely problematic statement: "Judges are bound to abide by law and justice, not by the wishes and sentiments of the public." Criticizing controversial judgments with reference to some diffuse sense of justice among the general population will gradually destroy the authority of the courts.

Disdain, devalue, or ignore: the defamation of judges is aimed – consciously or unconsciously – at the heart of judicial power, namely the confidence of the general public in an effective and independent judiciary, which remains high in Germany. Germans place more trust in the Federal Constitutional Court than almost any other state institution. As studies by political scientist Hans Vorländer have shown, even controversial decisions have not changed this situation, for instance when the decision about abortion rights caused an uproar in 1975, or in 1995, when the court ruled against the mandatory placement of crucifixes in Bavarian schools. According to Vorländer, the Constitutional Court even enjoys greater trust than other political institutions such as the legislature, the executive or the political parties.

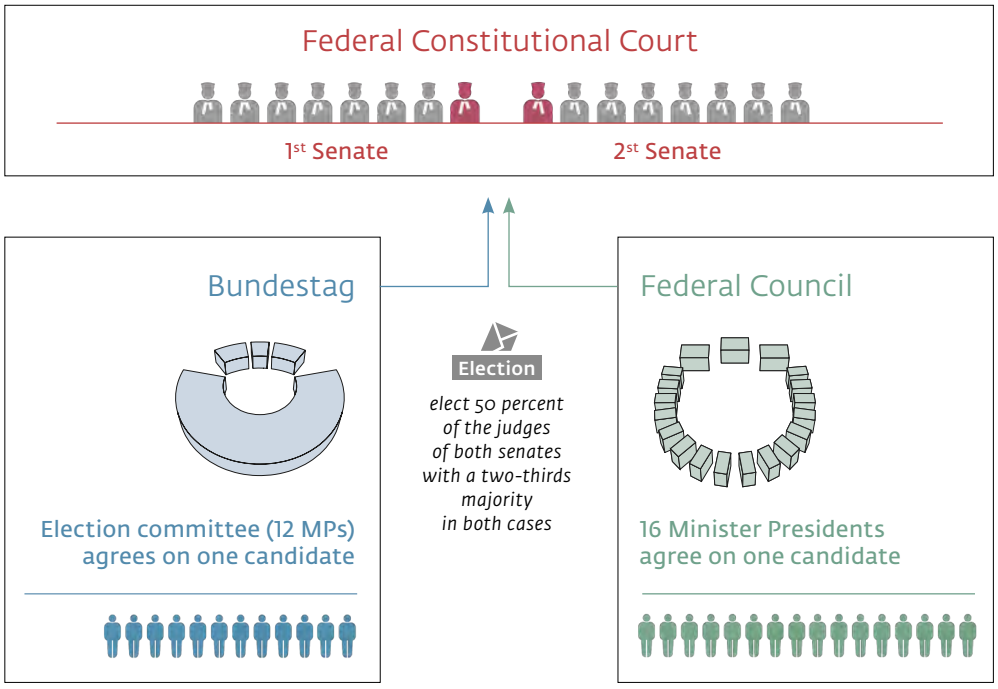
PERSONAL ATTACKS ON JUDGES ARE INCREASING

Yet the authority of the court is increasingly coming under attack. Judge of the Federal Constitutional Court Susanne Baer said at the Mainz symposium that she was worried "about the personalization, scandalization and defamation of

» If politicians criticize controversial judgments with reference to some diffuse sense of justice among the general population, it will gradually destroy the authority of the courts.

Photo: picture alliance/Jan Woitas/dpa-Zentralbildd/dpa

Election of constitutional judges



Elected by consensus: federal constitutional judges must be elected by a two-thirds majority. Their term of office ends after twelve years and they cannot be re-elected.

the judiciary as well as the activation of resentments against judges." Personal attacks against judges are increasing in private discussions, on the Internet, in the media and in parliament.

U.S. President Donald Trump is one prominent figure who berates judges. When a U.S. federal court ruled that a certain government action was illegal, Trump took to Twitter to defame the judges as "Obama judges," This gave a rise to a rare statement by the Chief Justice of the Supreme Court indirectly criticizing President Trump: "We do not have Obama judges or Trump judges, Bush judges or Clinton judges." he said. "What we have is an extraordinary group of dedicated judges doing their level best to do equal right to those appearing before them."

BORING REGULATIONS CAN HAVE A STING IN THE TAIL

Nor was Italy's former Interior Minister, Matteo Salvini (Lega Nord) backward in coming forward when it comes to condemning court decisions. He took to the media to inform the magistrate who released the German Sea-Watch captain, Carola Rackete, from prison that rather than being an expression of judicial independence, her verdict was "madness," and advised her to "hang up her judge's gown and apply for some political office for the Left."

And here too, political parties with autocratic tendencies know how to sow doubt, promote suspicion and arouse distrust via minor administrative regulations that often go unnoticed. But these "boring" regulations can have a sting in the tail: the AfD, for example, submitted a draft resolution to the Bundestag in December, according to which the Federal Constitutional Court must justify any non-acceptance of a constitutional complaint: the court currently has the discretion to decide whether or not to justify its non-acceptance. At just under 6000 complaints received per year, the court is already more than busy and, at less than three per cent, the number of successful complaints is low. And what many people do not know is that "a committee consisting of at least three judges decides on every complaint," explains lawyer Konrad Duden, who worked at the Constitutional Court as a trainee lawyer himself. "A comprehensive mandatory justification requirement may sound reasonable at first, but it would stretch the court to its limits and jeopardize its ability to function."

Yet, is it not the case that the Basic Law itself protects our constitutional democracy against attacks? "Not enough!" as Duden and Kunstreich both agree: "It would make sense to supplement it, as it contains no binding provisions relating to appointments to the Constitutional Court as yet. The number of judges, the two-thirds majority required for their election and their term of office could all be changed easily by law in response to changed majorities ratios in the Bundestag." Both Poland and the U.S. have demonstrated how quickly this can be done. In 2015, the Democrats in the U.S. abolished the requirement for a 60 percent majority for the election of federal judges in favor of a simple majority. Two years later the Republican Senate majority also overturned this higher hurdle for the Supreme Court.

Graphic: designergold based on an image by bpb – Federal Agency for Civic Education

» Parliament undermines its own authority when it fails to deal with controversial issues and acts only as an executive body for the enforcement of judicial decisions.

While there might be ways to gain political influence over the judiciary, is it not also the case that the judiciary itself sometimes acts beyond its remit? The Federal Constitutional Court, which has the sole authority to interpret the Basic Law, is a focus of criticism. "Both it and the European Court of Justice are repeatedly accused of overstepping the boundaries between politics and the law and interfering in fundamental political issues," Kunstreich reports. And that, as Duden adds, is no wonder: "almost every significant political issue in the history of the Federal Republic of Germany – from dealing with the legacy of the Third Reich to the RAF terror regime to the equality of homosexual couples – has been dealt with by the constitutional judges in one form or another."

POLITICAL MAJORITIES ARE BECOMING HARDER TO ACHIEVE

According to Oliver Lepsius, an expert on constitutional law, decisions by the Constitutional Court on individual cases become incorporated into the legislative process. The court sets standards that fit in the hierarchy of norms are situated between the Basic Law and general laws. However, these standards are beyond the influence of the legislature and can therefore hardly be changed.

Does the removal of such questions from political scrutiny or correction by the legislator adversely affect the political process in Germany? As Duden and Kunstreich recognize "promoting political objectives via the Federal Constitutional Court now seems to be an almost integral part of our system."

70 years after the introduction of the Basic Law, it is evident how difficult the task of the legislature has become. "There are all sorts of problems: achieving political majorities and reaching a consensus are becoming more difficult," says Kunstreich. The party system, he continues, is becoming more fragmented, and political parties are increasingly perceiving themselves as minorities and blocking decisions. With their integrative power and ability to objectify debates, he goes on, the courts fill this gap. "To a certain extent, they shoulder some of the parliamentary burden and relieve the pressure on politicians," says Kunstreich.

This is especially the case when controversial issues are concerned that could scare off core voters. "Political parties sometimes seem almost pleased when the Constitutional Court addresses issues that are hotly debated by the general public," Duden adds. "Take the gradual steps taken towards granting equality to homosexual couples, for example. For the federal government it seemed very convenient to be able to cushion the pressure for reform through selective changes whilst at the same time pointing out that it wasn't the government but the Federal Constitutional Court in Karlsruhe who wanted it that way."

But isn't this harmful to the political process itself? "Parliament undermines its own authority when it fails to deal with controversial issues and acts only as an executive body for the enforcement of judicial decisions," Kunstreich confirms. "The courts then run the risk of being seen as the scapegoat in debates that ought really to be conducted in parliament." And not just there. "As the fourth estate, the media but also the cultural sector and the sciences all have a responsibility to address various topics and expand public knowledge through the addition of context and detail."

Ultimately, this applies to society as a whole, to each and every one of us. Even 71 years after the introduction of the Basic Law, those who want an independent judiciary and a functioning constitutional democracy must never tire of learning about and defending these achievements, whether in conversations, on the street or especially in those forums for political discussion that would have been inconceivable to the authors of the Basic Law – the Internet and social media. ◂

www.mpg.de/podcasts/freiheit (in German)

SUMMARY

- **Autocratically oriented governments that undermine constitutional democracies often begin with the Constitutional Court, discrediting judges, ignoring verdicts, restricting resources and filling vacancies with their own supporters.**
- **Even in Germany, politicians exert their influence over the judiciary primarily through the provision of financial resources to the courts and the election of federal and constitutional judges.**
- **Examples of the executive simply ignoring or discrediting court verdicts have been increasing in recent times.**
- **On the other hand, the ruling parties often give the Constitutional Court a political role when they leave it to decide on controversial issues.**

Image change: Plattenbau estates such as Gera-Lusan were popular residential areas in the GDR era. Demand decreased after the reunification. Some houses were demolished, others refurbished.

Freedom foisted

30 years after the fall of the Iron Curtain, the separation between Eastern and Western Germany is still not over. Quite the contrary: when it comes to political issues in particular, the differences between the formerly socialist East and the now as then capitalist West seem to have increased in recent times. **Chris Hann** and his students at the **Max Planck Institute for Social Anthropology** in Halle are exploring the reasons for this development in their fieldwork in Hungary and Eastern Germany.

TEXT **JEANNETTE GODDAR**

To visit Elisabeth Köditz at the site of her field research in Gera, you take tram no. 3. The tram line connects Bieblach-Ost, a neighborhood in the northeast that is dominated by the typical prefabricated buildings known as "Plattenbau", with Lusan, a similar neighborhood in the southwest. On your way to Lusan, you pass the Gera Arcaden shopping mall, tattoo and tanning studios, a democracy center, and "Café Kanzler".

During the final years of the GDR, this suburb was home to 45,000 people who manufactured defense technology for Carl Zeiss Jena, extracted uranium ore for the Soviet-German Wismut corporation, and supplied machinery for a state enterprise (VEB) in the textile sector. Gera, a city that was hardly known to residents of the Federal Republic, was relatively industrialized compared to other administrative districts of the GDR. New apartment blocks were built whenever a new company began operations. There are seven tram stops in Lusan alone. It is almost eerily quiet for the middle of a sunny day.

"The population here is only half of what it was in the 1980s," says Köditz as the tram passes an abandoned building, one of two high schools obliged to close in the 1990s. How did it feel to be a high school graduate in an environment in which more and more of your neighbors were moving to the West, or to newly vacated apartments in the city center? The doctoral student at the Max Planck Institute for Social Anthropology in Halle intends to find out, as she is in touch with such a graduate, and also with an architect who supervises the dismantling of the Plattenbau buildings whose father was involved in their construction.

Elisabeth also knows what it is like to inhabit buildings of type P1, P2, QP or WBS 70 that everyone in the GDR was very familiar with. She lives in a one and a half room apartment in Lusan's last Plattenbau row, just a few meters from the terminus of tram line 3. Her

Photo: akg-images / euroluftbild.de


GLÜCK AUF

> What used to be normality was replaced by a time in which decisions were made by people who had until recently lived in another country – the old Federal Republic.

Field researcher in Zwickau: Katerina Ivanova examines the effects that the economic changes after the reunification have had to this day.

building has a concierge: not unusual in contemporary Eastern Germany, thanks to a mixture of marketing and the endeavor to adapt to demographic change. From 9 to 5, residents are able to order beverages, book the party room, or enquire about leisure activities, which is what Elisabeth Köditz did right after moving in. This is how she met a group of eight women that has become the core of her research. They meet every Tuesday to play rummy and talk, and Elisabeth Köditz records these conversations on her smartphone. With the women's permission, of course.

The next location is Zwickau in Saxony, 40 kilometers to the southeast of Gera. Katerina Ivanova, who is also a doctoral student at the Max Planck Institute for Social Anthropology, arrived in the former GDR, after completing a master's degree in social anthropology in Bratislava. Unlike Köditz, Ivanova examines the changes of the past 30 years more from an economic perspective. In other words: from the perspective of class.

The Belarus-born researcher interacts with workers in the automotive industry. With people who used to build Trabants for VEB Sachsenring, as well as those who now work for Volkswagen or one of its suppliers. "I want to find out how car industry workers have experienced the enormous changes that have occurred since the end of the GDR, and how they assess their current position," she says, "both in their working relations, and within society generally. I have found the two aspects to be closely interlinked."

INEQUALITY IN SAXONY AND LOWER SAXONY

For her research, Ivanova has chosen a place where the economic institutions of the GDR were not replaced by vast nothingness after the reunification. As a powerful symbol, the first VW Polo rolled off the assembly line in Zwickau simultaneously with the last Trabant in May 1990. The site is now home to a vehicle production plant capable of producing more than 1,300 Volkswagen cars in a single working day. Taking the supplier companies into account, the automotive industry in Zwickau has 40,000 employees, and the city is considered a showpiece of post-socialist transformation.

Nonetheless, many of the workers Ivanova talks to do not see their personal experience of transition as a success story. Their lives are shaped by memories of a system that was their normality, which has given way to a new era in which decisions were foisted on them by people from another country – the old Federal Republic. "Almost everybody has negative memories of the 1990s," says Ivanova. This is because they were affected by unemployment, reduced working hours, or early retirement, but frequently also because the freedom and democracy that had been fought for in 1989 – especially on the streets of East Berlin and Leipzig – were linked to the feeling of being subject to new external controls.

"Of course they are not opposed to the unification in itself," explains Ivanova. "However, many of them tell me about people from the West dominating their lives from then on – because they told them which qualifications were of value and which were not. Or because they chased quick profits, for example with insurance policies that nobody needed, or with cars that people in the Western states no longer wanted to drive."

The Treuhandanstalt, the organization that arranged the privatization, restitution or closure of more than 20,000 Eastern German enterprises between 1990 and 1994, also figures prominently in people's memories. "My impression is that the organization's work was perceived as corrupt and as a form of colonialization," says Ivanova. All of these aspects gave rise to a feeling of being treated as second-class citizens. >

Photo: MPI for Social Anthropology

Photos: fotofinder/Thomas Raupach (top); plainpicture/Westendöi/Sten Schunke (bottom)

Right Car construction in Zwickau: the legendary "Trabi" still rolled off the assembly line of VEB Sachsenring in 1989. Workers used to install many parts manually.

Bottom Nowadays, the production processes for the VW Golf, built in the successor plant, are mostly automated.

Top Teamwork: work had a pronounced social function in the GDR. It was a matter of course that birthdays were celebrated with one's colleagues at work.

Left Loneliness in the Plattenbau: empty apartments have been a conspicuous feature of Gera-Lusan and other Plattenbau estates since 1990. The tenants drying their laundry on this balcony were the only residents left in this building.

Photos: akg-images / picture-alliance / ZB / Wilfried Glienke (top); picture-alliance/dpa / ZB – Fotoreport (bottom)

» Socialist understanding is based on the idea that each individual makes a small contribution to the collective. After the reunification this changed, even for those who did find new jobs.

And what about now, almost 30 years later? Inequality between those working in Saxony, in the former GDR, and those working in Lower Saxony, in former West Germany, is still an issue. The situation was brought to public attention in May 2019 when representatives of the metalworkers' union IG Metall presented the Management Board of VW with a debt certificate for 16 million working hours: the number of extra hours (calculated according to collective wage agreements) that Zwickau-based VW employees had worked since 1990, compared to their western peers.

EVERYONE WANTS TO BE ACKNOWLEDGED FOR THEIR WORK

This is why the relationship with Volkswagen is rather ambivalent, Ivanova reports: "On the one hand, people are aware of the fact that the situation would be much worse without VW. On the other, the unequal treatment is perceived as discrimination." She also hears again and again about management positions still being monopolized by Westerners – "often by persons who only come to Zwickau for a few years in order to advance their career."

In the course of her research, Ivanova will explore how these perceptions have contributed to rising nationalism and ethnic segregation and the degree to which this has paved the ground for the rise of a right-wing populist party: "My hypothesis is that in Eastern Germany a form of economic dispossession took place in particular cultural and historic circumstances, including collective memories of socialism, negative experiences after the reunification, and the sustained feeling of being dominated by the West."

Both doctoral students anticipate shedding light on the rise of the populist AfD party. Elisabth Köditz attended an AfD rally in Erfurt shortly after the party had won around one in ten votes in Thuringia, enabling it to enter the state parliament in 2014. She did not attend as a protester, but as a seeker of answers. "I could feel that something was brewing in my environment. I wanted to understand what it was," she explains. "What better way to find out than to talk to people?" In effect, that day marked the start of the participatory observation that she now continues in Gera.

For Max Planck Director Chris Hann, participant observation is the most important method of social anthropology. It was pioneered by the Pole Bronislaw Malinowski, who 100 years ago conducted long-term research on the Trobriand Islands, now part of Papua New Guinea. A central characteristic of participant observation, Hann explains, is to "live like the locals as far as possible, and to observe them in their everyday lives and working relations as closely as they allow you to." Without, he adds, identifying with them: "The key to success is to develop empathy without going native."

According to Hann, it makes no difference in principle where the observation is performed: "Of course, there are great differences between Gera or Zwickau and New Guinea 100 years ago," he says, "however, anthropology at home is nothing new in our discipline." The key point is to question or suspend one's own world view. This effort to relativize is indispensable, even if one makes use of theories explicitly rooted in the European history of ideas, such as Köditz's operationalization of the recognition concept of social philosopher Axel Honneth, and conducts one's research in the heart of Europe.

Field researcher in Gera: Elisabeth Köditz is digging into the social background shaping the rise of the AfD in Eastern Germany.

Honneth, the former head of the Institute for Social Research in Frankfurt, considers the desire of human beings to have their achievements in society acknowledged to be a central dimension of recognition. Köditz also draws on Karl Marx's linking of production to social reproduction. "It is perceived as disrespect (*Missachtung*) if I cannot reproduce myself economically when I'm prepared to do so, but the opportunities are highly limited and the employment outlook is grim. If the jobs available don't pay a decent wage, don't acknowledge workers' previous experiences, and don't offer a long-term prospect, this is a disrespect to the individual. Disrespect is the op-

Photo: MPI for Social Anthropology

Long-term observer in Hungary: Chris Hann has witnessed the hopes placed on the country's EU accession, as well as the great disappointment that has occurred since.

posite of recognition (*Anerkennung*)," says Elisabeth Köditz.

Comparisons between the present day and the GDR era crop up frequently in her conversations. The women she meets to play cards with are pensioners who have spent most of their working lives in socialist enterprises. The doctoral student finds that they rarely invoke work as a source of income, but rather reminisce about their brigade and larger collectives, about enterprise cells of the SED (the Socialist Unity Party of Germany) or the FDJ (the Free German Youth), the Subbotnik – nominally voluntary work on Saturdays, often devoted to cleaning up the local environment – and going out to dance with colleagues.

"Work had a pronounced social function in the GDR. It was not unusual for work to structure large parts of leisure activities and private lives," explains Köditz. This aspect disappeared after the reunification, regardless of whether or not one could find a new job. The process of winding up the GDR transformed the notion of work "away from the socialist understanding of each subject making a small contribution to the collective, towards a concept of work as personal fulfillment for the individual citizen."

THE POST-REUNIFICATION PERIOD REMAINS UNRESOLVED

Elisabeth Köditz herself originates from Thuringia. This federal state did not exist when she was born. Along with so much else, the 14 administrative districts of the GDR disappeared in 1990, to be replaced with five new federal states. Having grown up in one of the new states is an asset to Elisabeth Köditz in her field research. "'Where are you from?' is often the first or second question that people ask me," she reports. "My place of birth has an impact on my life, both in the East and in the West, despite the fact that I was born just a year before the fall of the Berlin Wall."

When she was 19, Elisabeth Köditz moved to Duesseldorf to attend university. "At university I was considered 'the East German', in the 21st century, by fellow students who were my age." This is another central question of her research: "What are these values and experiences that are transmitted across generations?"

The research conducted by the two doctoral students is timely. It is becoming increasingly apparent that the end of the GDR cannot be considered purely as the advent of freedom. "From our social anthropological perspective, the concept of freedom – like any other concept – has to be placed within a societal context," says Chris Hann. According to the Max Planck Director, it is necessary to find out what freedom means for individuals in concrete terms: "How was freedom perceived in the past, and how is it perceived today? And how does it relate to socio-economic living conditions?"

Social anthropologists must adopt a critical stance to Enlightenment philosophers such as Immanuel Kant or Voltaire, who lay claim to universally valid concepts of freedom. According to Hann, "it is not enough to focus on the rights and aspirations of individuals. This is where other thinkers such as Herder and Rousseau come in, who were concerned with the flourishing of entire peoples, nations, and communities." He explains further that this critical approach often goes against the grain of dominant ideologies – of colonialism in the past, and of liberal ideas in the present day. Malinowski's most famous student, New Zealand-born Raymond Firth, once described anthropology as the "uncomfortable science," a conclusion Hann endorses.

The eastern *Bundeslaender* are by now hardly "new". Yet it is only slowly dawning upon the Western German public that reunification entailed millions of disrupted biographies. The "humiliations, insults, and injustices" of the post-reunification years need to be "addressed by a united Germany" – these are the very clear words used by Saxony's Integration Commissioner Petra Köpping in 2018 in her book titled "Integriert doch erst mal uns!" ("We need to be integrated first!"). Along with a number of journalists from Eastern Germany who have been pursuing the issue for several years, but have only recently begun to attract general attention, and have a few social scientists, the Halle-based doctoral students are helping to "close a significant scientific gap," Chris Hann comments.

LABOR MIGRATION TEARS FAMILIES APART

Hann himself has been conducting research in Hungary for more than 40 years. He traces the consequences that the changes that occurred after the fall of the Iron Curtain have had on large sections of the population. He reports, for example, about the employees of a

Photo: MPI for Social Anthropology

A symbolic act: on June 27, 1989 Hungarian Foreign Minister Gyula Horn (right) and his Austrian counterpart Alois Mock (left) severed the border fence in an iconic staged gesture. Hungary had been the first country of the Eastern Bloc to dismantle most border installations in May. Since 2015, Hungary has been using barbed wire to shut itself off once again – nowadays to the South, to keep out unwanted "migrants".

Photo: picture-alliance/dpa

Daimler Benz factory in the provincial capital Kecskemét, who work for around one quarter of the wages their colleagues in Stuttgart receive for performing essentially the same work. Hann considers such inequalities, and the disruption of families which occurs when young people opt for labor migration, to be among the main reasons for the success of the populist prime minister Viktor Orbán: "People expected a lot when Hungary joined the EU – because they were promised a lot. Few of these promises were kept." According to his analysis, the initial entrenchment of a neoliberal market principal in Hungary has generated populist "counter movements" that are exemplified in Orbán's Fidesz party.

Similar tendencies can be observed in other countries of East-Central Europe. The doctoral projects of Katerina Ivanova and Elisabeth Köditz are associated with the "Visegrád Anthropology Network," a cooperation involving social anthropologists in Hungary, Poland, Czechia and Slovakia – those four countries that have formed a loose political alliance following an agreement signed at Visegrád in 1991. The goal of the Network, initiated by Hann, is to support social anthropological research into post-socialist economic changes and their consequences for social and political relations throughout the region.

Elisabeth Köditz believes that the fact that the AfD is set to establish itself as the Eastern German people's party is linked to decades of Western German hegemony. She participates in the "Aufbruch Ost" ("Eastern Awakening") initiative that was founded in 2018, mostly by students from Leipzig who did not want the public sphere to be monopolized by organizations such as AfD or the anti-Islamic movement Pegida. "I have no doubt: one reason for their success is that they use racist attitudes to channel something that could and should be addressed in other ways," says Köditz.

She considers it important to contrast the right-wing populist narrative with an emancipatory left-wing alternative. Is she working as a scientist on behalf of the "Aufbruch Ost" initiative, which attempts to do just that? "I think of myself as an involved anthropologist," she replies. "It seems like a worthwhile endeavor to me, if I can contribute to finding new formats for acknowledging Eastern German histories." ◀

www.mpg.de/podcasts/freiheit (in German)

SUMMARY

- **Anthropologists are conducting field research in Eastern Germany and provincial Hungary to examine the impact on the local population of the fall of the Iron Curtain and ensuing transformations.**
- **The connective function that work had within the socialist system disappeared after 1990, and along with it the sense of community and recognition that had been crucial aspects of the working environment.**
- **Negative experiences during the years following reunification and lasting inequality lead people to feel disadvantaged and make them more likely to sympathize with populist parties.**

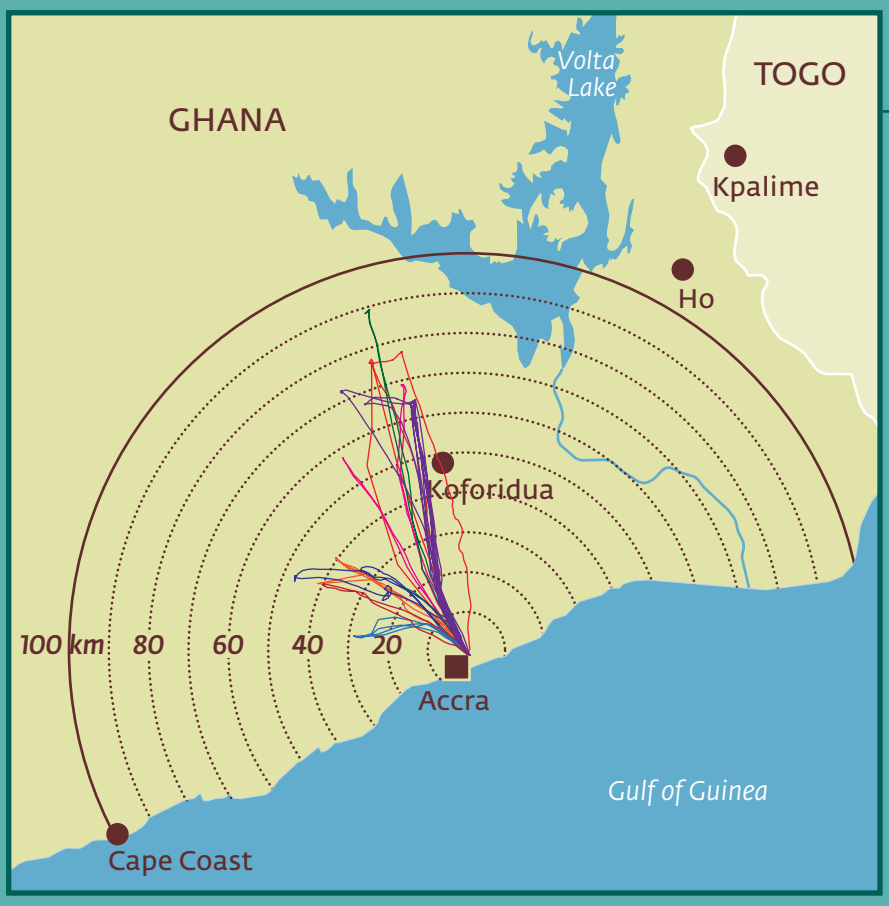
Reforestation courtesy of fruit bats

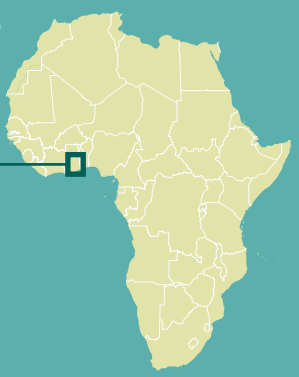
We humans benefit in many ways from an intact natural environment. Not only does it serve as a recreational space, but also provides financial benefits: insects, birds and bats pollinate crops around the world and eliminate animal and plant waste. Such ecological services equate to many billions of euros per year – not to mention the additional benefits of clean air and fertile soil.

Straw-colored fruit bats also provide a service to humans by eating various fruits and swallowing their seeds, which they then transport over many kilometers before excreting them as they return to their roosts. Researchers at the Max Planck Institute for Ornithology have calculated that a single colony of fruit bats in Ghana can reforest an area of 800 hectares worth 700,000 euros in this way.

Unfortunately, hundreds of thousands of straw-colored fruit bats are still being killed every year. Better protection for these animals would allow them to contribute more to the conservation of forests in Africa.

Night routes of the straw-colored fruit bats





75 km straw-colored fruit bat

25 km African elephant

14.5 km Trumpeter hornbill

1.5 km Colombian woolly monkey

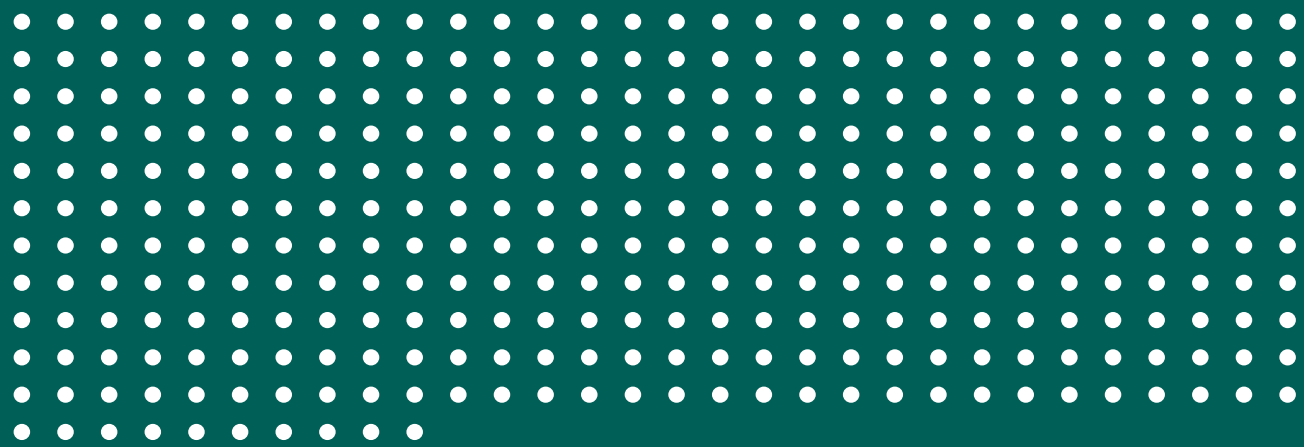
Erfurth Kluger Infographic for MPG

Fruit bats and their cargo

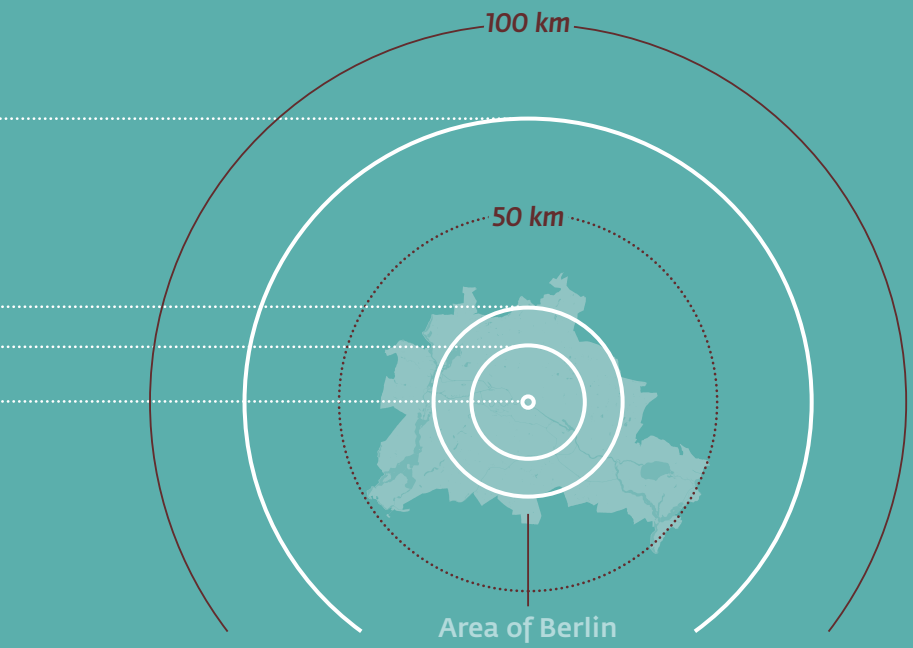
Maximum area of dissemination: **13,000 km²**

Size of colony: **150,000** animals

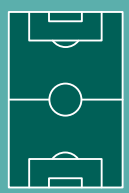
Number of seeds per colony and night: **340,000**



Animal seed couriers



800 hectares of new forest are created every year thanks to the distribution of the seeds. This corresponds to around **1,120** football pitches.



Minimum population in Ghana **2.5 million**

Every year, up to **1.5 million** animals are hunted

Those who live longer have fewer children

Research into aging processes in animals with short lifespans may underestimate the price of longevity

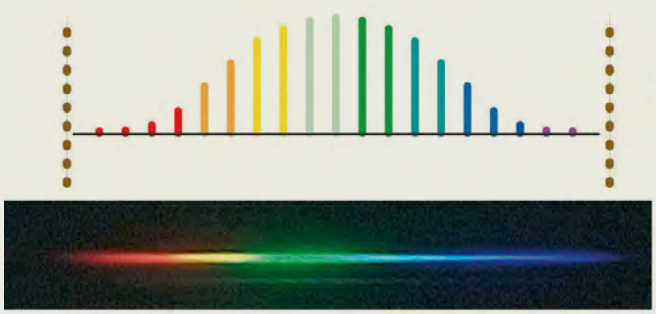
Until not so long ago, many people shared the desire to live a long life and have lots of children. However, a look at the animal kingdom makes it clear that high fertility and longevity are often mutually exclusive. Animals with particularly short lifespans are often highly fertile, while those that live longer often have fewer offspring. Mice, for example, only live for around two years but become sexually mature after just a few weeks and have litters of three to eight babies up to eight times a year. Elephants, on the other hand, may live for up to 80 years, but elephant cows can only give birth to up to ten calves during the course of their lives. Researchers at the Max Planck Institute for Evolutionary Biology in Ploen have now discovered how the trade-off between lifespan and fertility works. A seemingly insignificant increase in lifespan can have a serious impact on reproduction. However, the researchers have yet to determine how greater longevity would affect human fertility.
(www.mpg.de/13559984)

Elephants can live for up to 80 years. However, an elephant cow has comparatively few offspring, only giving birth to around ten calves during her lifetime.

Frequency comb trimmed for data communication

A new technology could make it possible to transmit information more efficiently in the future

A new optical component may reduce the energy required to transport data through glass fibers. Scientists at the Max Planck Institute for the Science of Light and the University of Otago in New Zealand have developed a technique with which they can create exceptionally high-quality frequency combs with the assistance of an electrical field. Frequency combs, which until now could only be generated optically, split laser beams into equally spaced sharp lines in different colors that resemble teeth in a comb. In 2005, Theodor W. Hansch from the Max Planck Institute of Quantum Optics was awarded the Nobel Prize for Physics for developing the basic technique with which laser light is split into different frequencies. The use of a frequency comb could drastically reduce the number of lasers currently required to transmit data through glass fibers in parallel. Optical effects that distort a transmission signal could not be controlled with the frequency combs previously available. The new electro-optical frequency combs make this possible, which means that they could be used to handle the increasing volume of data in the Internet and reduce the costs of transmission.
(www.mpg.de/13669026, in German)



A tooth for every color: a frequency comb splits laser light into many different lines. It can now be generated more efficiently using an electro-optical effect – a development that could be useful when transmitting data.

Photo: 123RF/Burdiak (top); graphic: MPI of Quantum Optics

Self-assembling micromachines

Polarizable microrobot components can be configured to find each other in an electric field

Constructors of micromachines will be able to use a new method in future. A team led by researchers from the Max Planck Institute for Intelligent Systems in Stuttgart has presented a concept that enables the components of microvehicles, microrotors and micropumps to assemble themselves in an electric field. This concept is based on the dielectrophoretic effect: a non-uniform electric field electrically charges a plastic frame together with other components made of plastic or quartz glass. During this process, the insulating components modify the electric field depending on their shape. Careful component design therefore enables them to position themselves alongside each other in precisely the format required for the construction process. This assembly concept could help construct microrobots that perform medical procedures in the human body or fit laboratory devices on a microchip. (www.mpg.de/13724619)

Origins of the potato

Numerous varieties and wild plants have made these tubers one of the most important agricultural products

The origins of the European potato have been the subject of debate for more than a hundred years. Genetic analyses performed by researchers at the Max Planck Institute for Developmental Biology have now revealed that our modern-day potato plants originated from two sources. The first potatoes collected by Europeans in the 16th century came from the Andes, in what is now Peru. In Europe, the nutritious tubers initially only developed in late fall. They were therefore very small, as they only had a short time to grow before the first frosts took hold. Other varieties were imported from Chile to Europe during the 19th century. The data obtained by the researchers showed that after the leaf and potato blight that ravaged crops during the 19th century, European farmers crossed cultivated potatoes with wild ones to make their crops more resistant to disease. The research findings therefore show how important it is to protect the diversity of species. Different varieties of cultivated plants and their wild-growing relatives can help protect agricultural crops from pathogens and the consequences of global warming. (www.mpg.de/13618613)

The plants with which researchers determined the origins of the European potato are up to 350 years old. They included plants collected by Charles Darwin in the Chonos Archipelago off Southern Chile in 1834.

Photo: Cambridge University Herbarium

The drug crisis and its offspring

Opioid abuse in the U.S. is causing a decline in life expectancy

For many people, it begins with a seemingly harmless painkiller. However, opioid analgesics not only alleviate pain, they can also intoxicate the consumer and make them dependent. This is exactly what has happened to many patients in the U.S., who have often been taking this medication for decades and were sometimes thoughtlessly prescribed it by their doctors. The number of drug addicts and drug-related deaths has therefore increased drastically. As a result, average life expectancy in the U.S. – unlike most other industrial countries – has decreased significantly for the first time since World War I. Between 2014 and 2016, it fell by three months for men and around one-and-a-half months for women. Mortality rates rose particularly sharply among people born between 1956 and 1966. The same applies to the first male millennials, who were born between 1979 and 1989. This means that the groups most affected are the baby boomers and their children – meaning that children may copy their parents' harmful behaviors with corresponding effects on their health. (www.mpg.de/13629156, in German)

Fire weakens tropical rainforests in the long term

Even ten years after a fire, tall, mature trees continue to die in larger numbers and the forests remain more vulnerable to fire and storm damage

Tropical rainforests are crucial for biodiversity and the climate, yet they are also highly vulnerable. An international team led by scientists from the Max Planck Institute for Biogeochemistry in Jena and based at the Tanguro Ranch research station in the Brazilian Amazon has found that the forest still shows signs of damage ten years after a fire. Even after this period, tall, mature trees continue to die in larger numbers since the air around the treetops in the decimated forest is drier and the trees consequently transpire more water than they can continue transporting in their leaves. They are then replaced by fast-growing species that store carbon significantly less efficiently. The forest was also found to contain significantly less biomass, and the trees – particularly those at the edge of the forest – were more vulnerable to storm damage. This is an important finding, as the Amazon rainforest is increasingly being broken up by large clearings. Finally, the scientists observed that grasses migrate into the forest, make it more susceptible to natural fires. However, there was also a positive finding: just seven years after the last fire, the rainforest was already using water just as effectively as the intact forest and was also forming the same volume of biomass, albeit at a lower level. (www.bgc-jena.mpg.de/www/index.php/PublicRelations/NewsSingle?jahr=2019&id=1561537574)

Controlled fires: an experimental area after a fire laid by scientists as part of a long-term experiment.

Photo: Tara Massad

Humanity's oldest workshop

Stone tools were presumably invented several times in different ways

Scientists from the Max Planck Institute for Evolutionary Anthropology in Leipzig have discovered the oldest-known systematically produced stone tools in northeastern Ethiopia. Under several meters of sediment, the researchers found hundreds of small stone chips and animal bones. These finds, which date back 2.6 million years, mark a turning point in tool production: until then, early humans had merely used simple stone hammers to smash nuts or shells. Afterwards, they began systematically striking larger pieces of rock to create smaller tools with sharp edges. These new discoveries have little in common with the stone tools found in Kenya that date back some 3.3 million years. The researchers therefore conclude that various hominins in different regions recognized the value of stone stools and invented them independently several times over. (www.mpg.de/13529015)

How humans began smoking cannabis

Findings prove that the narcotic was used 2,500 years ago in the Pamir mountains of western China

Farmers in eastern Asia have been cultivating hemp as an oilseed and fiber crop for millennia. However, most wild hemp species and the hemp varieties cultivated in the early days only contain small quantities of psychoactive cannabinoid compounds. For this reason, the question of when and how humans first realized that certain varieties of the plant had a narcotic effect has long been open to debate. A team of researchers from the Max Planck Institute for the Science of Human History working in cooperation with colleagues in China has now found tangible evidence. The researchers made the discovery while they were examining wooden censers found in 2,500-year-old graves in the Pamir mountains. These were found to contain a chemical signature identical to that of cannabis. The data also prove that the people in the Pamir mountains burned varieties of hemp with a higher THC content. These discoveries indicate that humans burned the narcotic plants at rituals performed in memory of the dead and inhaled the smoke. To date, it has not yet been clarified whether they cultivated cannabis themselves or deliberately collected plants with a higher THC content; neither is it known whether this society used cannabis in other ways. (www.shh.mpg.de/1338259)

Harmless weed: wild hemp covers wide areas of the Eurasian foothills from the Caucasus to eastern Asia; however, they contain hardly any cannabinoids.

Infanticide by mammalian mothers

Mammalian females sometimes know no mercy when it comes to the wellbeing of their own offspring

Among some mammals, most offspring are killed by others of their species. As a rule, the males kill their rivals' offspring in the competition for food or a mate. However, researchers at the Max Planck Institute for Evolutionary Anthropology in Leipzig have now discovered that the females of many mammalian species – such as meerkats and baboons – kill their competitors' offspring. This is particularly likely to occur when their successful reproduction is endangered by other young animals. Females can for example gain access to a burrow or enlarge their territory by killing the offspring of other females, thus driving them away. Sometimes, the females will even kill the offspring of their relatives: grandmothers may for example kill their grandchildren or aunts their nieces – even though they carry part of their own genome. The benefits for their own offspring must therefore at least compensate for this loss. (www.mpg.de/13710950)

Female meerkats kill the offspring of competitors to obtain advantages for themselves and their young. The victims are often the offspring of their sisters and daughters.

Photos: iStock (top), Alecia Carter (bottom)

The journeys of hoverflies

The animals also migrate long distances

Many animals move across the globe in response to the changing seasons. They include many species of insect – and new findings have shown that even hoverflies are numbered among them. Scientists at the University of Exeter and the Max Planck Institute of Animal Behavior in Konstanz investigated the migration patterns of two hoverflies species in the UK. They discovered that up to four billion of these insects migrate from the European mainland to the UK every spring and fly back in the fall. Such an enormous quantity of insects can pollinate billions of flowers in the UK, while their larvae can consume up to ten billion aphids. During their flight, the hoverflies also transport billions of pollen grains and distribute many tons of nutrients between the UK and Europe. Hoverflies could therefore hold a key to the preservation of biodiversity on Earth.
(www.mpg.de/13730049)

The marmalade hoverfly is one of 450 hoverfly species in Germany. Some adult insects overwinter here, while others fly to other regions in the fall.

Goliath's ancestors came from Europe

The biblical Philistines appear to have descended from people who crossed the Mediterranean Sea to Israel

The Philistines are mentioned in the Old Testament as the arch-enemies of the people of Israel. The story of the fight between David, a young Israelite, and Goliath, a gigantic warrior from the Philistine camp, is legendary. However, the ancient texts say little about the origins of this race. An international team of researchers led by scientists from the Max Planck Institute for the Science of Human History and the Leon Levy Expedition has for the first time examined genetic material from people who lived around 2,800 to 3,600 years ago in the port city of Ashkelon, which according to the Old Testament was one of the Philistines' five capitals. The analysis revealed that a European genetic component reached modern-day Israel at around the time the Philistines are believed to have arrived. This indicates that the Philistines' ancestors migrated across the Mediterranean and reached Ashkelon in the early Iron Age. However, these genetic components disappeared again within less than two centuries. Contrary to the accounts in the ancient texts, the newcomers probably married into long-established families with the result that their genetic traces were obliterated.
(www.mpg.de/13670046)

Searching for genetic traces: bones found in the Philistine cemetery in the city of Ashkelon provides clues to the origins of this biblical people.

Photos: Will Hawkes (top), Melissa Aja. With kind permission of the Leon Levy Expedition to Ashkelon (bottom)

Taking time to decide

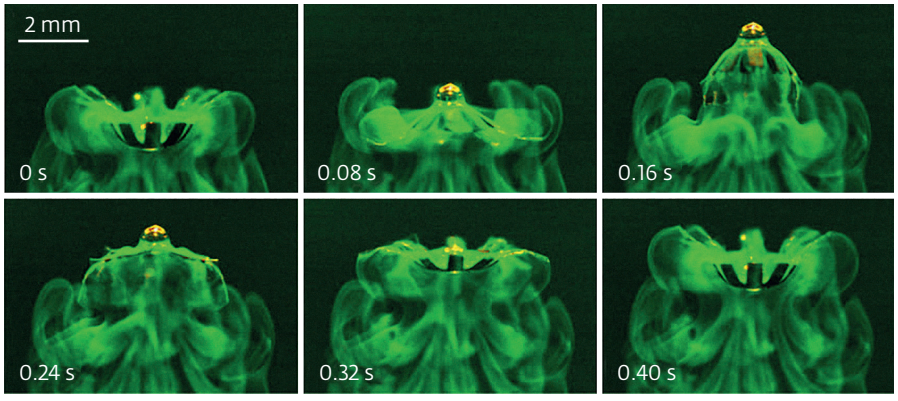
The brain replays decisions at accelerated speed

When we make decisions, various areas of our brain work together. According to researchers at the Max Planck Institute for Human Development in Berlin, some of these areas then replay these decisions at faster speeds during periods of rest. One such area is the hippocampus, which is located at the margins of the cerebral cortex and is also involved in learning and memory processes. During their study, the scientists used magnetic resonance imaging (MRI) to record the brain activities of test subjects while they were performing tasks that involved decision-making and during subsequent periods of rest. The results show that the hippocampus repeats the patterns of activity typical of the preceding decision-making phase while the participants rest – but do so more quickly than before. This ability on the part of the hippocampus appears to play a central role in whether decisions once made are stored in the long term. We can then draw on these when we have to made decisions or acquire new skills. (bit.ly/37OlswD)

Buoyancy for robot jellyfish

A magnetic device makes a tiny swimming robot move like a jellyfish

Marine animals have long been the inspiration for miniaturized submarines. Scientists at the Max Planck Institute for Intelligent Systems have now developed a tiny floating body just a few millimeters in size, which is made of rubber peppered with magnetic particles and looks and moves like a jellyfish. It can open and close with the help of an external magnetic field, thus enabling it to swim. In this way, the miniature swimming robot can also capture small particles. These swimming robots could for example be used to mix liquids, dig down into the beds of bodies of water or deliver medicinal substances to specific parts of the human body. (www.mpg.de/14132439)



A swimming robot performs the dance of the seven veils: a green dye shows the eddies that a jellyfish-like robot produces when a magnetic field opens and closes it like an umbrella to make it move forwards.

Photos: MPI for Intelligent Systems / Nature Communications 2019

Always play it safe!

Management personnel don't always make the best decisions to protect themselves

Superiors should always have an eye to the employer's needs when making decisions. However, bosses often choose the poorer alternative in order to protect themselves. This alternative may be more convenient, meet with less opposition or provide the opportunity to burden someone else with the responsibility should anything go wrong. In an anonymous study of 950 management staff from all hierarchical levels of a public institution carried out by the Max Planck Institute for Human Development, 80 percent of those surveyed said that at least one of the ten most important decisions they had made during the previous twelve months was defensive. On average, around 25 percent of the most important decisions were not made in the company's best interests. Initial results show that defensive decisions are even more common in DAX companies. According to the study, the most common causes are a deficient culture of error tolerance and a lack of opportunities to discuss ideas, opinions and concerns openly within the team. Management staff are more willing to make bold decisions if failures are not stigmatized and there is a good culture of communication. (www.mpg.de/13807856)

Inventory of the Universe

The European space observatory *Gaia* has surveyed approximately two billion stars with unprecedented precision – a treasure trove of data that has already changed our view of the Milky Way. **Coryn Bailer-Jones** from the **Max Planck Institute for Astronomy** in Heidelberg has been involved in the project since its inception. He compiled one section of the star catalog and, among other things, searched it for stars that have approached close to our solar system, or will do so in the future.

Graphic: ESA/ATG medialab; background image: ESO/S. Brunier

Viewing the Milky Way: the *Gaia* space observatory surveys the sky with unprecedented precision in three dimensions. The mission focuses on the stars of our galaxy.

TEXT **THOMAS BÜHRKE**

I sort of slipped into the *Gaia* project," says Coryn Bailer-Jones, recounting how the *Gaia* success story began. At the University of Cambridge, he had been working on how to effectively classify stars using large datasets: "The process I developed there was based on neural networks." After receiving his doctorate, the British-born scientist came to the Max Planck Institute for Astronomy in Heidelberg in 1998, where he initially researched brown dwarfs. It was a hot topic at the time, as celestial bodies of this kind had only been discovered a few years previously.

But then Bailer-Jones heard about the *Gaia* project and went to a meeting organized by the European Space Agency, ESA. There he caught the attention of one of the founders of the project, Michael Perryman, who immediately recognized his potential. "He convinced me to join *Gaia*," recalls Bailer-Jones, a decision that was to shape his future career.

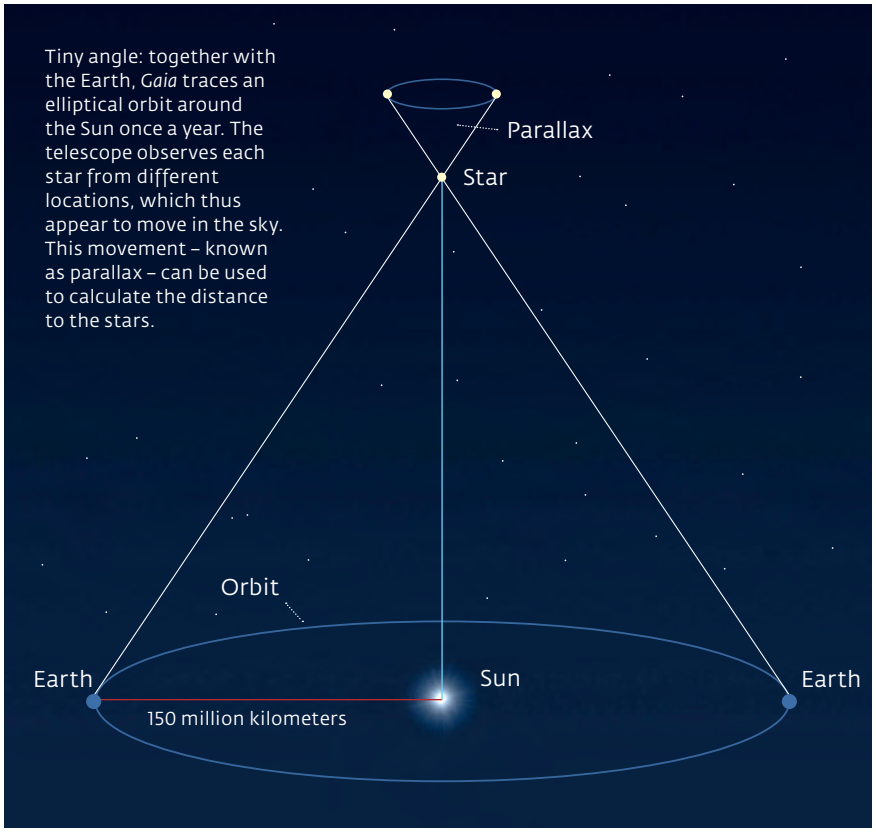
THE TELESCOPE THAT DOESN'T TAKE PICTURES

Launched at the end of 2013, the observatory has the largest camera ever deployed in space. But, unlike the *Hubble Space Telescope*, it doesn't take normal images of the sky. Instead, *Gaia's* task is to measure the positions, motions, luminosities, and colors of more than a billion stars in our Milky Way – a cosmic census of unprecedented magnitude and precision.

Gaia is so precise that, theoretically, it could detect the movement of a beetle on the Moon. It slowly rotates around its axis and provides images of the area of the sky currently in its field of view on a gigapixel camera. This consists of 106 CCD chips and measures around half a meter by one meter. At the end of the mission, each celestial body will have been measured about a hundred times.

The analysis of the *Gaia* data depends only on geometry, without making astrophysical assumptions about its targets. This makes use of *Gaia's* orbit around the Sun: the telescope orbits the Sun at a distance of approximately 300 million kilometers, staying close to the Earth, mapping the positions of the stars continuously. As it observes celestial objects from different locations during its orbit, their positions in the sky vary, describing a minute ellipse that reflects *Gaia's* movement around the Sun.

It's easy to visually demonstrate the effect. Hold your finger up in front of your face and look at it first with your left eye and then with your right. Your finger looks like it's jumping back and forth against the background. Your eyes correspond to two positions of *Gaia* on its orbit and your finger to a star. The closer the star is, the greater the perspective shift, which is referred to as "parallax". If you know the diameter of the orbit and have recorded the parallax of a star, you can calculate its distance.



Graphic: designergold after Mario Lehwald

Change of subject: originally, Coryn Bailer-Jones studied a particular type of star known as brown dwarfs. But then he found out about the *Gaia* satellite – and eventually joined the project.

In September 2016, the *Gaia* Consortium published the first catalog with about two million stars. As incomplete as this data set was, it was cause for celebration in the world of astronomy. But the second catalog from April 2018 surpassed expectations: it detailed the positions, brightness, parallaxes and movements of 1.3 billion objects. This treasure trove of data was made available by the *Gaia* Consortium and ESA to all researchers worldwide – an unprecedented act of generosity.

Within ten months of this data release, scientists had published more than a thousand scientific papers based on the data, the first appearing on preprint servers just a few hours after access was granted to the data archive. This was only possible thanks to extensive preparation.

In 2006, long before *Gaia's* launch, the ESA founded eight so-called Coordination Units (CUs). Astronomers and software specialists in these units prepare the data so it can be used for research without further processing. Two of these CUs are run from Heidelberg. The Astronomisches Rechen-Institute (ARI) at the Centre for Astronomy of Heidelberg University oversees CU3. Around a trillion individual measurements are processed and calibrated to yield astrometric values such as the positions, distances, and velocities of the stars.

CU8 was headed until mid-2018 by Coryn Bailer-Jones (he now concentrates more on the scientific and technical work within CU8). CU8's task is to distill astrophysical parameters from the *Gaia* data. "We work on the processed data results, so we have to wait for our colleagues," explains Bailer-Jones. "But of course, we started planning our approach long before launch." They used their expertise to develop software packages that would be compatible with each other, and tested this software using simulated data.

Astronomers with an interest in *Gaia* had long known in what form the data would appear. They had written their programs in advance and, to a greater or lesser degree, could start working with the data immediately after their release. The spectrum covers almost all areas of astronomy – from discovering asteroids in our solar system to identifying the motions of stars

RENDEZVOUS WITH A DWARF

In the 1970s, the space probes *Pioneer 10* and *11* and *Voyager 1* and *2* left Earth for the outer solar system. They are currently more than a hundred times further away from the Sun than the Earth and will continue into interstellar space. We are still in radio contact with the two *Voyagers*.

Should aliens ever spot one of the probes, they'll find messages on board. Recently Coryn Bailer-Jones together with a colleague from the Jet Propulsion Laboratory of the U.S. space agency NASA calculated when the probes will approach a known star in the next millions of years. The result: none of the probes will come closer than 0.6 light-years to any of the 7 million stars in *Gaia* for which we have the required data. The closest will be for *Pioneer 11* in 920 000 years, with a flyby of a dwarf star called TYC 992-192-1.

Photo: Wolfram Scheible

» The team around Coryn Bailer-Jones has used *Gaia*'s photometric and parallax data to determine the temperature of more than 160 million distant suns.

in streams through the Milky Way and surveying dark matter.

Coryn Bailer-Jones and his team have used *Gaia's* photometry and distances to determine the temperature of more than 160 million stars as well as the absolute luminosity and radius of 77 million stars. "We have produced the largest ever standardized dataset of the physical properties of stars," says the Max Planck astronomer. In addition to data on stars, the catalog contains asteroids, galaxies, and half a million quasars. The latter are extremely bright central regions of galaxies, each of which harbors a black hole. This draws in matter from its surroundings, which heats up and shines brightly.

Finding asteroids – small bodies within our planetary system – requires a very specific strategy, as, unlike stars, they move relatively quickly across the sky. To date, some 14,000 of these objects have gone online.

A CLOUD OF BILLIONS OF CHUNKS OF RUBBLE

While Bailer-Jones provides material for other scientists to make discoveries, he has also developed his own particular areas of interest over the years. One of these is the question of whether other stars have passed close to the Sun, going on to trigger comet showers.

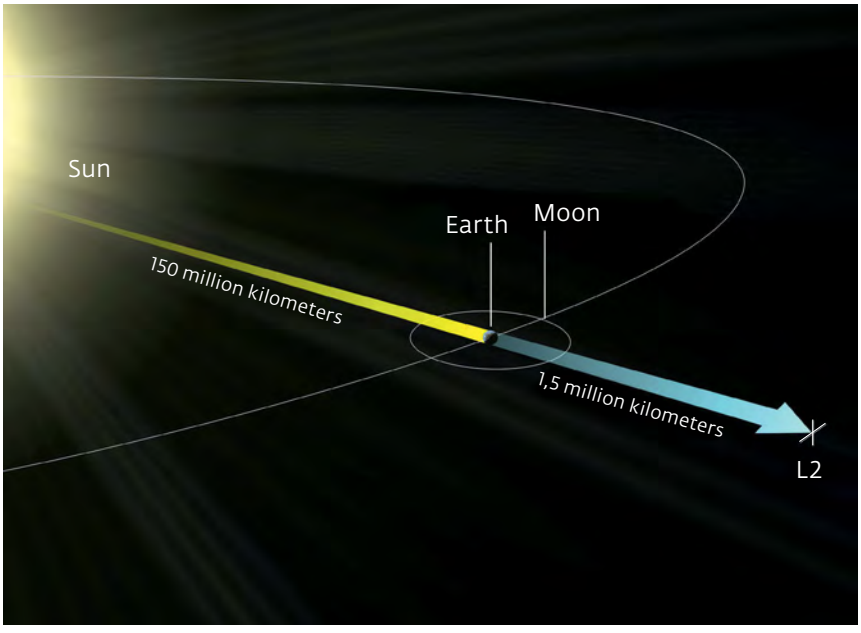
The idea has been around for a long time. Our solar system is surrounded by a sphere of billions of lumps of rock and ice. Astronomers call this the Oort Cloud. Normally, these objects orbit without being disturbed. However, if a star passes close to this cloud, its gravity can eject some of them from their orbits. If these pass close to the Sun, they heat up. Ice within them vaporizes, drawing dust with it. A comet is born.

As fascinating as we find their passage across the night sky, they can also have a devastating effect, for instance when a kilometer-sized lump collides with the Earth. Events of this kind have influenced the evolution of life on our planet. The extinction of the dinosaurs 65 million years ago has been attributed, at least in part, to the impact of such a cosmic body. We don't know, however, whether the visitor at that time was a comet from the Oort cloud or an asteroid from the inner solar system.

The *Gaia* data are uniquely suited to identifying stars that might have triggered such comet showers – or those that could do so in the future. The data can be extrapolated into the past as well as into the future. Astronomers suspect that the Oort cloud extends to 100,000 times the distance of the Earth to the Sun. That corresponds to one and a half light-years and, thus, about one third of the distance of Alpha Centauri, the nearest star to Earth.

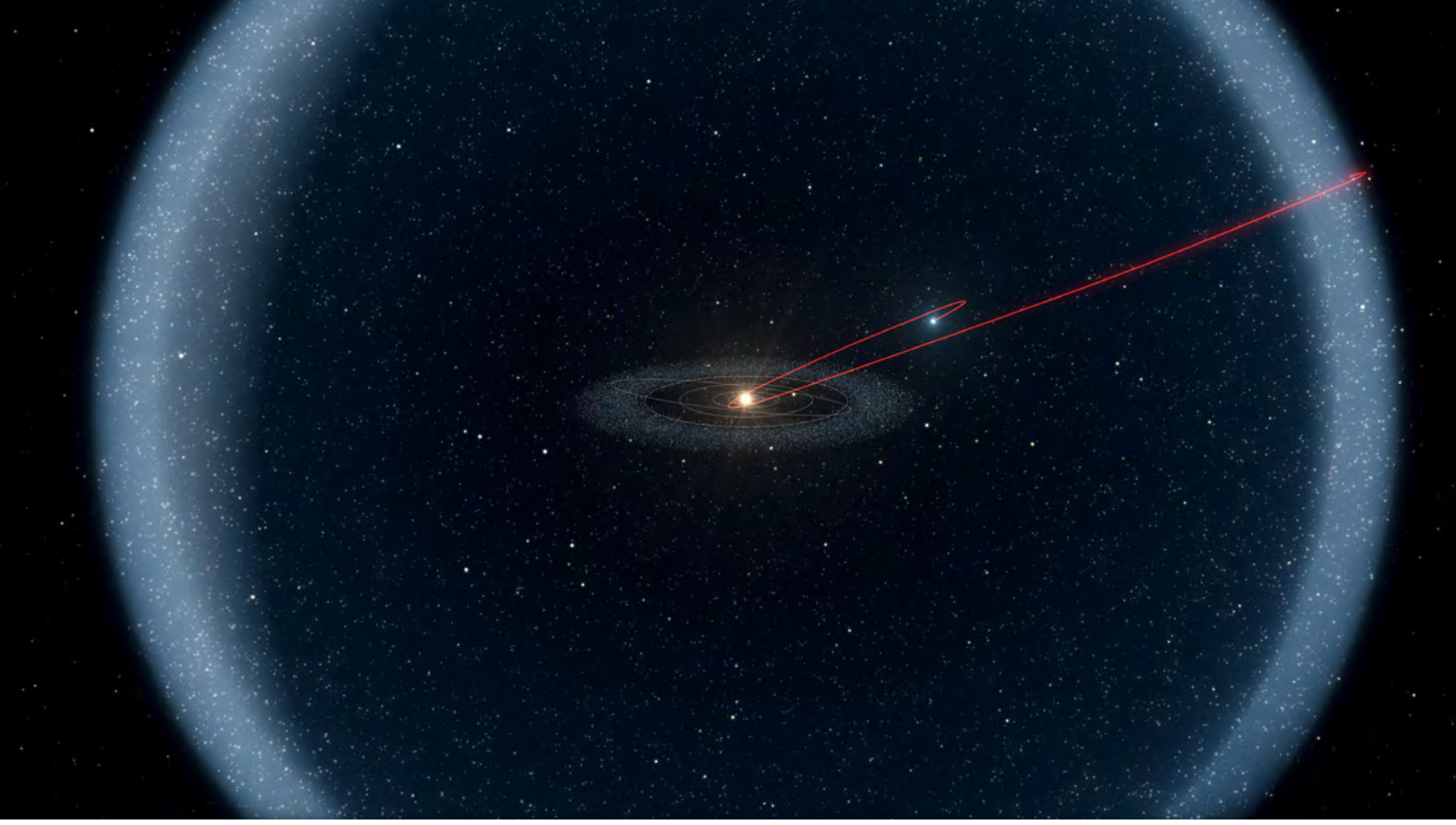
STELLAR STRANGERS PASSING OUR SUN

Coryn Bailer-Jones, therefore, searched the *Gaia* catalog for stars that had passed through this region of space, allowing him to systematically specify for



In outer space: a large number of science satellites are circling Earth. However, *Gaia* moves around Lagrange point 2 (L2). This is about 1.5 kilometers away from our planet, and permits observations that are largely free of interruption.

Graphic: ESA/NASA



Cosmic rubble field: about 70 years ago, the Dutch astronomer Jan Hendrik Oort theorized the existence of a spherical cloud of innumerable blocks of ice and rock. This Oort cloud is thought to extend up to one and a half light-years into space.

the first time how often this might occur. From a set of more than seven million stars that had the required data, he identified seven plausible intruders. The most interesting is a star called Gliese 710. "This is an old acquaintance of ours from previous research, but now we have much more accurate data on it," says Bailer-Jones.

According to his calculations, Gliese 710 will pass the Sun in 1.3 million years with a separation of only 14,000 Earth orbital radii. "It is also the star with the largest known impulse transfer to the Oort cloud," says the astronomer. Gliese 710 has only about 70 percent the mass of the Sun, but it moves relatively slowly, giving it enough time to eject cometary nuclei from their orbits.

It would, naturally, be a sensation if astronomers were to identify the star that caused the impact 65 million years ago. "But that's essentially impossible for several reasons," explains Bailer-Jones, as we can only calculate the orbits of stars accurately up to five to ten million years into the past or future.

Over longer periods of time, the associated errors of the calculations become too large. The accuracy of the orbits are limited both by the accuracy of the measurements, especially the radial velocities of stars, and by the gravitational field of the Milky Way, through which all of its stars travel. This gravitational field is generated not only by stars but also by large clouds of molecules and dust, and the enigmatic dark matter.

Moreover, *Gaia* only observes stars in a particular luminosity range: too bright and the detector is saturated, too faint and the telescope can't see them. However, we can estimate the number of these missing stars from other observations. With this method, Coryn Bailer-Jones has arrived at a statistical estimate according to which every 200,000 years one star on average travels past the Sun at a distance of no more than one and a half light-years. Many of these are dwarf stars, which, due to their low masses, barely disturb the Oort Cloud.

Given that several million years can elapse between the disruption of a comet's orbit and the arrival of a comet near to the Earth, his results indicate that the Oort Cloud is actually in constant turmoil. Even though Bailer-Jones will probably never catch the destroyer of the dinosaurs, he has made the first concrete estimate of how often stellar invaders penetrate the comet reservoir.

Another way that *Gaia's* treasure trove of data can be exploited for scientific analysis was demonstrated by the recent arrival of a mysterious messenger from the stars. On 19th October 2017, astronomers employing a telescope in Hawaii discovered a faint point of light moving across the sky. Initially, they classified it as just one more of the known 800,000 asteroids. But when they calculated the trajectory of the object, they were astonished.

It wasn't moving around the Sun in the same way as asteroids, but was flying out of our solar system at an extremely high speed of 95,000 kilometers per hour, almost perpendicular to the planetary orbital plane. It must have arrived from a distant star, and after briefly visiting the solar system, was already heading out on its interstellar journey. It was named 'Oumuamua, which in Hawaiian means 'messenger from the distant past'. >

Graphic: ESO/L. Calçada

Unknown messenger: in October 2017, researchers on Hawaii discovered an unusual celestial body that flew through our planetary system. Was it an asteroid or a comet? What is certain is that this object, 'Oumuamua, came to us from a distant star.

Graphic: ESO/M. Kornmesser

After the astronomers had identified 'Oumuamua as an interstellar traveler, they immediately alerted observatories around the world to examine it in detail while it was still visible. The scientists discovered that it must have an unusual shape, resembling either a cigar or a pancake around 400 to 800 meters in length or diameter. It also wasn't rotating around one specific axis, but was tumbling through space.

DID THE INTRUDER COME FROM VEGA?

Immediately, astronomers wondered where the intruder might have come from. The first orbital calculations pointed in the direction of the bright star Vega in the constellation of Lyra. However, over the course of a journey of about 300,000 years the stars have shifted considerably relative to each other, meaning that when 'Oumuamua set out it didn't do so from near Vega. Naturally, this was a perfect case for *Gaia*, as the observatory measures the positions and motions of stars with great accuracy.

"When I first heard about 'Oumuamua, I thought that one of my colleagues would already be working on it and would publish something within the next few days or weeks," recalls Bailer-Jones. The first attempts in the fall of 2017 were still based on the first *Gaia* catalog, which had too few stars for a comprehensive analysis. However, the situation didn't change quickly with the publication of the second catalog.

"In mid-July 2018, I received an e-mail from Karen Meech asking me whether I wanted to tackle the question of 'Oumuamua's origin," he recounts. Meech, from the Institute for Astronomy at the University of Hawaii, had led the 'Oumuamua research from the beginning.

Bailer-Jones quickly set to work, and within four weeks, together with colleagues, he wrote a paper in which he cited four candidate stars where 'Oumuamua's journey might have started more than a million years ago. This required another important observation: in June 2018, astronomers had discovered that 'Oumuamua apparently hadn't moved through the solar system solely under the influence of gravity. Near the Sun there must have been an additional force. Comets consist partly of ice, some of which is vaporized by solar radiation. Like a rocket, this provides them with propulsion. Although 'Oumuamua lacked some of the tell-tale signs of cometary activity, this remained the most plausible explanation for the additional force.

FOUR CANDIDATES LEFT STANDING

Only once Bailer-Jones and his colleagues had taken this effect into account could they correctly calculate its course and trace its journey back into the past. To do this, they also needed to

consider whether 'Oumuamua had been diverted on its journey to us by the gravity of other stars.

In their analysis, the team initially selected 7.2 million stars, 4500 of which were top candidates. The researchers calculated their motions over the past few million years, and further took into account all the uncertainties using a so-called "Monte Carlo" simulation. The procedure is a little like clay pigeon shooting in that each star is replaced by a swarm of stars differing slightly in trajectory.

In the end, Bailer-Jones and his colleagues settled on four distant stars as plausible origins for 'Oumuamua. One is the reddish dwarf star HIP 3757. 'Oumuamua passed close to it just over a million years ago. 'Oumuamua approached the Sun-like star HD 292249 even closer, 3.8 million years ago. It passed by two further candidates, about which little is currently known, 1.1 and 6.3 million years ago. In all cases, 'Oumuamua's trajectory was within a distance of two light-years or less.

Unfortunately we cannot prove that one of these candidates was 'Oumuamua's home star, not least because many other possibilities were not included in the analysis due to lack of a radial velocity measurement. It is also unclear by which mechanism 'Oumuamua was ejected out of its parent star system. "It could have been in a binary system and was flung into space by the gravity of one star when it came too close," explains Coryn Bailer-Jones. However, none of the four candidates is yet known to have a companion star. "It is also conceivable that a giant planet like Jupiter threw out 'Oumuamua."

But if the cosmic wanderer initially set off much more than five million years ago, all this speculation is moot. "If it was ejected a hundred million years ago, it has by now already traveled halfway around the center of the Milky Way, and retracing its route would be impossible," says Bailer-Jones.

Gaia's third data release will be in two years' time. The new catalog should contain the radial velocities of ten times more stars, as well as more accurate parallaxes and proper motions. This could lead to the identification of further candidates. So the search for 'Oumuamua's home country will continue, as will the many other investigations involving *Gaia's* data. "We've only just begun to sift through the immense treasure trove of data," says Bailer-Jones. "We'll be at it for decades to come." ◀

SUMMARY

- **The European astrometry satellite *Gaia* measures positions, magnitudes, parallaxes, and motions of more than one billion celestial bodies with unprecedented accuracy.**
- **This treasure trove of data enables in-depth insights into the structure and development of the Milky Way.**
- **Scientists can calculate the paths of stars through the Galaxy for millions of years into the past and the future.**
- **One project was to discover the origin of 'Oumuamua. The celestial body came from the vastness of space and recently entered – and left – our solar system.**

GLOSSARY

Asteroids, also known as minor planets or planetoids, are astronomical small bodies that orbit the Sun. They have diameters ranging from a few meters to about a thousand kilometers.

Astrometry is a branch of astronomy that involves precise measurement and calculation of the positions of the stars in the sky. This branch, also referred to as positional astronomy, is the basis of much research in astronomy, especially into celestial mechanics. From the astrometric measurements one can infer the parallax, or distance, to a star, as well as transverse velocity.

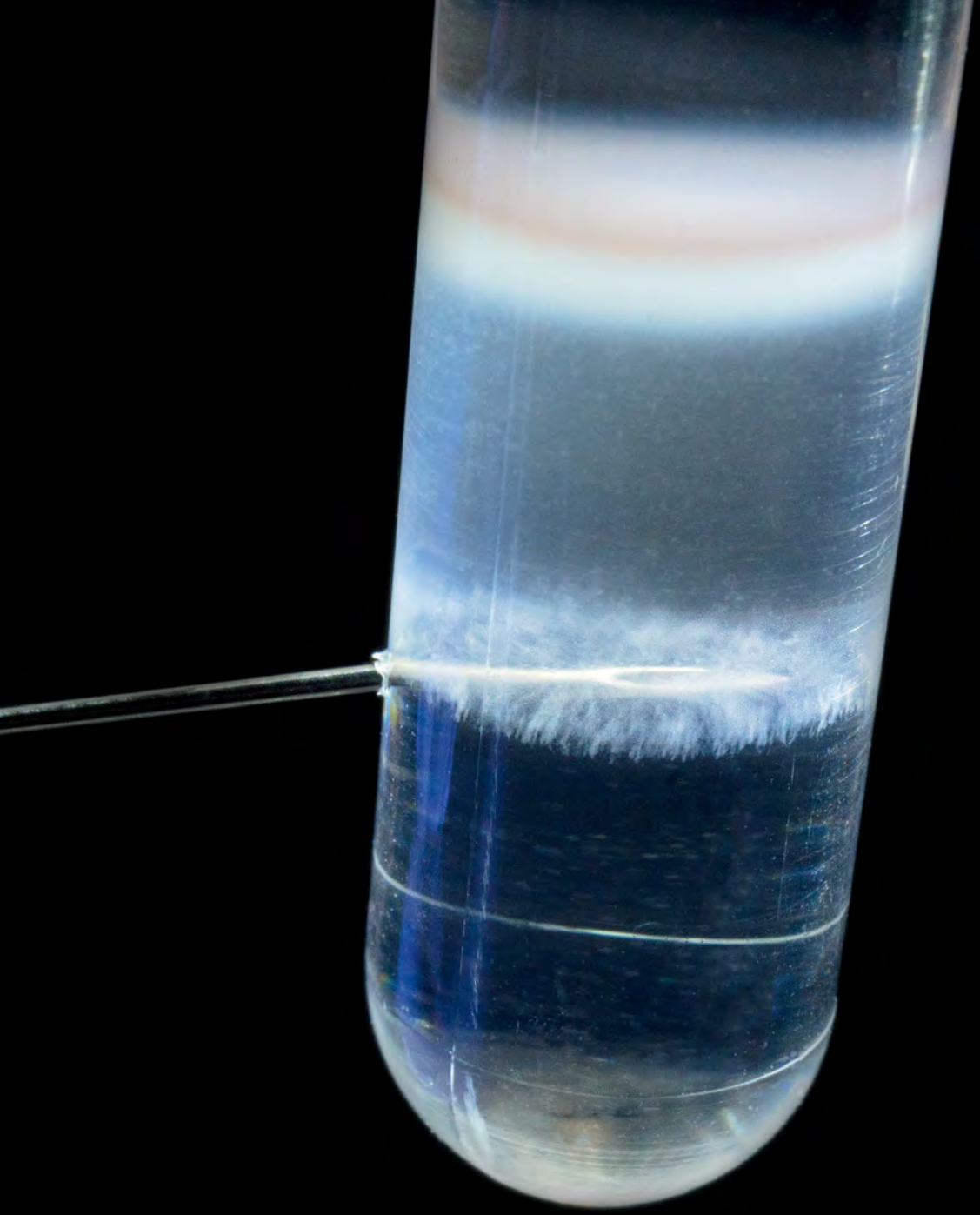
Radial velocity is the movement of a star directly towards or away from the observer. This velocity can be measured using the Doppler effect, which shifts the wavelength of light approaching an observer into the shorter wavelength blue region of the spectrum and into the longer wavelength red region of the spectrum when moving away from an observer.

Tiny giants

Viruses are usually incredibly small, but some deviate from the norm and reach sizes greater than that of a bacterial cell. **Matthias Fischer** from the **Max Planck Institute for Medical Research** in Heidelberg is one of a small number of scientists working on giant viruses of this kind.

TEXT **STEFANIE REINBERGER**

Photo: Wolfram Scheible



In the laboratory of Matthias Fischer at the Max Planck Institute in Heidelberg, vials containing water samples are lined up against one another, each containing a whole world of aquatic single-celled organisms and viruses. The labels reveal the origins of the samples: Guenzburg, Kiel, but also more exotic locations such as Tallinn or the British Virgin Islands. "The collection is the result of many years of work," the microbiologist explains.

Although they look like nothing more than vials of water to the naked eye, the samples are actually teeming with life, which only becomes visible when viewed through a microscope: countless tiny dots are scurrying back and forth. "The smaller ones are bacteria, which are devoured by larger cells that have a nucleus. These so-called protists are the reason we created the collection in the first place," Fischer explains. Indeed, these protists are susceptible to attack by giant viruses, which are Fischer's

As giant viruses are about the same size as bacteria, it is almost impossible to purify them by filtration only. However, as viruses and bacteria have different densities, they form layers when spun in an ultracentrifuge. Scientists can then extract the viral band using a syringe and needle.

Global microcosms: each vial teems with single-celled organisms and viruses isolated from different environments. Wheat grains in the vials stimulate the growth of bacteria, which in turn serve as a food source for protists.

main interest. Together with his colleagues, he therefore screens the waters of the Danube, the Baltic Sea or the Indian Ocean for single-celled organisms that can act as hosts for giant viruses.

A VIRUS DISGUISED AS A BACTERIUM

These viruses may be tiny by human standards, but they are the giants of the virus world. Indeed, they are so much bigger than other viruses that scientists initially mistook them for bacteria. The first example of these viral giants was discovered by researchers in 1992 in an amoeba found in the water circuit of an industrial cooling tower in Bradford (UK). Assuming the virus to be a bacterium, the researchers initially named it *Bradfordcoccus*.

It was not until 2003 that researchers at Aix-Marseille University realized that they were actually dealing with a virus – one that was even bigger than some bacteria, with a diameter of 750 nanometers. Moreover, for a virus, it also had a huge genome: with 1.2 million base pairs, it was twice as big as the largest known virus genome to date and encoded some 1,000 genes. By comparison, influenza viruses and HIV carry about a dozen genes.

The French researchers gave the giant a new, more suitable name: mimivirus, from mimicking microbe – a virus that pretends to be a bacterium. Many other giant viruses have since been discovered in oceans, salt lakes, sewage treatment plants, tree barks, forest soils and permafrost. Although the virus particles differ widely in terms of their genomes, structures and shapes, they have one thing in common: they blur the previously firmly established boundary between cells and viruses.

The unwritten rule among virus researchers was that viruses had a maximum diameter of 200 to 300 nanometers. Virus experiments were therefore carried out using small-pore filters that only allowed representatives meeting the common size definition to pass. As a result, giant viruses were simply filtered out of the sample material along with bacteria and other single-celled organisms – and therefore quite simply overlooked. "Ultimately, the fact that they remained undiscovered for so long is caused by our own preconceptions. One of the lessons giant viruses teach us is therefore to always question our assumptions if we genuinely want to discover something new," says Matthias Fischer.

A GROWING ARMY OF GIANT VIRUSES

Although giant viruses have received greater attention in recent years, there are still only a few scientists worldwide who study them. This may be due to the exotic nature not only of the viruses themselves, but also of their host organisms. Protists play an important role in the world's food webs, but only few species are of medical or economic significance, such as the pathogens responsible for malaria, sleeping sickness and toxoplasmosis.

So far, hardly any research has been conducted into the majority of protists, many of which are also hosts of giant viruses. The circle of colleagues with whom Matthias Fischer can discuss ideas and exchange knowledge and methods is thus rather small. Often, the

Photo: Wolfram Scheible

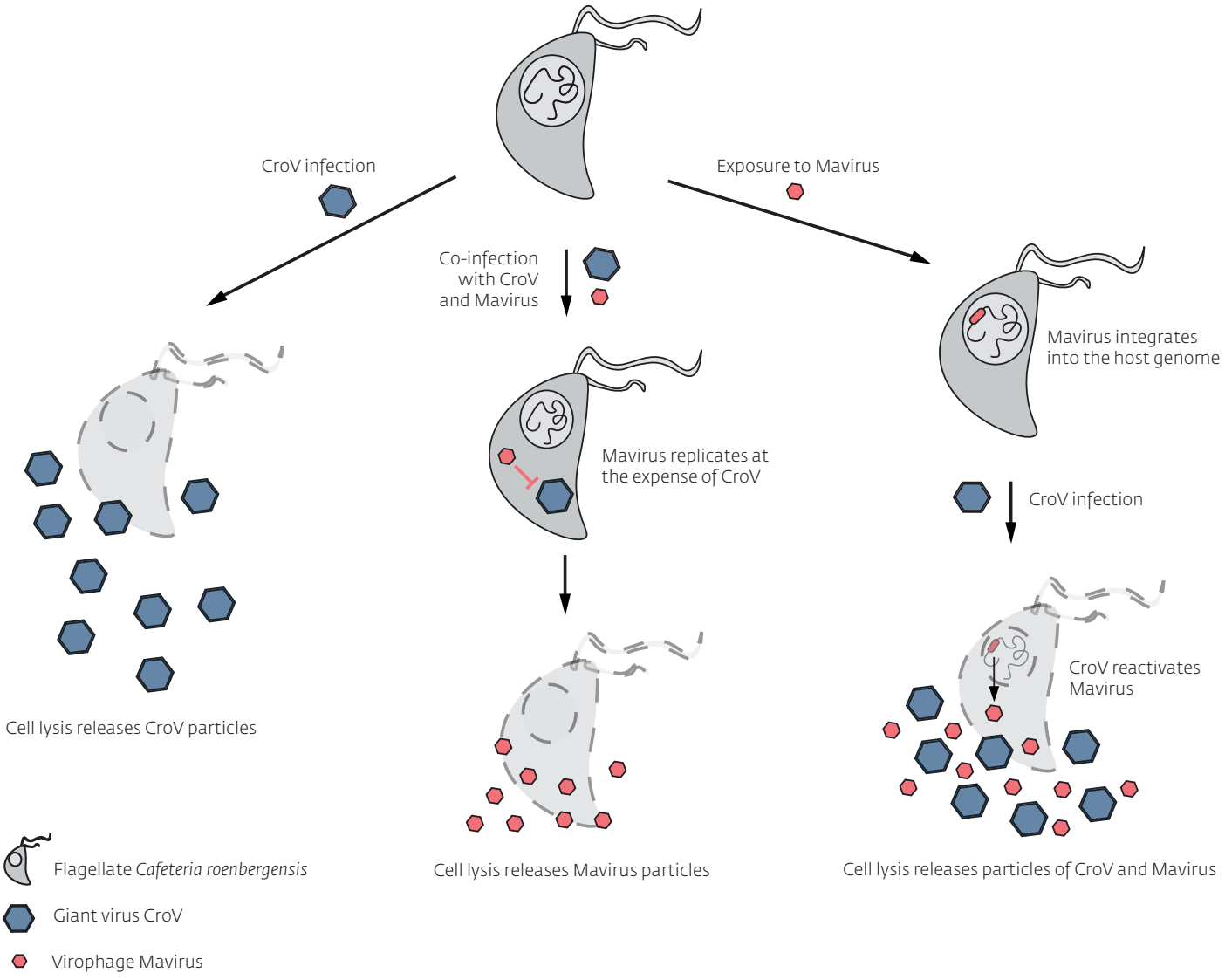
Matthias Fischer uses pulsed-field gel electrophoresis to separate the genomes of giant viruses for further analysis.

standard laboratory techniques don't work for giant viruses or their hosts. In that case, Fischer has to spend a great deal of time finding alternatives – or new techniques altogether. "On the upside, however, there's a good chance we'll stumble across something new and unexpected in each of our projects," he says.

You could describe the 42-year-old microbiologist as a modern-day discoverer. He has a sparkle in his eye as he talks about the unsolved mysteries of giant viruses, and you can sense his eagerness to crack as many of them as possible. And there is no shortage of riddles surrounding these giants. One question is how many different types of giant viruses remain to be discovered, another one is their unresolved evolutionary origin and why they are so big in the first place.

For some time, the question as to their origin has divided the small community of researchers into two camps. Some believe the giant viruses emerged from cells that gradually lost most of their genetic material. With the remaining genes, the diminished cells were no longer able to multiply on their own and became dependent on the machinery of other cells. Giant viruses may therefore be the remnants of an otherwise extinct domain of life, alongside bacteria, archaea and eukaryotes (cells with a nucleus). "However, our research findings – and those of colleagues – suggest that giant viruses rather evolved from smaller viruses,

Photo: Wolfram Scheible



One host, two viruses: when the giant virus CroV infects its host, the flagellate *Cafeteria roenbergensis*, it multiples inside the cell and kills it at the end of the infection cycle (left). If the flagellate is simultaneously infected with the virophage Mavirus, the giant virus is unable to produce new infectious particles and instead, Mavirus replicates. Although the infected cell ultimately dies, other host cells are protected from CroV infection by the action of Mavirus (center). Mavirus alone cannot multiply in the flagellate, but it incorporates itself into the host's genetic material, where it can persist for many generations until CroV infection reactivates the virophage (right).

continually incorporating new genes from other organisms while also duplicating their own," says Fischer.

NEW TERRITORY FOR RESEARCHERS

Fischer's personal interest in viruses was sparked towards the end of his degree in biochemistry in Bayreuth, when he came across a scientific article on the diversity of viruses in the ocean. "I was absolutely fascinated because, until then, I had no idea that every liter of seawater contains several billion virus particles," Fischer recalls. He then contacted the author of the article, Curtis Suttle, in Vancouver. "I applied for a doctoral position, booked a flight and stayed for six years."

This work set the course for Fischer's further scientific career. The first years in Vancouver demanded a great deal of perseverance. The young doctoral student from Germany set out to study a new virus, *Cafeteria roenbergensis* virus

Graphic: M. Fischer/MPI for Medical Research

» The small virus operates like a defense system, protecting the flagellates from the giant virus. Not all viruses are therefore parasites of their host organisms; rather, some viruses exist in a mutually beneficial symbiosis with their hosts.

(CroV), which later turned out to belong to the same family as the mimiviruses. CroV infects a single-celled organism by the name of *Cafeteria roenbergensis*, a widespread species of marine zooplankton that feeds on bacteria and is one of the most numerous predators on the planet.

TOXIC DNA

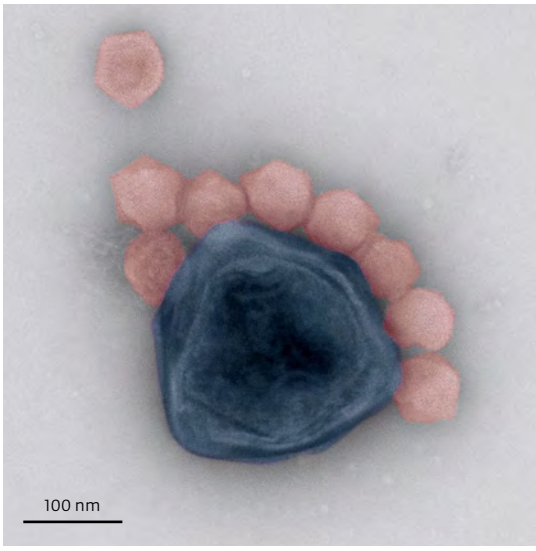
At the time, researchers had known about the giant virus for a number of years but hadn't investigated it further. It was Fischer's job to change that. Initially, however, luck didn't appear to be on his side: he planned to decode the viral genome by incorporating pieces of it into bacteria in order to multiply and decipher them piece by piece – but this experiment failed repeatedly. The viral DNA was apparently toxic for the bacteria. A few years later the arrival of new sequencing technologies would allow him to finally read more than 600,000 letters of the virus genome.

In the meantime, Fischer had other problems to deal with: the virus yield from his infection experiments was often so low that he couldn't use it for further studies. But this circumstance ultimately led to an important discovery, which continues to occupy the scientist to this day. Fischer realized that CroV itself is infected by a much smaller virus – a so-called virophage by the name of Mavirus. As Mavirus only multiplies within a host cell that is simultanously infected with CroV, it does not harm the host. On the contrary, because Mavirus acts as a parasite of CroV, it prevents the production of new giant viruses and thereby helps its host *C. roenbergensis* to survive albeit indirectly. This single-celled organism typically dies upon infection with CroV, which is a lytic virus: once it has multiplied in sufficient quantities, the host cell bursts and the viral offspring are released. However, when CroV is parasitized by the smaller Mavirus, the cell releases new Maviruses particles instead of CroV particles. Although this doesn't make a difference for the infected cell, it matters for its not yet infected neighbors: they are spared from infection with CroV and the population survives.

PROTECT YOUR KIN

"The small virus therefore acts like an altruistic defense system for the host cell in order to protect members of the same species against the giant virus," says Fischer. "Among microorganisms, it seems to be a widespread principle that single individuals are sacrificed to ensure the survival of the population as a whole." Not all viruses are therefore parasites of their hosts; rather, a mutually beneficial symbiosis exists between *C. roenbergensis* and Mavirus.

Fischer wanted to know more about this unusual alliance. Together with his team, the scientist began to study the infection cycle of Mavirus in greater detail. In the process, the Heidelberg-based researchers made an astonishing discovery: the small virus uses a protein known as an integrase to insert its own genetic material into that of the host cell. So far, this enzyme had only been



Particles of the giant virus CroV (blue) and the Mavirus virophage (red, false color).

Photo: M. Fischer/MPI for Medical Research

known to occur in retroviruses such as HIV and related jumping genes – known as transposons – but not in DNA viruses such as virophages.

For Mavirus, this appears to be a good strategy: if the virus does not rely on CroV for the incorporation of its genetic material, it can be passed from one cell generation to the next even without the giant virus. "This ensures that Mavirus is already present when a suitable giant virus infects the host cell," says Fischer. For multiplication, however the virophage depends on the giant virus and its replication machinery.

PARASITES ARE OMNIPRESENT

But does the behavior Fischer observed in the lab really play a role in natural ecosystems? To answer this question, the researcher analyzes *C. roenbergensis* genomes from various water samples. So far, he found Mavirus in all of them. And that's not all: other virophages are also present in the single-celled organism's genetic material. Some of the incorporated DNA is very similar to that of Mavirus, while others represent hitherto-unknown virophages. Moreover, some of the virophage genomes are interrupted by transposons. In other words, even virophages – which are parasites of parasites – have their own parasites.

Step by step, Fischer and his team are decoding an interwoven chain of single-celled organisms, viruses and parasitic DNA elements. For him, this is the crucial point. "Parasites that infect other parasites are a widespread phenomenon in nature," says Fischer. "They are a key driver of evolutionary processes." The reason for this is that every parasite leaves traces in its host, either because the host needs to adapt or because it assimilates some of its parasite's genes and capabilities.

Accordingly, parasites provide their hosts with new genetic information – and therefore new traits. This so-called horizontal gene transfer by viruses plays a central role in the evolution of microorganisms.

It may also have been the driving force for the evolution of giant viruses from smaller viruses. Ultimately, however, this principle applies to all living things, as the human genome is also littered with parasitic elements, such as transposons or remnants of viruses. In other words, viruses and other parasites played a substantial role in human evolution, too. "This is an incredibly exciting realization," says Fischer. "Although our research into giant viruses and virophages seems exotic at first glance, it provides us with deep insights into universal processes of evolution." ◀

SUMMARY

- **Giant viruses can contain over 1,000 genes and presumably evolved from smaller viruses, adopting their hosts' genetic material as well as duplicating genes of their own.**
- **Giant viruses are primarily parasites of single-celled eukaryotes (protists). However, they are sometimes infected with parasites themselves: virophages use the giants in order to multiply within the host cell.**
- **With the ability to incorporate their own genes into foreign genetic material, some viruses modify their hosts' genome, thus acting as a driving force of evolution.**

GLOSSARY

Giant viruses: These unusually complex viruses primarily infect single-celled eukaryotes. The largest specimens are approx. 2 micrometers long and contain over 1,000 genes, whose functions render giant viruses independent of the host cell in many biochemical processes. The particles (capsids) of giant viruses are made up of multiple layers consisting of hundreds of proteins, with special exit portals for the packaged virus genome. Despite their global distribution and diversity, the ecological role of giant viruses is still unknown.

Transposons: DNA fragments that can alter their position in the genome. They are also referred to as "jumping genes," although they often contain multiple genes. Transposons that multiply via an RNA intermediate are known as retrotransposons. These are probably also the origin of retroviruses, which incorporate themselves into the host's genetic material but can also infect other hosts by forming infectious virus particles.

Virophages: So far, only a handful of virophages are known. In addition to Mavirus, examples include Sputnik and Zamilon, which are parasites of mimiviruses. Virophages can only multiply in host cells that are infected with a suitable giant virus at the same time. They replicate at the expense of giant viruses by hijacking some of their enzymes. In other words, virophages are parasites of giant viruses and therefore beneficial to their host cells.

A researcher on the road: Anja Feldmann loves her work and travels a great deal. However, she sometimes takes a break and plays a computer game to clear her head.

A tour de force on data highways

Today, the Internet is just as much a part of our everyday life as our refrigerator. Yet researchers are constantly working to develop it further so that it can continue to function despite all the innovations. **Anja Feldmann**, Director at the **Max Planck Institute for Informatics** in Saarbruecken, is one of them. However, there are some problems that she can only solve when she focuses her entire attention on her hobby.

Photos: Stills from the film about Anja Feldmann from: Vodafone Stiftung für Forschung

TEXT **KLAUS JACOB**

She knows all the clichés: computer scientists are nerds; they hammer away incessantly on their keyboards in their hoodies and only rarely emerge from their dark basement rooms. They survive almost entirely on fast food, only reach for a comb and soap when they absolutely have to – and, of course, they are male.

Anja Feldmann embodies the opposite of all these prejudices. The 53-year-old computer scientist works in a bright office on the fifth floor with large windows looking out onto a green view. She works long hours and is enthusiastic about her subject, but she's more than just a scientist. In her view, constant work does not necessarily increase productivity. She claims that after taking a break, you see things in another light and can achieve "three times as much." That's why she sometimes gets intensively involved in a computer game during the course of the day, although she spends most of her free time at an equestrian center.

Her eyes light up as she shows me photos of her three horses on her cellphone. Horse-riding is her way of relaxing "and clearing my head." Besides being at home in the saddle, she sometimes also sits on the seat of her own carriage. This allows her to take visitors who are not able to ride themselves.

A TASTE DEVELOPED AT SCHOOL

Anja Feldmann has succeeded in forging a career for herself in a male-dominated subject area. However, she doesn't feel that obstacles are placed in women's paths in this field per se. "I personally tended to be treated favorably, since mentors opened doors for me," she says. It is not in her nature to give lengthy answers and to talk a lot about herself. Instead, she always gives brief, precise responses to my questions. Her manner has brought her a long way, and she is now one of the leading researchers in her field worldwide. She has won several prizes, including the Leibniz Prize, which is worth 2.5 million euros, and which is the most important research prize in Germany. She has been Director at the Max Planck Institute for Informatics in Saarbruecken since 2018.

Her career choice is not one that runs in the family. Her father worked as a sales engineer, while her mother was a housewife before working as a shop assistant. A basic course in computer science in senior grade gave her a taste for the subject. However, she also loved chemistry. When deciding what to study, she couldn't make up her mind between the two subjects. She finally decided on computer science since it

» As with car traffic, when it comes to the Internet, the aim is to avoid jams. Here, too, the framework conditions are constantly changing, with an ever-increasing number of users, connected devices, and new applications.

appeared that getting a doctorate was virtually mandatory in the field of chemistry and she did not want to commit herself to doing one right from the start.

As a holder of a scholarship from the Studienstiftung des deutschen Volkes, the "Study foundation of the German People", she had the opportunity during her course of study to attend summer schools, such as on Lake Constance or in Italy, and to gain her first international experience. She wrote her diploma thesis in Paderborn under the supervision of Thomas Lengauer, whom she would meet again decades later. Lengauer moved to the Max Planck Institute for Informatics, where he worked until about two years ago. It was his post that was recently given to Feldmann.

THE INTERNET NEEDS PLANNING, JUST LIKE ROADS

After her diploma thesis, Feldmann wanted to branch out into something new. She had grown up in Bielefeld and studied in Paderborn. Now, she looked to the U.S. as her next destination. She originally intended to spend a year there, but it turned into ten.

She gained her doctorate at the Carnegie Mellon University in Pittsburgh, Pennsylvania. This elite university is considered one of the most prestigious institutions in the field of information technology. After her doctorate, she was again faced with a decision: to return to Germany or to gain practical experience in the industrial field in the U.S. She was offered a job at AT & T Bell Laboratories, which are renowned worldwide for their outstanding information technology research. It was an offer she couldn't refuse.

It was here in New Jersey that she found the research topic that has been the focus of her work ever since: the Internet. For people who are not specialists, it is probably hard to understand how anyone can spend decades researching nothing but global data flows. After all, there are probably very few people who stop to ask themselves how the Internet actually works. For a long time now, the Internet has been just as much a part of our everyday lives as our refrigerator. However, a great deal of planning and work goes on behind the scenes.

Anja Feldmann likes to compare the data network with road networks: both of them require constant planning since the details change on a daily basis. Sometimes, simply changing the way a traffic light is switched, for example in order to give right of way to a tram, is enough to create a traffic jam. Then a large number of drivers might look for new routes and drive through residential areas, meaning that traffic planners are needed. And this is just one very small planning element in the gigantic road network. In short, the work never ends. The same applies to the Internet, which is subject to constant further development.

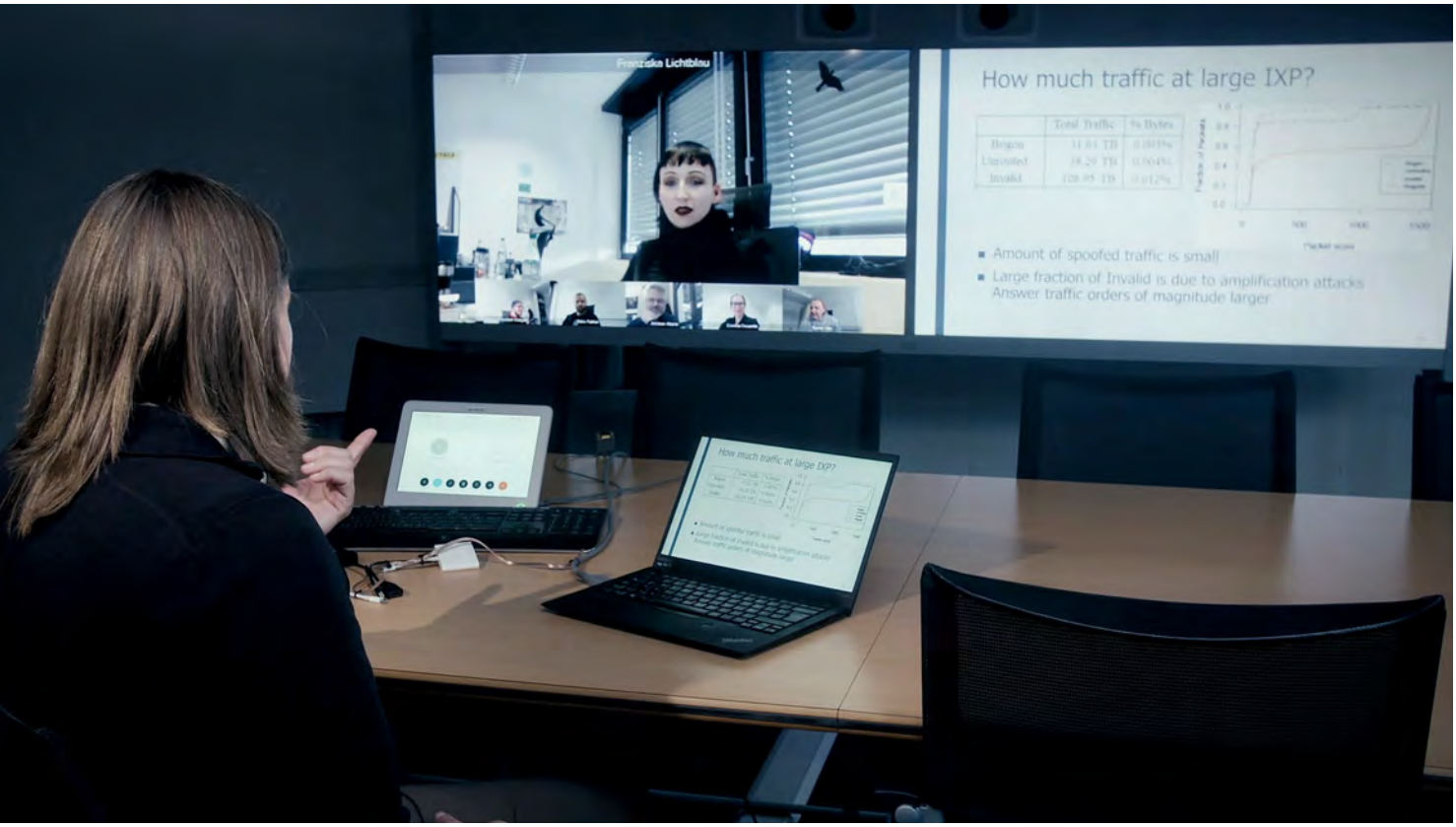
As with road traffic, when it comes to the Internet, the aim is to avoid jams. Here, too, the framework conditions are constantly changing, with an ever-increasing number of users, connected devices, and new applications such as Netflix or YouTube, which generate more traffic. Last but not least, Internet users should continue to enjoy wide-ranging freedom. In fact, it's amazing that the Internet continues to function at all. "Originally, it was no more complicated than five supercomputers," Feldmann explains. Then changes were made and services were expanded and patched in order to retain control over the increasing data flows. This didn't always yield the best results.

If the pioneers had known just how big their creation would become, they might have opted for another concept. Some experts have already thought about how to build up an entirely new network without the flaws of the current system. Feldmann, too, has been involved in such studies, which are an investment in the future. Today, this is almost entirely impracticable, particularly since it would currently be almost impossible to transfer all the data from the old system to the new one in the blink of an eye. However, this level of speed would be necessary in order to avoid complete chaos. That's why for now, we'll have to stick with the old version, which has been repaired many times over. As Feldmann casually puts it, "Never change a running system."

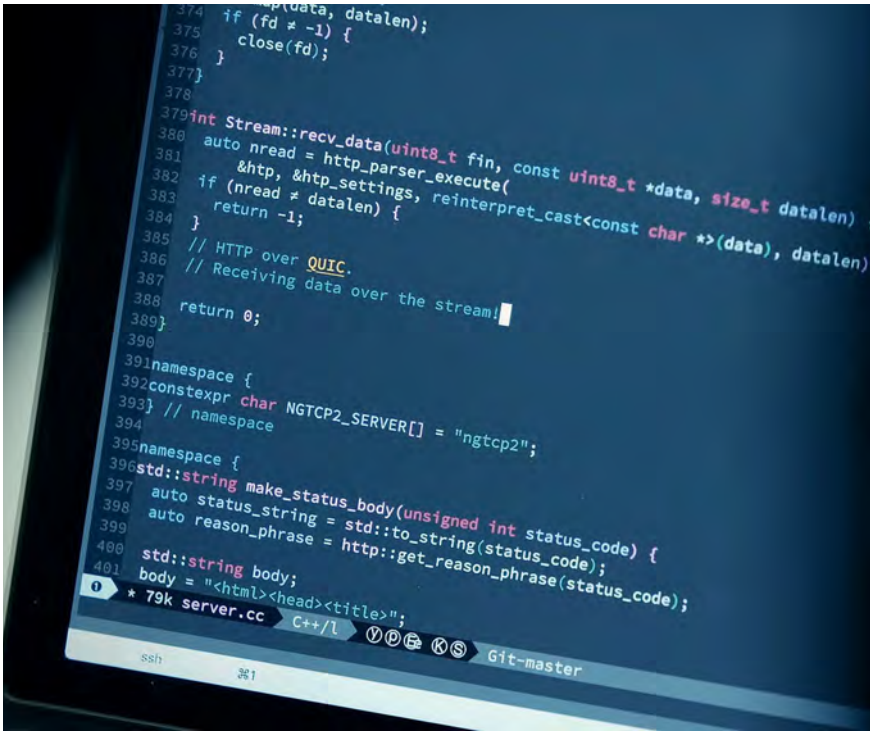
DATA SHOULD NOT TAKE A LONG DETOUR

However, the network "has become so complex that we can no longer easily understand it, which is why we need to analyze it." That's why she first looks for bottlenecks, jams and data loss in the data flows in order to find solutions. The purpose of her work is to ensure that data does not need to make long detours. After all, it makes no sense for an email to be sent from Hamburg to China before it finally arrives in Berlin. Every detour enlarges the flow of data and increases the risk of the lines becoming blocked.

Feldmann's field of research also includes security, which is of considerable importance. After all, the Internet has long since become an essential part of



Traffic planning for the Internet: Anja Feldmann discusses how to prevent data flow traffic jams with colleagues from all over the world. However, the researchers also have to program in order to check whether the concepts really work.



Photos: Stills from the film about Anja Feldmann from: Vodafone Stiftung für Forschung

society, just like blood circulation in the human body. By way of clarification, Feldmann asks two simple questions: "Would we still have power without the Internet? Would we still have water?" In fact, hardly anything functions nowadays without the global flow of data. The entire infrastructure would collapse. "We must be aware of the fact that we depend on this system," she says. And there is a high risk of a crash: "I have no doubt that if certain people wanted to, they could bring down the network tomorrow. And we're not just talking about state operatives."

After a decade in the U.S., she returned to Germany, in part because she wanted to be closer to her family and friends, but also because by that time, she had decided that she wanted to obtain a professorship. In fact, she was given one immediately, at the University of Saarbruecken, just a stone's throw away from where she currently works. However, she stayed there for just two-and-a-half years. She was headhunted by both the Technical University of Munich and the ETH Zurich. Feldmann decided to opt for Munich – "a gut reaction," in her words. "I want-

A healthy distraction: while riding, here on her mare Fontana, Anja Feldmann has to stop thinking about work and focus all her attention on the horse. Afterwards, she can find an even better solution to certain technical problems.

ed to stay in Germany and work in a larger city." She took over the chair of network architectures.

She enjoyed living in the cosmopolitan Bavarian city, as well as the fruitful collaboration with the Leibniz Supercomputing Center. "I didn't think that I would leave," she says. However, Deutsche Telekom then established an endowment professorship at the Technical University Berlin, with excellent facilities. Feldmann was so attracted by the combination of industrial company and university, practice and theory, that she threw her plans overboard. She hoped to gain an even better insight into current network problems by collaborating with the company. She moved to Berlin 13 years ago.

In Munich, Feldmann started to ride. However, the move to Berlin put an end to this chapter in her life for the time being. She threw herself into her work. Overall, she loves working with students and doctoral students from all over the world as well as her research and teaching activities. At some point, her Berlin doctoral students presented her with a rocking horse. It was a subtle hint that she should not neglect her personal life. The hint was taken: Feldmann started to take riding lessons again, and later even bought her own horse.

HORSE-RIDING AS A HOBBY, BUT A SERIOUS ONE

"I thought, I can't have pets, since I'm out and about so much," she says. However, a horse lives in a rented stable and is given all the everyday care it needs, allowing Feldmann to spend a week away without any worries. She now owns three horses: a mare, who is also trained for dressage, and two geldings, which she bought as foals. Giving three animals the care and attention they need is a challenge that Anja Feldmann is happy to take on. When she is not traveling, she spends many of her evenings riding or working in the stables. "I often get impatient at around 6 or 7 in the evening because I want to go and see my horses."

While the computer scientist rides as a hobby, she takes it very seriously. She wants her horses to have all-round training and to be able to tackle small jumps in the field and master the basics of dressage. They also need to be able to draw a carriage. For her, the fact that very different qualities are needed in horse-riding than at her place of work means that her hobby offers a healthy balance.

"When I'm with my horses, I have no time to think about computer prob-

Photos: Stills from the film about Anja Feldmann from: Vodafone Stiftung für Forschung

» She also wants to use her enthusiasm to recruit young people to her subject. She aims to awaken pupils' and students' curiosity, particularly since this field is becoming increasingly important.

lems. They demand my full attention." This becomes clear when you take a carriage ride with her, for example with her gelding Phoenix. At first, she didn't want to buy him at all, but was unable to resist when she actually met him. While driving the coach along the lanes through the fields, she is constantly focused on the horse to make sure that it doesn't just do whatever it wants. This is essential, since she sometimes meets a tractor on the narrow lanes and has to turn the carriage around quickly.

In Berlin, at the "Intelligent Networks and Management" endowment chair, Feldmann worked side by side with Telekom staff members. The focus of her work was also to optimize the company's network infrastructure. "We contributed a large number of useful ideas that saved the company money," she says. It was then that she came up with the idea of virtualizing home gateways, for example. This makes it possible to use a private router publicly with a second channel. Today, this concept is used by companies such as Telekom, Vodafone and O2.

The endowment chair expired after around seven years. This was the time when everything revolved around apps and nothing else. "A new app, a new app," she says, shrugging her shoulders a little ironically. She decided to stick with the Internet as the focus of her work and with her professorship at the Technical University Berlin.

By that time, she had already joined the supervisory board of SAP. Once again, the press made her gender the focus of attention, since she was the first woman to join the body on the employer side. She is quite clear about the reasons why. At that time, there was political pressure to break the male dominance of the supervisory boards of the companies listed on the DAX, the German stock exchange. It was for that reason that the co-founder of SAP and its supervisory board chairman, Hasso Plattner, nominated Anja Feldmann as a member. She has no issues with the subjects discussed on the supervisory board when it meets three times a year. "SAP products and platforms are nothing other than complex systems that have to be programmed while observing the relevant security standards – just like with the Internet."

Around two years ago, she finally moved to Saarbruecken, to the Max Planck Institute for Informatics, in order to be able to conduct basic research with a good level of basic funding. She also wanted to escape from the excessive bureaucracy at the university and the heavy burden that came with giving lectures – in some cases to over 800 students.

HANDLING INQUIRIES WITH SURGICAL INSTRUMENTS

Here, too, she continues to conduct big data analyses in order to locate bottlenecks and security problems on the Internet. One example illustrates just how complex her work is. Every so often, hackers bombard a company with a flood of inquiries and bring data traffic to a halt by overloading the server. The experts call this a Distributed Denial of Service Attack (DDoS). For many commercial users, such as Internet traders, an attack of this kind is a disaster because it leads to a breakdown of their basis for working. What's more, the number of such attacks is increasing.

What can be done? Until now, the experts have been taking drastic measures. They shut down the entire computing center that contains the server under attack until the situation calms down. They pull the plug, as it were. However, in so doing, they deny other users access to the Internet. According to Feldmann, this approach uses "abattoir equipment" rather than surgical instruments. Together with colleagues from the Technical University Berlin and the German Internet node DE-CIX, she is therefore looking for a means of filtering attackers out of the data flow in a targeted way – without incurring major costs.

Her approach is known as "advanced blackholing". This is like a new traffic sign and will be set up on all Internet routers that transport the data packets used in the attack. It makes it possible to precisely regulate which data packets from specific senders to specific recipients need to be processed. The data that is filtered out can be diverted or, in the case of a DDoS attack, simply deleted. This surgical knife has already proven its worth many times over in practice. However, it also generates a new problem: criminals can use the traffic sign for targeted attacks. They can for example deny certain users access to the network or divert interesting data in order to spy on it.

This example is typical for the Internet, since every change brings new challenges. However, it is precisely this aspect of her work that fascinates Feldmann: "It never gets boring." She also wants to use her enthusiasm to recruit young people to her subject. She aims to awaken pupils' and students' curiosity, particularly since this field is becoming increasingly important. After all, digitalization is penetrating into more and more areas of life. According to Feldmann, information technology specialists can focus on abstract or practical tasks. "The main thing is that you find something that fascinates you so much that you are willing to put all your energy into it." ◂

Partners in the deep

It is truly a feat to create conditions like those in the deep ocean in a research laboratory. **Gunter Wegener** has mastered the art. Together with his team from the **Max Planck Institute for Marine Microbiology** in Bremen, he hopes to discover how microorganisms degrade methane and other hydrocarbons on the seabed.

TEXT **KLAUS WILHELM**

The heap of mud is the starting point for Gunter Wegener's scientific adventure. It originated in the depths of the ocean. In 2009, Wegener dived with a research submarine in the Guaymas Basin in the Gulf of California and sampled the seabed at a depth of 2000 meters.

"I'm in the process of writing for a chapter of one of the standard textbooks in microbiology," says Wegener. "I always dreamed about passing on knowledge by writing a book for students." His chapter deals with how microorganisms degrade natural gas in the absence of oxygen – known to scientists as anaerobic oxidation of methane – and Wegener's own discoveries in the field.

The focus of the research of Gunter Wegener and his team is a biocommunity of so-called archaea and bacteria in the seabed. These organisms really like it hot. Archaea are organisms that look like bacteria, but they are fundamentally different genetically. Scientists, therefore, place them in a separate domain in the tree of life.

At the time of that dive in the Gulf of California, little was known about the microorganisms that degrade natural gas without the help of molecular

In the Guaymas Basin in the Gulf of California, brine flows out of the seabed at a depth of 2000 meters and forms towers of minerals. The yellow microbial mats (in the background) contain communities of bacteria and archaea. Diving in the research submarine Alvin, Gunter Wegener took samples, which he later cultivated in the laboratory.

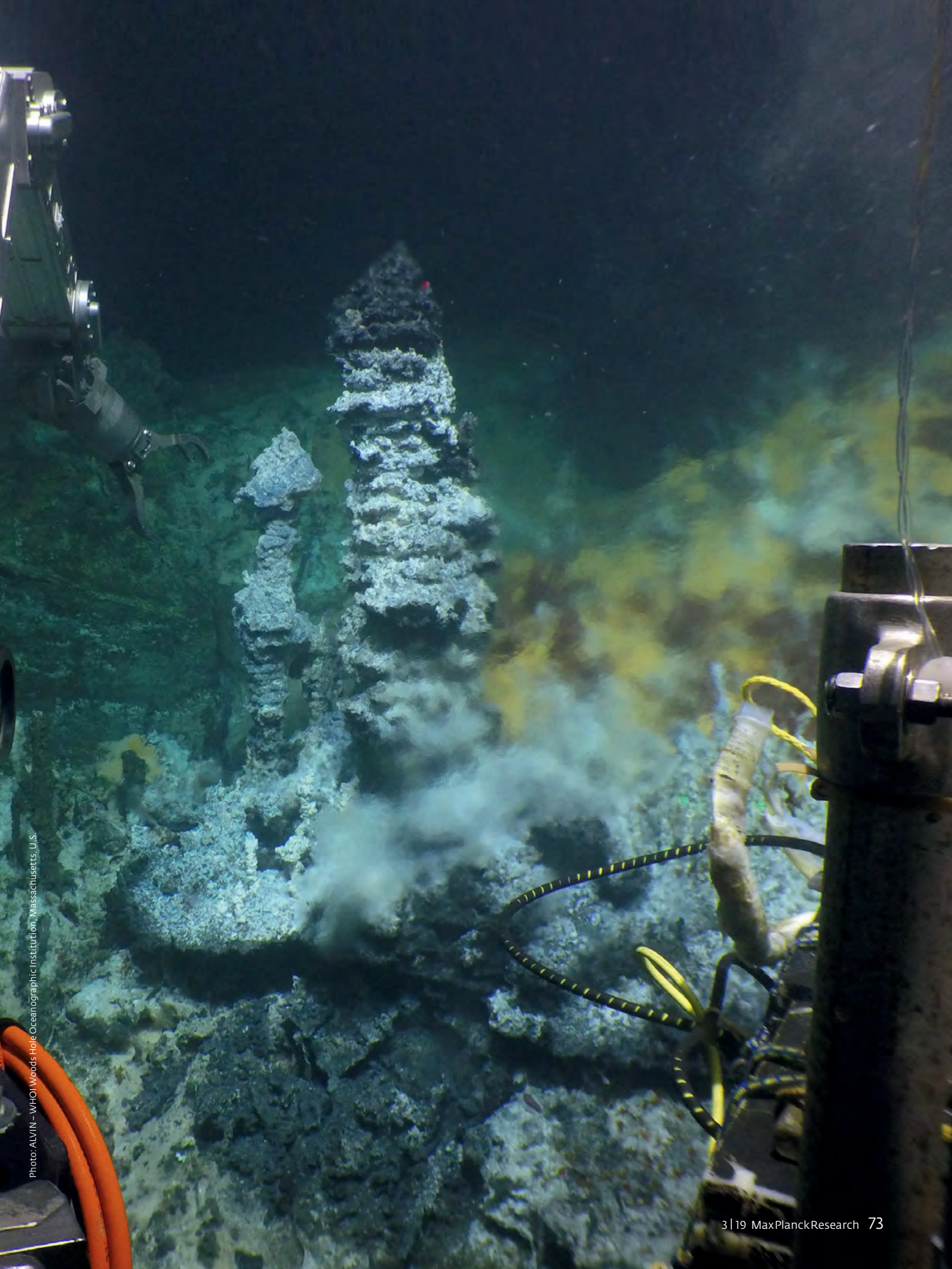


Photo: ALVIN – WHOI Woods Hole Oceanographic Institution, Massachusetts, U.S.

» Archaea make an important contribution to the formation and degradation of hydrocarbons on Earth.

oxygen. In the Guaymas Basin, geological processes in the Earth's crust produce large quantities of methane. Nevertheless, only small amounts of the greenhouse gas ascend and enter the atmosphere. For this reason, scientists suspected for a long time that there must be organisms degrading the methane. It wasn't until 2000 that Antje Boetius from the Max Planck Institute in Bremen was able to prove that it was a combination of archaea and bacteria that convert methane – even without oxygen, which does not exist deep in the seabed.

It seemed that these archaea generate energy from the oxidation of methane to carbonate. Their partner bacteria benefit, because they consume sulfate and an intermediate product, unknown at the time, produced during methane oxidation. "They reduce sulfate to sulfide," Wegener explains, using the correct scientific terminology.

There was a problem however. Boetius and her colleagues only found the aggregates of methane-oxidizing archaea and sulfate-reducing bacteria in cold habitats at minus 1.5 to 20 degrees Celsius. Under these conditions, the organisms reproduce incredibly slowly: once every six months. And at that rate, it's almost impossible to cultivate the organisms in the laboratory and analyze metabolic processes such as methane degradation.

Archaea from hot biotopes such as the Guaymas Basin reproduce much more rapidly, as has been known for some time. Some methanogenic species can also produce methane under pressure at over 100 degrees. And because anaerobic methane degradation is biochemically very similar to methanogenesis, Wegener was crossing his fingers that he might be able to find the methane-consuming species in the pile of mud.

THE ART OF BREEDING MICROBES

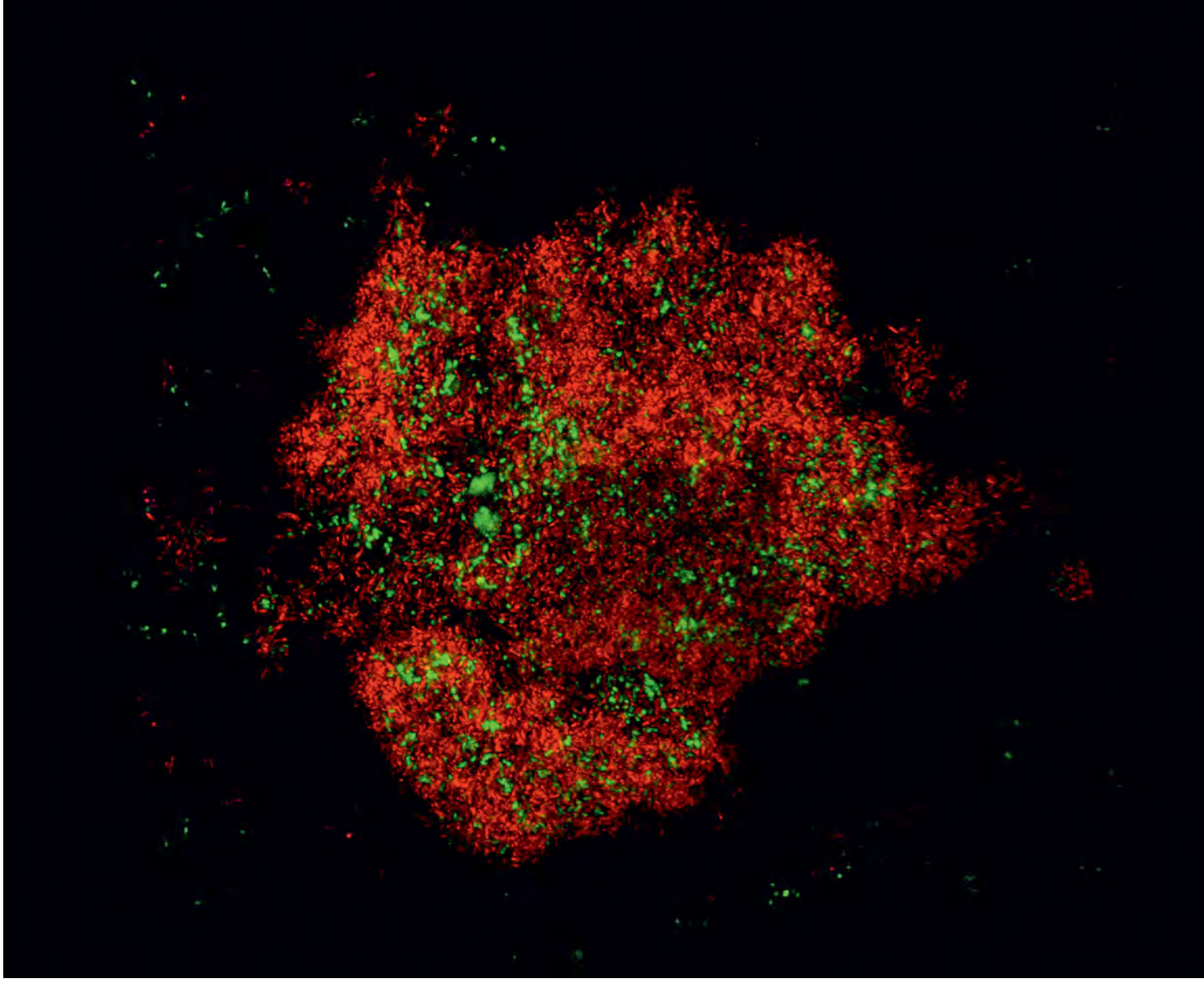
The research team at the Max Planck Institute succeeded in extracting and cultivating the sought-after archaea from the mud. "It actually wasn't that difficult," says Wegener, "you only need two things: time and patience." Because both are in short supply nowadays, Wegener's colleagues have somewhat lost the art of cultivating microorganisms. Instead, researchers have focused on collecting the genetic material of all organisms contained in a water or soil sample, decoding it and attributing it back to individual living organisms. The method, known as metagenomics, provides a quick but rather superficial insight into the abilities of organisms.

At the Max Planck Institute in Bremen, the microbes drift in small bottles of artificial seawater completely devoid of oxygen. "The art consists in simply doing nothing and just waiting," explains Wegener, who was born in the Harz region in Germany. "After five weeks at the earliest, I start checking the cultivation success." It's a formula that has remained successful to this day and for Wegener a competitive advantage over scientists under the pressure of short-term contracts.

Wegener and his colleagues had to bide their time for a year and a half before they could reliably reproduce the microbes. Only then did they have a stable culture without sediments that they could study. They discovered that the community of archaea and bacteria in the Guaymas Basin optimally oxidizes methane at 50 degrees, although it can still do so at 70 degrees. At optimal temperature, the microbes double in number about every two months – much faster than their relatives from cold seas.

The microbial communities consist of methane-oxidizing archaea, known as ANME-1 (ANaerobic MEthanotrophs) and *Desulfofervidus auxilii*, the heat-loving sulfate-reducing helper bacterium. The two partners form aggregates of many thousands of cells, or they combine in chain-shaped shells to create a kind of residential community.

Following this first discovery, the discoveries came thick and fast. First, the scientists showed that the methane-oxidizing archaea use the same enzymes as their methane-generating relatives but in the opposite direction. They employ a catalyst called methyl-coenzyme M reductase to activate methane. The archaea produce it in



Microbial community under a fluorescence microscope: the archaea (red) convert butane to carbon dioxide, while their partner bacteria (green) utilize sulfate.

Photo: Gunter Wegener/MPI for Marine Microbiology

large quantities. The methane molecule is linked to the sulfur compound coenzyme M in this enzyme to form methyl-coenzyme M, and in further reactions it is completely converted to carbon dioxide and finally carbonate.

POWER CABLES CONNECTING THE CELLS

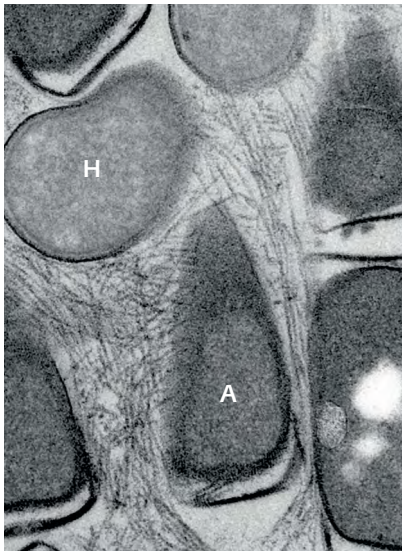
But what holds the partnership of archaea and bacteria together? Wegener has a spectacular answer: "Tiny cables of protein." During methane oxidation, the archaea liberate positively charged protons and negatively charged electrons. The microscopically small power cables allow the electrons to flow into the bacterial cells where they are used for sulfate reduction.

The same bacteria can also be found in other microbial communities. They also live together with archaea called Syntrophoarchaeum, which degrade butane rather than methane, as Wegener and his colleagues have discovered. Surprisingly, Syntrophoarchaeum also utilizes methyl-coenzyme M reductases. Until then, experts had assumed that these enzymes were exclusively involved in methane metabolism. However, Wegener and his colleague Rafael Laso-Pérez have discovered new variants of the enzyme that activate molecules with several carbon atoms.

With the help of this metabolic pathway, the newly discovered archaea also degrade propane and ethane – all the short-chain hydrocarbon gases that rise from the seabed in the Guaymas Basin. The discovery has opened up a whole new field of research. Since the findings of Wegener's team, several researchers have detected methyl-coenzyme M reductases in other archaea. "The results suggest that archaea play

Top Rafael Laso-Pérez and Gunter Wegener have had to adapt their microbes to life in the laboratory in order to study their metabolism. It required a great deal of patience, but they were able to develop techniques that allowed the microorganisms to feel comfortable away from the deep-sea sludge.

Below Methane-oxidizing community under the electron microscope. The cable-like structures are thought to allow electrons to flow from the archaea (A) to the bacteria (H). This allows the archaea to convert methane into carbon dioxide and the bacteria to convert sulfate into hydrogen sulfide.



a more important role in the hydrocarbon cycle than previously thought," says Laso-Pérez.

WIDESPREAD GENES

This hunch was borne out by an analysis of genome databases carried out by Wegener and colleagues from the Jiaotong University in Shanghai to identify gene sequences for methyl-coenzyme M reductases. The researchers discovered several previously unknown genes coding for the production of these enzymes. With the help of the new genes, the researchers then reconstructed the genome of the associated organisms in the mass of existing sequences. To the surprise of the researchers, many previously unknown archaea strains possess methane metabolism genes.

Just what the microbes do with the enzymes has not yet been clarified. Some seem to generate methane, others to degrade it. "We have probably discovered the first archaea that can use methane with without sulfate-consuming partner bacteria," explains Gunter Wegener. The electrons released during oxidation are then presumably transferred to receptor substances such as oxidized iron (rust) or other metal oxides.

Wegener now intends to analyze samples from oil wells in northeastern China. The organisms in these samples are apparently capable of converting crude oil into methane – possibly with the aid of methyl-coenzyme M reductases: "We're hoping to test this hypothesis and be the first to cultivate the organisms."

In the future, Wegener intends to concentrate not only on pure research but also on the potential applications of his discoveries. One example is the

Photos: Tom Pingel (top), G. Wegener/MPI for Marine Microbiology (bottom)

formation of ethane using archaea. Unlike the widespread and industrially produced gas methane, ethane is not a greenhouse gas and therefore doesn't contribute to global warming.

However, despite the best efforts of researchers, no organisms have yet been found in nature that produce ethane or other short-chain hydrocarbons. The microbes discovered by Wegener in the Guaymas Basin only degrade ethane. "But in the same way that identical enzymes are involved in the degradation and generation of methane, the process that degrades ethane might make it possible to generate it," explains Wegener.

Gunter Wegener and other researchers are, therefore, planning to genetically modify archaea to produce ethane. From the modest beginnings of a small pile of mud, one day a raw material for plastics or climate-friendly fuel for cars could be born. ◂

SUMMARY

- **In the seabed of the deep ocean, bacteria and archaea form a living community. The archaea obtain energy from converting methane, while the bacteria extract it by reducing sulfates.**
- **The archaea and bacterial cells are connected to each other by tiny cell extensions. The electrons generated during methane oxidation can flow through these micro-cables to the bacteria, which need them to reduce sulfate.**
- **A key enzyme in methane degradation is methyl-coenzyme M reductase. Variants of the enzyme that can also activate other hydrocarbons, such as ethane, could potentially be used to generate fuels that are more climate-friendly.**

GLOSSARY

Archaea: Organisms in the Archaea domain are as extensive and diverse as bacteria. Almost every month, a new branch is added to their family tree. At the turn of the millennium, experts had only recognized two principal phyla in the domain: the heat-loving Crenarchaeota and the Euryarchaeota. They were followed by the Nanoarchaeota along with several others that are related to the Crenarchaeota. Contrary to earlier assumptions, archaea don't just live in extreme environments such as hot springs, but also in temperate habitats. However, there they are outnumbered by other organisms and are, therefore, frequently overlooked. Archaea are vital for the natural world, as they are involved in all the key substance cycles.

The virus from the basement

The theoretical physicist **Max Delbrück** is considered to be one of the co-founders of molecular genetics. He began his career in biology in the 1930s when he was an assistant at the **Kaiser Wilhelm Institute for Chemistry**. He was awarded the Nobel Prize for Medicine 50 years ago, for his work on the genetic structure of viruses and how they reproduce.

TEXT **ELKE MAIER**

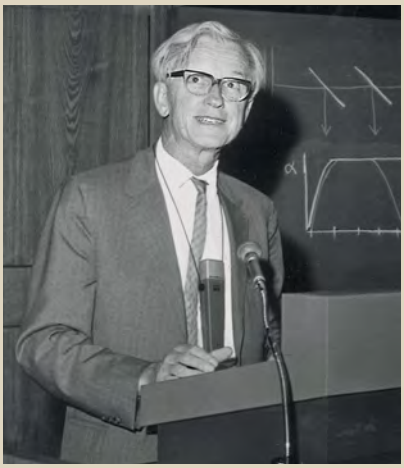
Pasadena, October 13th, 1969. The phone in the Delbrück residence at 1510 Oakdale Street rings in the early hours of the morning. It's a call from Sweden: the Nobel Committee of the Karolinska Institute congratulates Delbrück on winning the Nobel Prize for Physiology or Medicine, which they awarded him along with Salvador E. Luria and Alfred D. Hershey.

When a journalist asks him about his initial thoughts after this call, he answers: "These folks in Stockholm should bear in mind the 9-hour time difference between Sweden and California. It's a terrible thing to call a guy before breakfast."

Max Delbrück, the youngest of seven siblings, was born into an educated family in Berlin on September 4th, 1906. His father was the historian Hans Delbrück and his great-grandfather was Justus von Liebig, a chemist who founded the field of organic chemistry. Delbrück began studying astronomy in 1924. After working in Tuebingen, Berlin and Bonn, he relocated to Goettingen, which at that time was the center of an exciting new scientific discipline – quantum mechanics.

He therefore shifted his focus from the vastness of space to the world of atoms. He obtained his doctorate in theoretical physics under the supervision of Max Born and received a scholarship from the Rockefeller Foundation, which enabled him to work with Niels Bohr in Copenhagen and Wolfgang Pauli in Zurich.

His research career took a radical turn on August 15th, 1932, when Niels Bohr gave a lecture on "Light and Life" at an international conference about light therapy (heliotherapy) in Copenhagen. According to Bohr, just as in atomic physics, where an electron can be thought of either as a wave or a particle, but never as both simultaneously, a complementarity of observational viewpoints also exists in biology. The young Max Delbrück was sitting among the audience. Fascinated by Bohr's ideas, he decided to set off in search of the "elementary fact of life."



At home in two worlds: Max Delbrück considers questions of biology from the perspective of a physicist.

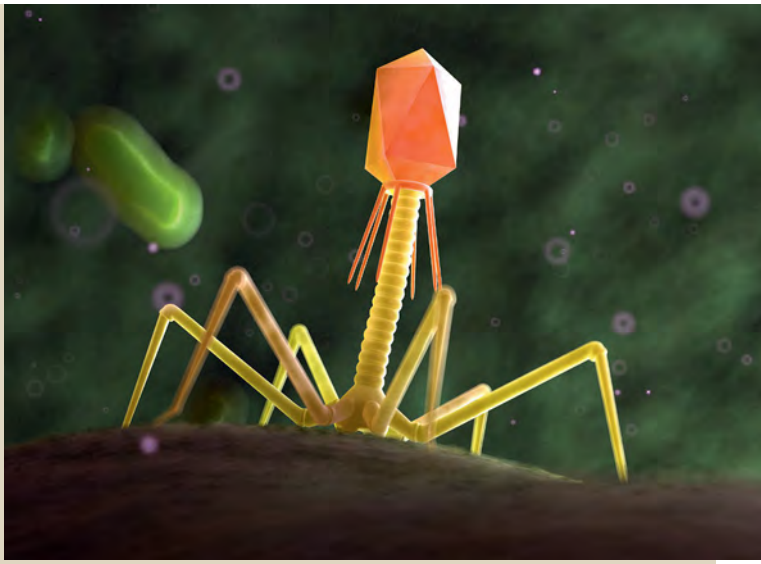
In the same year he began working as an assistant to Lise Meitner at the Kaiser Wilhelm Institute for Chemistry in Berlin-Dahlem, where he attended to his duties as an "in-house mathematician and theorist." Later, he admitted to having misinterpreted experimental results, thereby delaying the discovery of nuclear fission by years. He devoted his spare time to his new passion, biology, organizing private meetings with like-minded people at his parents' home in Kunz-Buntschuh-Strasse in Grunewald. Each of these four-hour sessions, he said, "took place in Papa's large study, into which I had already moved by then. We had painted an old cutting board black and hung it on two coat racks to make a blackboard. We would sit around in very comfortable chairs and sofas and would meet at around four in the afternoon. [...] someone would usually hang around and have dinner with my mother after most of the others had left at around half past seven or eight [...]."

Nikolaj V. Timoféeff-Ressovsky, a Russian geneticist who worked at the Kaiser Wilhelm Institute for Brain Research in Berlin-Buch, where he was experimenting with X-rays to produce mutations in the genome of the fruit fly Drosophila, was also a member of the group. Delbrück published a paper in 1935 entitled "On the nature of gene mutation and gene structure", which he co-authored with Timoféeff-Ressovsky and the physicist Karl Günther Zimmer.

In it, the three scientists were the first to describe the gene – until then an abstract unit – as an atomic structure within which mutations can occur as a result of the rearrangement of atoms or bond dissociation. This famous "three-man book" – also known as the "green pamphlet" – paved the way to modern genetics.

Its success helped Delbrück to obtain a second Rockefeller scholarship, with the aid of which he traveled to California, where he worked with Thomas H. Morgan, a drosophila geneticist and winner of the Nobel Prize for Medicine, at the California Institute

Photo: Archive of the Max Planck Society, Berlin-Dahlem



Lunar Module in miniature format: a phage touches down on a bacterium to smuggle its genome in.

of Technology (Caltech) in Pasadena. However, he soon realized that working with the fruit fly would get him nowhere: he wanted to discover how genes multiply, and for that he needed a simpler system. He was also running out of time, as his scholarship was limited to just a year.

That was when, having almost given up any hope of success, he came across the viruses. He had just returned from a camping trip in early 1938 when he noticed that he had missed an interesting seminar at the Institute, in which biochemist Emory Ellis had presented his experiments with bacterial viruses – the so-called bacteriophages. So Delbrück paid a visit to his colleague, who was of the same age, in his basement laboratory.

The bacteriophages – or phages for short – are viruses that infect bacteria. The so-called T-phages specialize in the intestinal bacterium *Escherichia coli*, and consist of a head, which contains their genetic material, and a tail, which serves as grappling hook. Whenever a phage encounters a bacterium with an appropriate cell surface, it attaches itself and introduces its genetic material into the bacterial cell.

The phage genes then reprogram the cell in such a way that it starts producing new viruses as if on an assembly line until it finally bursts. The new phages are released and immediately enter any other "suitable" bacteria in the immediate vicinity. After just a few hours, holes become visible on a bacterial lawn cultivated by researchers in the laboratory and inoculated with phages. Ultimately, each of these holes is created by a single virus.

Ellis showed Delbrück his equipment: all the phage researcher needs for his work are a few petri dishes, pipettes and an autoclave. Delbrück can't believe it: "I was absolutely overwhelmed that such simple procedures could be used to make viruses visible [...] You could conduct the simplest experiments with something akin to the atoms of biology."

Frankfurter Allgemeine Zeitung March 19th,1981

» Delbrück was one of the founders of the new biology. His research into bacteria and bacteriophages in the 1940s laid the foundations for modern genetics.

With that, Delbrück had found the perfect model system, and without hesitation, he asked his colleague if he could collaborate with him. Whilst Ellis had to give up the phages a year later because his sponsors were no longer prepared to cooperate, Delbrück won the Nobel Prize three decades later.

After his scholarship expired, he took up a position as a physics lecturer at Vanderbilt University in Nashville, Tennessee and continued his research into phages on the side. Having become an American citizen, Delbrück then accepted a professorship at Caltech in 1947. He transformed phage research into a predictable and reproducible science that soon attracted more and more enthusiasts. In the 1940s he founded the legendary "Phage Group" – a loose association of scientists all conducting research into the T-phages.

The phage courses he presented each summer at Cold Spring Harbor near New York also became widely known, and attracted researchers from all over the world. During the early 1960s, the courses were also offered in Germany. The Institute of Genetics was founded at the University of Cologne and Delbrück was appointed as its Director. He continued his research and teaching activities on the banks of the Rhine from 1961 to 1963,

during which time Fritz Melchers, now Senior Research Group Leader at the Max Planck Institute for Infection Biology in Berlin, was a PhD student at the Institute. He remembers Max Delbrück, his "second doctoral supervisor" very well: "His working environment was characterized by a cheerful kind of anarchy, which he had inherited from Niels Bohr's laboratory," he remembers: "His colleagues didn't always have an easy time with him. His first reaction when someone presented important new research results would be: 'I don't believe a word of it!' And he liked to interrupt seminars with statements like: 'I haven't understood a single word yet. Start from the beginning please! And would you please use three short sentences instead of one long one'." His phage courses also achieved cult status in Cologne: "Everyone in Germany who had helped to advance the field of molecular biology had taken part," says Melchers.

One of Delbrück's most important works was published in the journal Genetics in 1943. It describes the so-called Luria-Delbrück experiment, in which he and the physician Salvador E. Luria demonstrate that mutations, which make bacteria resistant to phage attacks, are random and do not occur as an adaptation to the viruses.

Max Delbrück, Salvador E. Luria and the biologist Alfred D. Hershey won a Nobel Prize in 1969 "for their discoveries on the mechanism of replication and genetic structure of viruses." By that time, Delbrück had long since moved on to other fields of research. Phages had become too fashionable for his liking, and the versatile scientist was currently working on questions of perception, such as the reaction of fungal cells to light.

The field of molecular genetics that Delbrück and his colleagues set in motion is still developing at a rapid pace today. Reminiscing towards the end of his life, he once said: "What I discovered for myself at a very early stage is that as a scientist, you could potentially change the world to a far greater extent than Caesar or any of the great military or political figures ever did. And you can sit in a corner and relax while you're about it." Max Delbrück passed away in Pasadena on March 9th, 1981.

Photo: fotosearch/csp_Eraxion

Working together for a better future

Junior scientists and alumni meet at the Harnack House for the fourth Max Planck Symposium

How can diverse teams solve social problems? Vice-President Ferdi Schüth (left) discussed this topic with the keynote speakers.

Photo: David Ausserhofer

"Sustainability, climate, and their connection with diversity" – this is one slogan that the Max Planck alumni, alumnae and junior scientists who attended the fourth Max Planck Symposium could have given the now annual exchange that took place in Berlin's Harnack House in September.

"We at the MPG make sure that origins, gender, age and other non-scientific factors play no part in the achievement of our scientific goals," said Vice-President Ferdi Schüth during the panel discussion. The Max Planck sustainability network and the junior scientists who are members of the Max Planck Society's PhDnet are also strengthening their commitment to sustainability and diversity. Whether in fields such as diversity consulting, agriculture and environmental research, on committees such as the International Panel for Climate Control or in companies such as Bosch: this year's keynote speakers were international alumni and alumnae from all walks of life whose daily work is dedicated to the creation of a sustainable and diverse future.

The unusual alumni projects that brought both groups together were particularly interesting. "How many of you have been to New York City?" asked keynote speaker Gabby Pereyra at the beginning of her presentation. 80 percent of those present raised their hands. "And how many of you could imagine living there for more than two years?" Almost all the hands went back down. "In my job, I work towards making metropolitan areas like these more livable for everyone."

As the Project Leader of GrowNYC, the alumna of the MPI for Biogeochemistry has the task of assisting small organic farms around New York City with their management and logistics, thus enabling them to attend the city's weekly farmer's markets. This is a win-win situation, as access to fresh organic produce is by no means a matter of course for the socially disadvantaged citizens of New York. Short transport routes and a network of volunteers keep prices affordable. But what does this have to do with diversity? A lot, as Gabby knows. The organic farms in New York State that receive support from GrowNYC are managed by families and communities of every possible culture, gender and religion.

Gabby drew on her personal experience to summarize the connection between sustainability and diversity: "In the early days, I had to deal with the accusation that I had only been appointed because of my Hispanic origins. But then my response was: I have a Master's degree in agriculture and a doctoral degree in biogeochemistry; I have years of experience in project management and I speak English, Spanish and German. I'm not a 'diversity hire' – I'm a key to the success of this project."

The Max Planck website is one of the most successful media pages

According to an analysis by the online statistics portal Statista, the domain www.mpg.de was one of Germany's twelve best-linked websites in 2019. The first two places in this category went to the U.S. digital corporations Google and Amazon. The highest-ranked German-language news portal was "Spiegel-Online", which came in third.

The analysis performed by Statista encompassed media sites with .de domains. In 2019, the search engine Google and the online dealer Amazon were the websites most intensively linked with other web pages in Germany. The domain www.mpg.de came in tenth, making it the only science website in Statista's top twelve. It was ranked above the technology website 'Heise.de' and the daily newspaper 'Sueddeutsche Zeitung'.

Three at once

Tatjana Hörnle, Ralf Poscher, and Jean-Louis van Gelder join the MPI for Foreign and international Criminal Law as new Directors

No less than three Directors have taken up appointments at the MPI for Foreign and International Criminal Law this year: Ralf Poscher, Tatjana Hörnle and the Dutch appointee Jean-Louis van Gelder are all in the process of setting up their Departments.

Ralf Poscher was previously a professor at the University of Freiburg, where his tasks included the directorship of the Centre for Security and Society. He has been in principal employment at the MPI for Criminal Law since 1st August and is setting up the new Department of Public Security Law; this Department will focus primarily on government measures to prevent criminal activity. In criminal law, jurists use the term "preventive turn". At the same time, Poscher is investigating the boundaries that have to be set for these measures in a new "preventive state". Ralf Poscher was born in 1962 and completed his doctorate and habilitation at the Humboldt University of Berlin; afterwards, he was a professor at the Ruhr University in Bochum and the University of Freiburg. Guest professorships took him to Osaka, the Institute of Advanced Study in Princeton and the European University Institute in Florence.

Tatjana Hörnle has been in full-time employment as the Director of the Institute's Department of Criminal Law since the beginning of October. Hörnle has authored many publications on legal theory and the philosophy of law; here she places particular emphasis on the theory of criminal law and questions of criminalization, for example in the service of cultural taboos. Her other areas of work include the law on sexual offenses, which is a new discipline at the MPI in Freiburg. Tatjana Hörnle was born in 1963; she sat the second legal state examination in Berlin and obtained her doctorate in 1998 from the LMU in Munich, where she also completed her habilitation in 2003. She then took the chair in criminal law at the Ruhr University in Bochum; in 2009, she was appointed to the post of professor at the HU in Berlin. She has been the recipient of various grants and is a member of three academies: the Berlin-Brandenburg Academy, the Mainz Academy and the Leopoldina.

Jean-Louis van Gelder will be moving to Freiburg at the beginning of 2020. The Dutch scholar is a jurist and psychologist; he was previously appointed to a professorship at the University of Twente in 2017. Van Gelder will be taking charge of the existing Department of Criminology and plans to completely reorient its research. His projects will include the use of virtual reality to find out why people decide to commit a crime. Van Gelder worked at the Netherlands Institute for the Study of Crime and Law Enforcement for some time. In 2017, he received an ERC Consolidator Grant for his project "Crime and Time", which also falls within the field of criminal psychology.

Photos: Hörnle: Hath, Poscher: Michael Bamberger, van Gelder: Charles Kuiper (top); MPG (bottom)

"The fact that so many web pages link to the Max Planck Society website proves that many people rate its content as particularly sound and reliable. At the same time, it shows that www.mpg.de provides easy access to a lot of information that is highly relevant to society," says MPG press spokesperson Christina Beck.

According to Statista, the most commonly linked websites worldwide are Google, Facebook, YouTube, Twitter and Linkedin. The Internet now consists of more than 1.7 billion pages. This figure is 60 percent up on the number of pages online in 2016.

WELL-CONNECTED MEDIA PAGES

The top 12 websites with the top-level domain .de rated according to the number of subsites that linked to them in 2019.

1	google	62,955
2	amazon	45,405
3	spiegel	40,836
4	businessinsider	36,480
5	blogspot	31,400
6	ccc	28,878
7	bund	28,878
8	welt	27,304
9	siemens	25,947
10	mpg	25,368
11	heise	24,652
12	sueddeutsche	22,834

The courage to build bridges

How the Collaborative Science Symposium is fostering scientific exchange with African students

When she moved from New York to Tuebingen in 2013, Renée Hartig could never have dreamed that she would be actively helping to shape scientific exchange between Africa and the Western world right at the start of her scientific career. However, with a generous portion of courage and perseverance and the help of numerous supporters, the doctoral student at the MPI for Biological Cybernetics has succeeded in initiating an innovative program in Africa known as the Collaborative Science Symposium.

"Our African students were so excited!" she says. Months after the Collaborative Science Symposium in Zambia and Kenya, the American scientist can still see the shining eyes of the 18 to 23-year-old participants in her mind's eye. "Life in Africa is dominated by a vicious circle of poverty, starvation and disease. That's why I found the courage, optimism and enthusiasm of these young people all the more moving." One of these students was James Nkhoswe from Zambia. On being asked why he took part in the Science Symposium, he answered, "I want to do something for the future of my country."

Ana Silberling, coordinator of the TReND volunteer program in Africa, also knows how important scientific collaboration with Africa is for the continent's future. "Initiatives such as the Collaborative Science Symposium help strengthen the African research sphere in the long term by providing local training for tomorrow's scientists." Silberling supported Renée Hartig's ambitious plan to create her own volunteer project right from the start. The PhD student initially managed to forge links with two universities which were willing to host the Collaborative Science Symposium.

"Our contacts at the Universities of Zambia and Nairobi were incredibly helpful," says Renée Hartig of D. Chuba, Director of the Biological Sciences Department in Zambia, and Paul Rabala, School of Computing & Informatics in Nairobi, Kenya. A team of volunteers also had to be recruited. "Making people enthusiastic about Africa is one thing, but we needed more: we had to find like-minded people who were willing to put up with some hardships," recalls Hartig.

Around 35 students from Zambia and 20 from Kenya took part in the Collaborative Science Symposium in Africa. The scientists who flew out to the Symposium gave the participants an insight into various scientific theories.

Despite the vaccinations, malaria prophylaxis, and increased security measures due to the recent terrorist attacks in Nairobi city center, Hartig was able to put together a team of six volunteer helpers. From 21st January to 1st February, the young scientists became part of a special adventure that had both a human and an intellectual side. Renée Hartig flew to the African continent with Ana Vedoveli, MPI for Biological Cybernetics, Rea Antoniou, MPI for Intelligent Systems, Ali Karimi and Mike Hemberger, MPI for Brain Research, and Leonardo Christov-Moore and Pamela Douglas from the University of California, Los Angeles, and the University of Central Florida (U.S.).

The students who took part in the workshops came from various disciplines: biology, chemistry, physics, or mathematics. Following an introduction to scientific theories, methods and techniques, focusing in particular on the area of biology and the neurosciences, the scientists set great store by doing practical exercises with the young students. "It was great how we did experiments using the simplest of materials," recalls James. These included the use of foldscopes, optical microscopes that can be made using a sheet of paper and a lens and which cost less than one dollar.

"Everyone in our team found creative solutions to problems on just a small budget, and we were all inspired by the participants every day," says Hartig when asked about the collaboration with the students at the Symposium. Neither did this stop after the Symposium ended. "We are still in contact with Zambian students like James Nkhoswe." The team is currently assisting James with his applications for grants which will enable him to study abroad. "I'd like to study environmental sciences in Germany," says James, confidently adding, "I'd like to take what I learn in Germany back home to my own country. I'd like to build a bridge so that my country will be better off in the future!"

Photo: Renée Hartig/MPI for Biological Cybernetics

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