

Max Planck RESEARCH



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Europe

ECONOMIC SOCIOLOGY
The power of expectations

TSUNAMI RESEARCH
Atoms make waves

CHEMISTRY
Material mix from the food processor

MOBILITY
Buses on demand



Daniel Hincapié,
Research Engineer at
Fraunhofer Institute,
Munich

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Treasuries of knowledge

Scholars immersed in contemplative silence and surrounded by books – for centuries, they were the personification of learning. But can libraries still function as central “research locations” when the digital age has seen most sources made available online? Researchers worldwide would answer this question with a clear “yes.” The printed book is still the preferred publication medium in many areas of knowledge, while libraries can be seen as well-equipped labs without which no research would be possible. It therefore comes as no surprise that guest scientists often have to plan their stays at the Max Planck Institutes according to the capacities available for library use.

However, the quality of a library is not judged solely by its collections, as valuable as these may be. It is the accessibility of the knowledge that matters. This is the responsibility of the librarians: they comb all the available sources for new, relevant publications, prepare data in keeping with modern technological standards, and also assist researchers during the publication process. This naturally applies not only to the printed word but also to other media such as images, audio and video material.

The 120-year-old library of the Kunsthistorisches Institut in Florenz, shown here, is one of the world’s most renowned libraries of art history. It provides access to around 300,000 monographs, 50,000 volumes of serial publications and more than 1,000 specialized journals. Approximately 7,000 new acquisitions are added each year. The library naturally also contains laptops, computer terminals and electronic media – even though they are not visible in this picture. Along with its print media, the library provides access to 2,500 e-journals and around 100,000 e-books on fine arts and related subjects.



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In the European Union, ideas about what constitutes a state under the rule of law have been drifting apart for some time now. Poland and Hungary in particular are defining their own rules. At the Max Planck Institute for Comparative Public Law and International Law, researchers are analyzing the causes of the crisis and the different ways in which the EU can respond.

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Opinions are divided when it comes to the question of whether and how Europe should grow closer together. In light of the major differences between the countries, scientists at the Max Planck Institute for the Study of Societies are critically questioning the closer integration of members.

ON THE COVER It is not just the facade that is crumbling; the European Union is currently undergoing several crises at once. Brexit – as illustrated by artist Banksy on a building wall in Dover – is just one of these, and in the view of many scientists is not even the most serious. Researchers are more alarmed by the drifting apart of notions of what constitutes a state under the rule of law and by the major structural inequalities between the member states. However, a look back at the history of the community of states also shows that Europe has also overcome several severe crises in the past.

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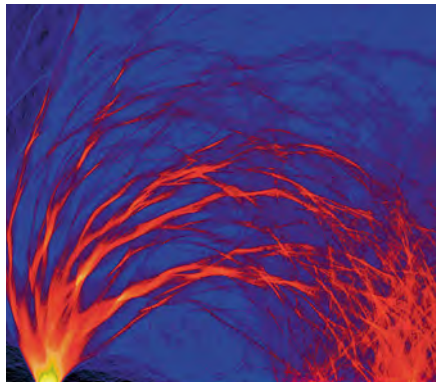
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Researchers are experimenting with pasta machines, pizza ovens or mixers in order to obtain new substances from sustainable raw materials. During the process, they have already produced a robust wooden material, bioplastic and biofuel.

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There are usually not many options available to people wanting to use public transport in the country. Researchers have now developed a system in which customers can order a bus to stop directly outside their front door. A software program optimizes the routes for customers and operators.

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Award-winning!

2019 Leibniz Prizes for three Max Planck scientists



Women of influence at the Max Planck Society: Leibniz Prize winners Melina Schuh, Ayelet Shachar and Brenda Schulman (left to right).

This year, no less than three Max Planck scientists are being awarded Germany's most prestigious research prize: Melina Schuh, Ayelet Shachar and Brenda Schulman will be formally presented with the Gottfried Wilhelm Leibniz Prize, endowed with up to EUR 2.5 million, on March 13, 2019 in Berlin.

Melina Schuh is being awarded this prize for her vital work on reproductive biology. The Director of the Max Planck Institute of Biophysical Chemistry in Goettingen has contributed crucial insights into how a mature, fertilizable egg cell forms and what the consequences are when errors occur during this sensitive process. The recent Leibniz Prize winner explained to the FRANKFURTER ALLGEMEINE ZEITUNG (FAZ) how her research helped women who wished to have children. The FAZ also devoted an article to the work of Ayelet Shachar, Director at the Max Planck Institute for the Studies of Religious and Ethnic Diversity in Goettingen, under the title "The rights of displaced persons". Schachar's multidisciplinary work on citizenship and legal framework conditions in multicultural societies has made her one of the leading experts in this field. Brenda Schulman, Director at the Max Planck Institute of Biochemistry in Martinsried, is being awarded this prize for her work on the molecular mechanisms of the ubiquitin system, focusing in particular on their biochemistry and structural biology. Any faulty regulation in this system can lead to numerous functional disorders such as cancer or neurodegenerative diseases.

Recognition for achievements in protein research

Franz-Ulrich Hartl receives the Paul Ehrlich and Ludwig Darmstaedter Prize 2019

This year, two scientists are to receive this special award for their pioneering research into protein folding: Franz-Ulrich Hartl, Director at the Max Planck Institute of Biochemistry in Munich, will be sharing the prize with his U.S. colleague Arthur L. Horwich from Yale School of Medicine and the Howard Hughes Medical Institute. The prize, which is endowed with the sum of EUR 120,000, will be presented to the researchers on March 14, 2019 at the Paulskirche in Frankfurt. Hartl and Horwich have proven that the proteins in all organisms are folded by means of a complex, energy-consuming process which is dependent on helpers known as "chaperones". This work is also highly significant for the medical field, as incorrectly folded, agglutinated proteins are a significant characteris-



Master of protein folding:
Franz-Ulrich Hartl, Director of the Max
Planck Institute of Biochemistry.

tic of many neurodegenerative diseases such as Alzheimer's and Parkinson's. Better understanding of this protein

folding malfunction could therefore open up new approaches to treating these diseases.

“At the mercy of a future with no alternatives”

Lisa Suckert investigates the motives behind the Brexit campaign



Lisa Suckert

Since the referendum of 2016 in which the British people voted to leave the European Union, the nation has been fighting over its future. Lisa Suckert from the Max Planck Institute for the Study of Societies in Cologne has been analyzing the Brexit campaign. In the sociologist's view, this is a good example of how ideas about the future shape a society – an example from which the EU can draw a number of important conclusions.

Ms. Suckert, the Brexit vote was a shock for Europe. Have the British fallen prey to a new form of nationalism?

Lisa Suckert: We have to be careful not to pigeonhole the people who voted to leave the EU. We are quick to call them “nationalists”, “stupid racists” and “die-hards” with no understanding of economic relations who are afraid of anything foreign. Migration was of course one of the most important issues, and parts of the “Leave” campaign were clearly xenophobic. However, putting everything down to radicalism is oversimplifying the situation. We need to take a closer look.

In what respect?

Brexit supporters cover a wide spectrum from the far right to the far left and criticize the EU from very different perspectives. For some, the European Union is a neoliberal enemy, which is too business-friendly and concerned only with free markets. Others think that the EU has too

much power over the economy and want to leave the EU so that Britain can at last have truly free markets. Some of the people who voted “leave” want to restrict migration and return to times of greater national sovereignty. In contrast, others believe that the EU treats refugees poorly and inhumanely. Once out of the EU, they could do things better. These are strongly contradictory opinions that cannot be reconciled rationally.

So what do Brexit supporters actually want?

For many, the present is highly complex – this is probably true of more countries than Britain. People have the impression that they no longer have any decision-making power over their own lives, that there are no alternatives for their future. The desire for greater sovereignty, to regain control, to have clear borders – all this played a dominant role in the campaign. This has more to do with longing for a time and a world that was supposedly safer and happier. For many, this means the golden age of the British Empire and later of the Commonwealth. This past is used as inspiration.

Didn't the people think about what the consequences of their vote would be?

In 2016, many people did indeed vote without thinking through the consequences of leaving the EU. Around 70 percent of the people who voted for Brexit believed that the outcome of the referendum would not make a significant difference, i.e. that not much would change whatever happened. If the British do end up with a hard Brexit, this may turn out to have been an error of judgment in terms of economic policy.

The British had a referendum on leaving the EU once before, in 1975. However, two-thirds of the voters elected to remain. Which arguments were used back then?

They were very similar to those used today. Great Britain dreamed of resuming its status as a global power. By contrast, EU supporters wanted to actively influence the future project of Europe. The overall mood was more optimistic. Both sides asked themselves how it might be possible to

create a better future inside or outside the EU. In 2016, both the “Leave” and the “Remain” campaigns were concerned with avoiding risks and hazards.

So did people have different ideas of the future back in the 1970s?

Not really in terms of content, but there was a different underlying mood. The future was presented as open, as something that could be influenced. For a society, it is of central importance how its members envisage the future. If they feel that there is no scope for shaping the future, many things will come to a standstill.

What might a “better” future for the British look like nowadays?

That's difficult to say; at the moment, the situation is muddled. The country is deeply divided. In the long term, the British have to find a way to reconcile these contradictory needs, i.e. to participate in globalization while maintaining a certain level of seclusion and control over their own economic area.

How can the EU react to this?

It could help find a solution by making changes. More and more people are becoming dissatisfied with the EU. It has been concentrating almost exclusively on the economy and the free market for far too long. This has not been very convincing so far, at least not as far as European integration is concerned. Perhaps it should soft-pedal economic integration and pay much more attention to social standards and European culture. It would also be worth taking another close look at the needs that influenced the Brexit supporters' decision so that the EU learns from this event.

Interview: Martin Roos

Fathoming the oceans

Bremen-based start-up wins European founder's award

"95 percent of the ocean floor is as yet unexplored," says Hannah Brocke. The biologist and her colleagues Guy Rigot, Joost den Haan and Raja Kandukuri want to change this. The four

scientists have set up PlanBlue, a start-up originating from the Max Planck Institute for Marine Microbiology in Bremen. Their vision: to survey the entire ocean floor and address important

problems facing humanity. The effects of climate change could then for example be tracked by observing changes in coral reefs. Measurements can be taken under water using a special hyperspectral camera. The technology for this was developed at the Max Planck Institute for Marine Microbiology, and PlanBlue has turned it into a new, user-friendly product. The camera scans sea, lake and river beds automatically. It can be used by any experienced diver – not just by experts. In all, PlanBlue's technology is faster, more accurate and cheaper than other methods used to explore underwater terrain to date.

The new business model is already celebrating its first successes in December 2018, PlanBlue won the Galileo Masters, a European start-up competition for the aerospace industry that distinguishes ideas associated with the European navigation system of the same name. PlanBlue uses Galileo to locate the data on the map after collection.



Surveying the submarine world: divers can map the ocean floor using a special camera developed by Max Planck researchers.

Measles viruses for cancer therapy

Max Planck Innovation enters into licensing agreement with Themis Bioscience

As the pathogens that cause influenza, herpes, measles or smallpox, viruses are actually our enemies. However, they can be surprisingly helpful when treating cancer. This is because cancer cells are highly susceptible to infection by viruses, which can destroy them extremely efficiently. Scientists call this process "oncolysis". The Vienna-based biotech company Themis Bioscience has now been licensed to develop, manufacture and market treatments based on an oncolytic measles virus platform. The licensed technology was developed by the Max

Planck Institute of Biochemistry in Martinsried in cooperation with the Eberhard Karls University of Tuebingen. It uses a modified measles virus based on the genome sequence of the established measles strain with which billions of people have been vaccinated worldwide. These oncolytic measles viruses will in future destroy cancer cells more efficiently, thereby stimulating and strengthening the cancer patient's previously underactive immune system. In ideal conditions, all tumors will be brought permanently under the control of the immune system.

A victory for Open Access

Agreement concluded by DEAL and Wiley

In January, after almost three years of negotiations, Project DEAL, a consortium representing approximately 700 academic institutions in Germany, finally signed an initial agreement: the consortium has agreed to enter into a groundbreaking national partnership with U.S. publisher John Wiley & Sons, one of the world's leading publishing companies in the field of research and teaching. For an annual fee, the newly concluded three-year agreement grants all institutions represented by Project DEAL access to the scientific journals published by Wiley as far back as 1997. Researchers at these institutions can also publish their articles in Wiley's journals as Open Access publications. The Max Planck Society – as a member of the alliance of German science organizations behind the Project DEAL consortium – established the company Max Planck Digital Library Services GmbH to facilitate the signing of the agreement by Project DEAL and Wiley. Public access to the agreement is now available (also refer to page 76f.).



Signing the agreement: Guido Herrmann, Managing Director of Wiley, and Frank Sander, Managing Director at Max Planck Digital Library Services GmbH.

On the net



Shining a spotlight on our devices and our researchers

In our more than 80 Max Planck Institutes, the Max Planck Society offers its researchers access to often very specialized equipment and machines. To illustrate our hidden equipment treasures, ranging from gravitational wave detectors over lasers, cell sorters and vacuum chambers to 30-m single dish telescopes, we have started a social media campaign under the hashtag #mymachineandme, aimed at shining a spotlight on our research infrastructure and the early career researchers working with it. The photographs can be found on Instagram and Facebook accounts as well as on Twitter:

www.instagram.com/maxplanckgesellschaft

<https://bit.ly/2FYRTIP>

Self-help for traumatized refugees

About 20 to 30 per cent of refugees suffer from major depression or a pronounced post-traumatic stress disorder and are in need of treatment. Psychiatric care of refugees in Germany needs to be optimized. The Max Planck Institute of Psychiatry wants to contribute to this process. Within the 'RefPsych project', part of the initiative "People for People", it has produced two short films, each available in 13 different languages, for refugees and helpers explaining possible somatic and mental symptoms which can occur after flight and migration. The second, most recent video, "Flight and Trauma - Self Help" explains how refugees can, in a first step, help themselves: https://youtu.be/R_kP-qLhKok

Open letter on green genetic engineering

98 leading research institutions have signed an open letter to Jean-Claude Juncker, President of the EU Commission, expressing concern about restrictions on the use of CRISPR Cas9 technology in plant cultivation. Unlike in the past, however, foreign genetic material is no longer transplanted into soy or potatoes. And what's more, the plant varieties cultivated in the laboratory could just as well have been grown naturally – by means of natural mutation or conventional crossbreeding. The open letter, which was composed in English, is signed by several Max Planck Institutes and can be viewed by clicking on the following link: <https://sciencebusiness.net/news/scientists-urge-new-eu-rules-gene-editing-crops>

The power of expectations

Advertising tells us that wishes really can come true. With the right deodorant, anyone can be a cool guy. The new yogurt is guaranteed to make you slim. Paradise is waiting for you at the seaside resort. It is well known that advertisements tell fictional stories designed to arouse the expectation that the product in question is going to make us cool, slim, or feel rested and refreshed. Our author explains that the economic system as such functions in a very similar way. Stories play an equally vital role in the seemingly rational world of investors and analysts.

TEXT JENS BECKERT

We think of the economy as the embodiment of rational thinking. Investors and entrepreneurs make decisions and maximize their returns based on sophisticated mathematical models, detailed calculations, and precise prognoses. At the beginning of the 20th century, the

Nobody can predict
if an idea can be realized,
if a product will find a buyer

sociologist Max Weber referred to modern capitalism as an “iron cage” that forces all participants into a mode of rational calculation. To this day, we are familiar with this idea of the economy as a place of rationally calculated actions. It is conveyed in eco-

nomics textbooks, as well as in statements explaining the decisions made by economic actors who strive to maximize profits.

However, at best this image reflects only a part of the modern economy. After all, the future is unknown and therefore uncertain. It is characterized by genuine novelty, by developments that are unique, and not part of what already exists. This was once true for the telegraph, and it is now true for artificial intelligence. Nobody can predict what discoveries will be made, whether an idea is technically feasible, and if there will be a market for the products based on it. All investment decisions are therefore based on assumptions whose correctness can only partially be evaluated and people are generally aware that they will often turn out to be wrong in retrospect. Even for less groundbreaking

Bright prospects: the store window suggests that the clothes on offer will place their wearers in the limelight. The fashion company thus highlights the fact that its products are status symbols.



innovations, decision-making situations can be so complex that it is impossible to consider all relevant influencing factors. This is only possible in the models in economics textbooks, with their many narrowly defined assumptions. In real life, players are

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Even the world of investors and analysts only appears to function purely rationally

unable to fully take all causal relations into account. This problem is further intensified by the social character of economic activities: unlike chemical molecules, the reactions of the players and their interactions cannot be predicted, in part because the players will behave differently when observed.

Nevertheless, decisions need to be made regarding innovation projects, capital investments, investment in professional qualifications, even decisions to purchase consumer goods. Actors do this based on expectations regarding future developments. However, these expectations cannot simply be derived from past experience. In addition, participants in modern economic systems do not simply follow traditions or conventions. Therefore how can we understand expectations, and the decisions driven by them, if a situation is characterized by fundamental uncertainty, and it is impossible to rationally calculate optimized decisions?

The answer is: as fiction! This might seem far-fetched at first. After all, economic actors would not want to waste their money on made up stories. On closer inspection, however, there is a striking correlation between the nature of fictional texts and the context in which economic actors make their decisions under uncertain conditions.

These decisions reflect the economic actors' visions of a future world. As there can be no facts about the

future, and the future does not simply behave like a continuation of the present, these assumptions are not a guaranteed flash-forward to the future present. Instead, imagined futures are stories used as "placeholders" that enable the actors to make decisions, as if the future was going to develop in the way anticipated. To do so, they must be convinced of the story: it must appear plausible to them, but it does not have to be accurate. Novels and fictional stories are also based on the author pretending that a certain sequence of events has taken place as described, and the readers go along with this assumption. Decisions made under the condition of uncertainty and, fictional stories have something in common: both authors and recipients have a broken relationship to reality. It goes without saying that there are also differences, in particular the fact that economic actors will critically question the story repeatedly, revising it as needed, if new facts become known, or if there are new ways for interpreting the situation. However, one thing is still true at the end of the day: expectations remain fictional, as there can be no future facts.

Innovations may well be the prime example of the fictional character of economic decision-making. In his *Theory of Economic Development*, Joseph Schumpeter recognized already in the early 20th

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The economy is fueled by decisions with uncertain consequences

century that any innovation exists only in the entrepreneur's imagination to begin with. As an aspired ideal, so to speak. The entrepreneur adjusts demand for production factors, as though the innovation had already been realized, and – if successful – they thus transfer their imagination to the real world.



Schumpeter's assumptions are confirmed by studies in which innovation processes are examined in practice. Innovation processes start with "promissory stories" – promises used to illustrate a particular technological future that is often presented as being inevitable. An agenda is created in which the path towards this future is shown, and in which the individual actors are assigned their roles, much as in a novel. If a story appears plausible, scientists, government funding, and private investors will follow it. The current discussions about artificial intelligence are an example of this type of narrative motivation for present-day decisions based on an imagined future.

At the beginning of innovation processes, nobody knows if they will be successful. There is no knowledge about the finished product, but only an imagination from which a hype can develop, if the vision is considered to be credible. However, such a hype is not simply irrational enthusiasm, but an essential prerequisite for the dynamics of capitalism.

To find out whether an idea is just a pipe dream or could actually be realized, it is often necessary to mobilize significant resources. Scenarios and forecasts are drawn up, usually backed up by a wealth of figures. The story of a possible future emerges, and if the players find it sufficiently plausible, funds are made available to allow the idea to be tested. According to the organizational researcher James March, organizations must succeed in creating shells in which "craziness is protected."

One might assume that basic research also takes place in such shells. The results and likelihood of success of such research are extremely uncertain. In particular, it is impossible to predict if and to what extent it will result in marketable applications. From a purely rational point of view, basic research is bound to struggle. Any practical use that can be expected from it appears too uncertain and too distant. So why invest in something that has at best vague prospects of economic success? Such objections may be understandable, but they remain problematic. After all it is not only innovation, but the

entire dynamics of modern economies that depends to a considerable extent on scientists, entrepreneurs, investors, and consumers daring to make decisions, whose likelihood of success is unknown and that will incur considerable costs if they fail. If they do succeed, however, they are the drivers of capitalist dynamics. Researchers as well as research organizations react to these circumstances, by outlining how central societal problems can be solved through a

Economic competition is largely about competition for the more convincing story

future discovery, or by highlighting the purpose-free character of scientific knowledge. In doing so, they legitimize the use of resources despite the uncertainty of success. Societies react to this by providing state funding to cover a large share of the costs of basic research, to enable it to take place despite a lack of short-term commercial pressure.

When it comes to private companies, it is start-ups in particular that use fictional expectations to facilitate their innovative activities. In the search for capital, they have to pitch their ideas to potential investors, who will make their investment decisions based on an oral presentation and submission of a business plan. For start-ups, the product that is being sold often does not even exist, since the funds being sought are intended to create it. Nevertheless, business plans contain detailed descriptions of future turnover, market shares, and the costs of competing products. These figures are, however, merely more or less plausible assumptions: stories about a future that the parties involved picture as if they have already been realized. In this sense, all business plans represent a disrupted relationship with reality. Competition is largely about competing for the more convincing story. >



What is true for innovations is true for the capitalist economy as a whole. The entire dynamics of modern economies are heavily dependent on scientists, entrepreneurs, investors, and consumers making decisions whose likelihood of success is unknown. Decisions regarding career choices are characterized by a wealth of fictional expectations regarding one's own future position, which is imag-

Crises occur if expectations suddenly appear unreliable

ined in the form of a future that has already been realized. A doctoral student sees themselves as a professor; a business student as the head of marketing at a large company. The entire monetary system is based on the fictional expectation that figures in bank accounts or on bank notes, although valueless in themselves, can be traded for valuable goods in the future. Every monetary system depends on this collective fiction. Currency crises show how fragile such expectations can be. Consumer decisions are linked to notions of a future life with the product in question. This anticipative consumption is fueled by travel brochures, car catalogs, movie trailers, lottery tickets, or product presentations from the computer industry, where the motives for purchasing decisions are presented as anticipations of the future.

However, it takes more than just any random story to achieve credibility. Fictional expectations in the economy are subject to ongoing critical review, not least in the markets. Is Tesla going to be the car manufacturer of the future, or will the share certificates just be waste paper a few years down the line? The term capitalist dynamics encompasses phenomenal economic growth, as well as economic crises

that have been occurring time and time again, ever since the initial spread of capitalist economic principles. Crises occur if expectations that were considered to be credible suddenly appear unreliable. Markets lose their faith that Greece's sovereign debt will be paid back; consumers no longer see a brand as reflecting their desired social identity. Turnarounds like this are not triggered simply by new information. Much more frequently, it is a new interpretation of established information or – in the case of consumer goods – a new hype that makes existing products look outdated.

The imagery of worlds that do not exist but that are to be created shows that human beings are capable of fiction. This may well be the most fundamental ability of humankind. It is in this very ability that creativity is expressed, and it is this creativity that has been driving the incredible growth dynamics of capitalism ever since its beginnings in the Italian trading cities. However, this also creates new problems. Among these are the vulnerability of economic systems, whose development is based on the credibility of stories. This also includes the possibility of fraud: take Elizabeth Holmes, for example, chairwoman of the former showpiece company Theranos in Silicon Valley, who, despite knowing it to be false, convinced her investors with the story of the expected further development of her revolutionary blood analysis device. After a journalist from the Washington Post found out about the deception, the company's valuation fell from nine billion dollars to zero.

It also holds that narratives are used deliberately, to *create* a future. While the future cannot be predicted, it can be shaped through prophecies whose narratives motivate decisions. This can lead to a stabilization of the economy, for example when currency crises are prevented, or when politicians "guarantee" in public speeches that bank balances are safe. This power to influence expectations was used by both President Roosevelt in the 1930s and Chancellor Merkel in 2008.

Techniques for predicting and creating credible narratives of future development can also be used to serve political, ideological, or business interests. Examples of this are industry representatives fighting the introduction of minimum wages by forecasting rising unemployment figures, or populists prophesying that taking in refugees will lead to an Islamization of German society. Technological visions, such as those currently being propagated by a handful of players in Silicon Valley, always contain social development models, generated by these technologies, but which largely evade social debate. This shows that a politics of expectations exists. Control of our visions of the future is among the most important tools of power; and this is true historically, as well as in the present day.

If economic decisions are not thought of as being determined rationally, but as the result of futuristic visions that are ultimately contingent, this will also lead to a new understanding of the economic sciences. Since the 19th century, economics has been modeled after physics. It has been assumed that there are economic laws, in the same way that there are natural laws, and that the economy tends towards an equilibrium, much like the equilibrium of forces in physics. However, if the participants' interpretations play a decisive role for economic dynamics, and future developments are determined by the plausibility of stories, then economics should not be modeled after physics, but after hermeneutics – the study of interpretation. Nature does not tell any stories, while the economy is based on them. As in all social action, participants in the economy act based on the meaning a situation takes on for them. The situation needs to be “read”, and of course this also involves mathematical models. The Nobel Prize winning economist Robert Shiller speaks of “narrative economics.” If this proves to be true, it is the disciplines dedicated to the analysis of structures of meaning that deliver the model for understanding the economy: the humanities and social sciences. ◀



THE AUTHOR

Jens Beckert, born in 1967, has been a Director at the Max Planck Institute for the Study of Societies, and has held a professorship for Sociology at the University of Cologne, since 2005. Places where he has previously taught include Goettingen, New York, Princeton, Paris, and Harvard University. His research work is focused on the social embedding of markets including illegal markets, and the issues of inheritance and wealth inequality. In 2018, Beckert was awarded the Leibniz Prize by the German Research Foundation.



THE BOOK

Jens Beckert
Imagined Futures
 Fictional Expectations and
 Capitalist Dynamics.
 Harvard University Press 2016
 569 pages, EUR 42



Family life on the Pacific coast

Max Planck scientists cooperate with partners in around 120 countries all over the world. Here they write about their personal experiences and impressions. Carolin Hillemanns from the Max Planck Institute for Foreign and International Criminal Law spent seven months in California with her family. Here she met a bicycle thief, a lot of homeless people, just one Trump supporter and some remarkably friendly, generous neighbors.

Santa Cruz is the birthplace of mountain biking; moreover, the city has produced some legendary skateboards and is above all a Mecca for surfers. Even though it meant my husband had to commute to Palo Alto, we decided at a very early stage to settle in Santa Cruz a small, accessible city right on the Pacific Ocean, rather than in Silicon Valley, where the wealthy live secluded from real life and where the rental prices are horrendous. Even in Santa Cruz, we once had to move because the rent on the house we lived in would have been 9000 US \$ a month during the summer season.

It is hardly surprising that such a sky rocking housing market produces many homeless people, among them women, elderly people and people with mental illnesses. Many of them are drug addicts; drug-related crime is correspondingly high. The disproportionately high number of homeless people in Santa Cruz is also due to the fact that they are tolerated – unlike in other cities, where they are driven out of town.

Crime is a problem. Living in Freiburg we were already used to bike thefts, but in Santa Cruz it seems extreme. One afternoon, I caught a thief red-handed who carried my daughter's locked bike out of our back yard. I ran after him and shouted at the top of my lungs; he threw the bike over my neighbor's fence and strolled off, not really concerned. Everybody knows that you have to lock your bike as securely as possible. Otherwise, you should take it inside even when you go shopping – this is actually what people do.



Dr. Carolin Hillemanns, 46, obtained her doctorate from the Institute for Public International Law and Foreign Constitutional Law at Zuerich University. Her scientific research focuses on areas such as corporate social responsibility and transitional justice. Since 2007, Hillemanns has been working at the Max Planck Institute for Foreign and International Criminal Law in Freiburg, where she recently took up the position of Research Coordinator. In 2018, she accompanied her husband to California for a sabbatical and continued her own work there.

Apart from this, Santa Cruz is a liberal, alternative city that seems to have almost as many dogs as inhabitants and is home to a vibrant music and art scene. However, I don't think that my children really got to know "the U.S." during the seven months we were there. California is exceptional, and Santa Cruz even more so: over the seven months, I met just one person who expressed support for President Trump – a tourist from Northern California. The annual Women's March showed us just how committed to Liberalism the city is. Thousands of people turned out onto the streets to show their support for women's rights and demonstrated against Trump. It was rather like the protests of 1968 – truly impressive!

Generally speaking it was a very exciting half year. We lived right on the Pacific Ocean and were able to cycle along the coast oftentimes carrying our longboards to go surfing. Even my youngest daughter who was just about to learn English got a taste of a completely different daily routine and way of life. This highly valuable experience sharpened our perspectives of both our homeland and host country. My kids all found out that classroom discipline was much stricter than in their schools back home and that the teachers were committed to all their students and treated them with great respect and goodwill. For my part, I was very impressed by both the academic and athletic prowess of many of these young kids and adolescents.

What I am sure to remember most is the help, support, friendliness and respect we received in California. We were overwhelmed with gifts. The Pacific is always cold, summer and winter, so our neighbors and friends gave us e.g. appropriate wet suits for the kids. The importance and value of respect and kindness are highly stressed and thus deeply ingrained in childhood education. It's quite likely that the mostly peaceful co-existence of people from different cultures and ethnic backgrounds would otherwise not be possible.

I hope we will keep up this warmth and kindness in Freiburg, besides taking a more relaxed attitude towards life. By the way, my youngest daughter has now made up her mind where she wants to spend the rest of her life: in Germany.



A battle-tested community

The Europeans have plenty of experience of dealing with crises. If we take a look at the history of the community of European states, one thing becomes clear: more or less heated controversies have been a regular occurrence over the decades. However, it has always been possible to find strategies for overcoming them, as the team headed by **Stefan Vogenauer** at the **Max Planck Institute for European Legal History** in Frankfurt/Main is finding out in the course of its research. During the process, the researchers have also gained new insights into the current state of the European Union.

TEXT **MECHTHILD ZIMMERMANN**



A summit with new delegates: in October 1972, the six founder states of the European Community were joined for the first time by Great Britain, Ireland and Denmark at a meeting of the European heads of state and government. In the years that followed, vetoes by individual members repeatedly blocked agreements on a large scale.

Brussels, in the summer of 1965: *“Three minutes after midnight, the lights went out in the Palais de Congrès. The ministers gathered in Brussels (...) were sitting in the dark. Anyone who might have regarded this as a bad omen would soon see their fears confirmed: after the short circuit had been repaired, it only took another 107 minutes for the negotiations to fail. On 1 July, shortly before 2 o’clock in the morning, the most severe crisis yet to hit the Common Market began.”*

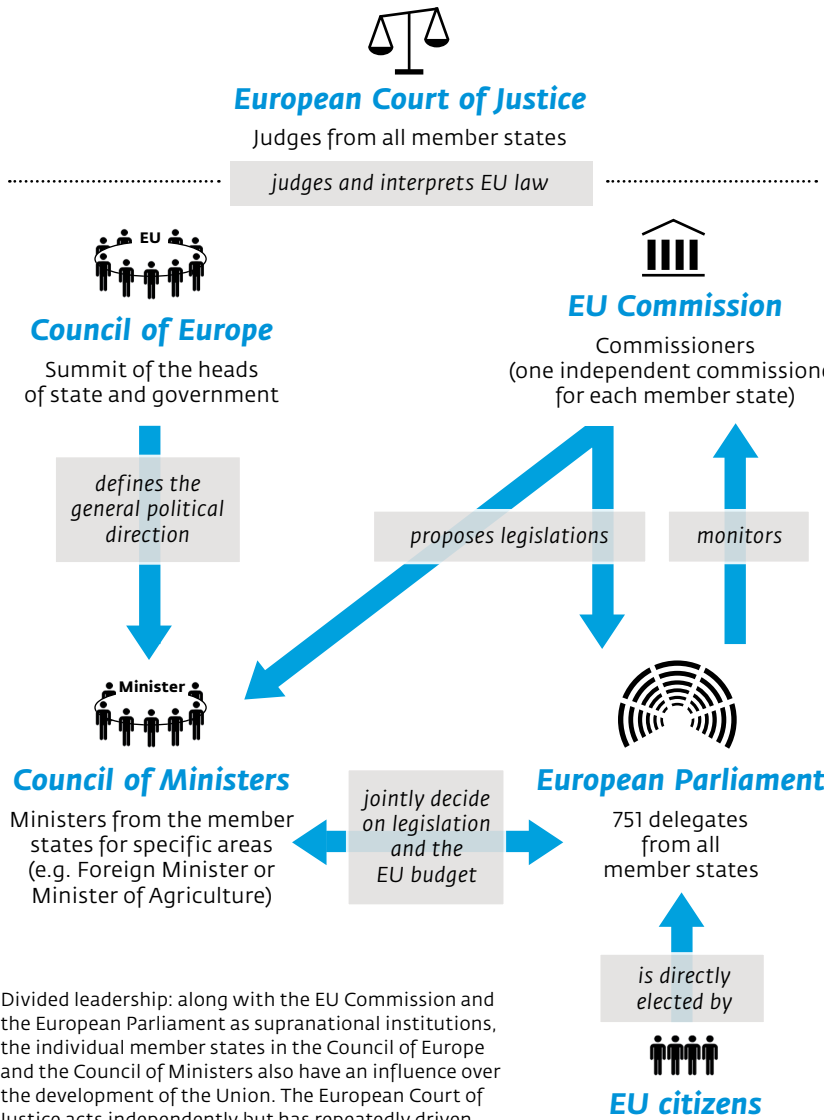
The night of 9 July 1965, the bitter end of which was described by the weekly newspaper *DIE ZEIT*, marked the beginning of the use of the empty chair

policy. According to Stefan Vogenauer, Director at the Max Planck Institute for European Legal History, this phase was marked by the most severe crisis in the history of European integration. As an act of protest, the French government at the time recalled its permanent representative in Brussels, refused to attend the meetings of the Council of Ministers, and in so doing, blocked the entire Community for half a year.

Only seven years previously, Germany, France, Italy, Belgium, the Netherlands and Luxembourg had joined together to form the European Economic Community (EEC). The Treaties of Rome had come into force in January

1958. It was agreed in these treaties that the establishment of an internal European market and the gradual convergence of economic policy was to promote prosperity in the countries and improve relations between the states. However, opinions about how far integration would have to go varied widely.

The French President at the time, Charles de Gaulle, could certainly be described as a Eurosceptic from today’s perspective. While he was in favor of a Europe with France and Germany as supporting pillars, his greater priority was helping his country regain its former global status. For de Gaulle, national independence was of key impor-



Divided leadership: along with the EU Commission and the European Parliament as supranational institutions, the individual member states in the Council of Europe and the Council of Ministers also have an influence over the development of the Union. The European Court of Justice acts independently but has repeatedly driven forward integration in the past.

tance, and he accordingly took a critical view of cross-state European institutions. The controversy that ultimately culminated in the crisis of 1965 flared up over two issues. Majority voting was to be extended to a series of important questions. Moreover, in de Gaulle's view, the EEC Commission under Walter Hallstein was acting like "a European government", since it was planning for example to introduce a separate Community budget.

However, there were other reasons for the French blockade. The French President wanted to secure a dominant role for his country in the European Community and to strengthen the influence of the national governments overall. It was not until January 1966

that the French returned to the table with the other EEC members, where they then negotiated what became known as the "Luxembourg Compromise": a veto option for certain states which regarded their national interests as being in danger.

INTEGRATION THROUGH CRISIS – THE MORE SEVERE, THE BETTER

Events show that the atmosphere in Europe was by no means more peaceful and harmonious in the past. "There have always been crises," says legal historian Stefan Vogenauer, "and they are easily forgotten. Since I've been following its development, the European Union has in fact been in permanent

crisis mode." One of the few exceptions was the period at the end of the 1980s and the early 1990s, when Jacques Delors was President of the European Commission and agreement was reached over the Single European Act and the Treaty of Maastricht. "There have always been times when giant strides towards European integration were made," says Vogenauer. "However, they were again followed by long periods of tactical withdrawal or stagnation."

Nevertheless, there are always two sides to a crisis. Walter Hallstein, who was the first President of the EEC Commission from 1958 to 1967, firmly believed that the European Community could "gain in stature and stability, particularly in times of escalating crisis," explains Philip Bajon, a historian in Vogenauer's team. "This was a part of his theory and his self-identification as President of the Commission: integration through crisis – the more severe, the better."

Hallstein was a professor of law and a staunch European. As one of the founding fathers of the European Community, he regarded Europe as a Community of Law (*Rechtsgemeinschaft*) – an idea that has since played an important role in the debate surrounding European integration. Even so, it is not so easy to clearly define what the "European Community of Law means," explains Thorben Klünder, who is examining the concept for his doctoral thesis. "On the one hand, it is assumed that there was already a Community of Law before the European states came together by signing an agreement." The European Community is therefore something akin to a community of values that had already had a common legal basis for hundreds of years in the form of Roman law.

On the other hand, the term is also used in the sense of an ideal, according to which the European states should become ever more closely aligned in legislative terms, as Klünder explains: "In the view of Walter Hallstein, for example, we were a Community of Law and were to become an even stronger one." According to Klünder, there is no

doubt that the different meanings of the word have influenced our understanding of the European Community: "The Community of Law can certainly be perceived as a narrative of how European integration can succeed, namely through the law."

However, what might sound good in theory is proving difficult to realize in practice. Even if there is a certain degree of consensus in Europe about the rule of law or basic rights, matters get complicated as soon as it comes to the details. Since the European Union's main focus is still the internal market, the goal in question is "merely" the creation of equal terms for the economies of all member states. However, these terms ultimately influence topics that relate to everyone: consumer protection, environmental protection, workers' rights, and national ways of dealing with issues ranging from food production to the design of car number plates.

A BLACKCURRANT LIQUEUR CHANGES POLITICS

Philipp Schmitt, who is also a doctoral student in Vogenauer's Department, explains how it soon became clear that agreeing on entirely congruent legal rules for all states was an impossibility. "The European Commission wanted to drive forward the Community of Law and attempted to achieve legal standardization. However, time and again, the countries expressed their opposition. This became particularly problematic in areas in which the members were supposed to agree unanimously." Schmitt is researching the development of a legislative technique known as minimum harmonization. This offered a way out of the dilemma that was frequently used from the 1960s until the recent past. For EU directives, i.e. for rules that need to be converted by the individual states into their own laws, it created room for maneuver for national concerns. The states only needed to agree on a minimum standard, with more stringent rules possible.

Schmitt cites an early example from the 1970s, the reduction of lead



in petrol. "Germany was the only country to have already significantly reduced the lead content by law when the standard was to be unanimously aligned at European level. The other members wanted to reduce the lead content in stages; however, Germany successfully proposed a derogation that permitted more stringent limits." In his analyses, Philipp Schmitt also comes across country-specific patterns: "It is those states that have high standards in certain areas that most frequently press the case for derogations. Environmental protection was often an important issue for the Germans, while the Danes insisted on asserting their principles when it came to social matters and the British were particularly keen on animal welfare."

Working for Europe: when in 1975, the British first voted on membership of the European Community, Margaret Thatcher as the leader of the Conservative Party advocated saying yes to Europe. She met with success: more than two-thirds of voters were in favor. The arguments on both sides at that time are largely the same ones that are used today.

While minimum harmonization may not conform to the ideal of legal unification, the EU has in Philipp Schmitt's view certainly benefited from the option of allowing more stringent measures: "I think that in a Europe with opposing views, this was a good way of making progress in the single market without ignoring social issues or environmental and consumer protection." After all, this is precisely the danger

that arises when a group has to agree on the smallest common denominator: “In general, there is the risk of a race to the bottom; in other words, at the end of the day, the lowest standard sets the benchmark.”

Today, the European Commission is anything but supportive of derogations for more stringent national standards. Schmitt can certainly understand why: “It’s a question from which angle you look at it. As important as the deviations upwards were for consumer protection, for example, for the economy, different periods for the right of withdrawal or claims for damage compensation might be an obstacle.”

One important question in this context is to what extent it is actually necessary for the single market to regulate details centrally. The European Court of Justice (CJEU) passed an important ruling in this respect at the end of the 1970s. The case may at first sound banal, since the subject of dispute was blackcurrant liqueur. A German supermarket wanted to start selling French Crème de Cassis as part of its product range. However, since the alcohol content did not conform to the German law on spirits, the liqueur could not be sold. The company filed an objection and was given a favorable ruling by the CJEU. The judges explained their decision by saying that national regulations may only restrict the European internal market when this is deemed necessary to fulfill mandatory requirements, for example for fiscal supervision purposes or when there is a risk to public health. In the case of the liqueur, the court did not find that such grounds applied.

Philipp Schmitt says that the so-called *Cassis-de-Dijon* judgment of 1979 set new standards for the alignment of legislation: “A certain alcohol content would have previously been specified in a directive on ‘Euro liqueur’, since it appeared to be necessary to set uniform requirements in order to enable the free movement of goods. The CJEU judgment prepared the path away from product alignment and towards more mutual recognition.”

This was not the only ruling with which the European Court of Justice



Joint investigation: the team headed by Stefan Vogenauer (above right) studies the European Union and its history. Insa Jarass (above left) is working on issues relating to European private law. Philip Bajon is studying the veto after the Luxembourg Compromise, while Philipp Schmitt is researching the development of minimum harmonization, and Thorben Klünder is focusing on the concept of the European Community of Law (below from left).



facilitated the advance of the single market in Europe. For decades, it was considered to be the “engine of integration” – a role that is contentious. Criticism has been voiced not only by politicians who see their national interests as being at risk, but also from the academic arena, particularly by political scientists and sociologists (see also “The Union of disparity”, page 30). They are critical of the fact that the Court of Justice has consciously acted in a political way over the years, and in so doing has acted *ultra vires*.

In his research, Stefan Vogenauer has focused on the history of the European Court of Justice. He and his team are studying this institution’s past, and

not only with reference to files, protocols and other written documents, but also by recording its oral history in a pilot project. In interviews, they are questioning judges, Advocates General and high-ranking administrative officials who used to work there in the past, and are comparing their memories with the official written records.

One question in their interviews relates to the possible political role played by the Court. The answers differ, according to Philip Bajon, who has been conducting some of these interviews together with a colleague. “Many interviewees insist that the CJEU was only applying the law – that there was therefore no political role, no activism, no

room for maneuver involved. There are only a small number of people who say that its role was occasionally also a political one.”

Regardless of its own understanding of its role, judgments by the Court of Justice often triggered fierce emotional reactions in the member states, particularly when traditional national regulations were affected. Stefan Vogenauer cites the ruling on the 1987 German regulation on the purity of beer as an example: “That was the first time that the German public said: ‘These people just came in from Brussels and overturned our purity regulation.’ That was truly traumatic. Today, no-one talks about this any more. German beer sells well abroad. And here in Germany, it’s probably possible to purchase beer that has not been brewed in accordance with the purity regulation standards; it’s just that no-one buys it.”

NO ATTEMPT WAS EVER MADE TO PUT A STOP TO THE DEVELOPMENT

For Vogenauer, the purity regulation is an example of how in every nation, there are strong, ultimately often uncompromising positions that citizens expect politicians to defend. It is therefore not surprising that the heads of state and government in the Council of Ministers are often vehement in their defense of their national interests – today just as they were in the past.

In the 1970s in particular, the Luxembourg Compromise was often used. This was the agreement that brought Charles de Gaulle’s “empty chair policy” to an end. At that time, the members negotiated an arrangement whereby every state could veto a majority decision when “national interests” were at stake. These “national interests” were not defined in greater detail, and the Luxembourg Compromise never became European law. The governments were happy to accept an informal, more political deal, since it gave them more room for maneuver when they invoked it in order to block majority decisions in the Council of Ministers. During the 1970s, the large number of vetoes led to what became known as “Eurosclerosis”,

an extensive blockade of European policies. It was only with the major revisions of the Treaties from the mid-1980s onwards that the decision-making culture began to change.


Philip Bajon has conducted a close study of the Luxembourg Compromise and its application. It is noticeable that during the 1970s, precisely during the period of Eurosclerosis, the European Court of Justice facilitated the advance of European integration to a significant degree with rulings that were of fundamental importance. According to Bajon, the legal and political spheres were therefore working in opposite directions: “Even so, no major attempt was ever made to limit the competences of the CJEU, to put a stop to the development or even to turn back the clock of history.” He concludes that the veto was a tool used to bring the critics on board and make it easier for them to cooperate. “It gave the governments the impression that they were still in control of the process of European integration.”

Only once did an attempt by a member to veto a decision fail, and it did so in spectacular fashion. In 1982, the United Kingdom was outvoted in its attempt to block a vote. At that time, the British had made their support for common agricultural prices conditional upon budget concessions. This went too far for the other states, and the prices were approved without the consent of the UK. “The British regarded this as an enormous blow to their sovereignty,” Bajon explains, “with all the consequences that this entailed. Even at that time, various Brexit scenarios were already being published in the press.” The arguments put forward in the de-

bate were the same as those used today: the fear of loss of autonomy and the desire to have full sovereignty over regulations in their own country.

For Stefan Vogenauer, Brexit ultimately reflects the tensions that have surrounded the European Union since it was founded as an economic community: how can I enjoy all the benefits that standardization brings, with access to the market, low production costs, and less bureaucracy for patent applications without giving up my identity or the values underlying my national legal system, concerning, for example, consumer and environmental protection? “It isn’t always easy to find the right balance here,” Vogenauer stresses. “The example of Brexit shows that the British want to square the circle. On the one hand, they want full access to the single market, while on the other maintaining full sovereignty over their own regulations and standards. But it’s impossible to have both at the same time.”

For Vogenauer, there is a positive side to Brexit. Current surveys in Europe show that, at present, no majority in any member state would vote against the EU. Before the United Kingdom voted in favor of exiting the EU, the picture was different. In the legal historian’s opinion, it is by all means possible that Brexit will weld together the other member states and facilitate a major step forward – entirely in the spirit of the first President of the European Commission, Walter Hallstein, who saw every crisis as an opportunity for Europe to grow closer together. ◀

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(in German)

SUMMARY

- European unification has been a source of tension from the beginning: the common internal market demands standardization. However, the states are also unwilling to give up their national self-determination.
- Compromises such as those that take the form of minimum standards with national derogations have made it easier for European states to grow together in the past.
- An informal veto option, which was frequently used from the mid-1960s until the mid-1980s, left national governments under the impression that they were still in control of the increasing degree of integration.



The struggle for common legislation

The European Union is not only an internal market, it is also a shared legal space. However, ideas about what constitutes a state under the rule of law are drifting further apart. For some time now, Poland and Hungary in particular have been defining their own rules. **Armin von Bogdandy**, Director at the **Max Planck Institute for Comparative Public Law and International Law** in Heidelberg, is conducting research into this “constitutional crisis” and the possible responses that can be made by the EU.

Under the banner of the law: judgments passed by the European Court of Justice play an important role for the rule of law in Europe. With the Latin term *curia*, which stood for the judgment of the king in the Middle Ages, the Court of Justice places itself firmly in the European tradition.

TEXT CHRISTIAN RATH

The EU is a community based on the rule of law. The internal market would barely be able to function if there were no common rules. National authorities apply European rules, while national courts monitor their application. The European Court of Justice (CJEU) is only involved in cases of doubt or conflict.

Over the last 20 years, close collaboration has developed between the courts and the investigative authorities. Judgments are being mutually recognized. Police forces are assisting each other. Extraditions within the EU have been made much simpler thanks to the European Arrest Warrant. For all this to work, there has to be mutual trust between the EU states, since equivalent rule of law standards apply and are upheld everywhere.

Article 2 of the Treaty on the European Union lists the basic European values: “the respect for human dignity, freedom, democracy, equality, the rule of law and respect for human rights.” It is claimed that these characterize the EU and are shared by “all Member States”. But is that really the case?

Armin von Bogdandy, Director at the Max Planck Institute for Comparative Public Law and International Law in Heidelberg, has his doubts. For about ten years now, he has been researching the “EU constitutional crisis and the rule of law.” How can Europe function as a community based on the rule of law when the Member States themselves have difficulties with the rule of law?

States with weak institutions, such as Greece, are problematic. “The inefficiency with which Greek tax law was

implemented was one reason for the dramatic financial situation in Greece,” von Bogdandy explains. The country’s administration is regarded as non-transparent, bloated and corrupt.

Romania and Bulgaria, which joined the EU in 2007, also have significant problems. At that time, the judicial system was not capable of acting effectively against organized crime and corruption. For this reason, both states had to commit themselves to a mandatory monitoring process. Every year, the EU Commission writes a report on judicial reform and the fight against corruption. In most cases, these reports are not encouraging.

TRUST IN THE JUDICIARIES OF THE OTHER STATES IS KEY

However, these problems have long been dwarfed by the disputes with Hungary and Poland. Since 2010, Viktor Orbán has been transforming Hungary into what he himself calls an “illiberal democracy.” The government is pursuing the goal of expanding its influence over the media, educational institutions and also the courts.

In Poland, the governing PiS party under Jarosław Kaczyński has been attempting to bring the judicial system under its control since 2015 by introducing numerous new laws. It has made sure that the majority of judges on the Polish constitutional court are pro-government. The Council for the Judiciary, which appoints the Polish judges, is now also controlled by the political majority. The Minister of Justice can also replace all presidents of the district, regional and voivodeship courts.

Recently, the government attempted to bring the Supreme Court of Poland into line and to dismiss Małgorzata Gersdorf, the President of the Supreme Court, who had refused to bow to the government’s will.

Armin von Bogdandy is a key figure in the discussion surrounding the safeguarding of EU rule of law. In particular, he develops arguments and legal concepts as a reminder of the basic values of the EU, especially for the states that are drifting away from them.

According to von Bogdandy’s central theory, “The EU must take action wherever there are systemic deficiencies.” By this, he does not mean problems that occur occasionally. “A systemic deficiency is said to exist when trust in the law and its enforceability is lost in important areas.” Here, von Bogdandy means not just the application of EU law, but also of purely national law. Trust in the law and its institutions is important for citizens and companies doing business and planning their lives. Trust is fundamental to the EU, which specifies rules for the Member States and in some cases also transfers considerable sums of money. Trust is also necessary when Member States cooperate with each other on police and judicial matters. In von Bogdandy’s view, it is difficult for the EU to function as a community based on the rule of law if there are systemic deficiencies in individual states.

Some time ago, he presented an argument on handling systemic deficiencies in the application of the rule of law. In exceptional cases, EU citizens should be able to assert claims to the European protection of fundamental rights either in the national courts (if they are still

independent) or directly at the European Court of Justice. Armin von Bogdandy talks of a reversed “Solange” doctrine, referring to a decision made by the German Federal Constitutional Court in 1986. At that time, the court in Karlsruhe decided that it would not monitor EU legal files for compliance with fundamental rights “solange”, or “so long”, as the CJEU guaranteed a largely equivalent protection of fundamental rights. Conversely, this means that the institutions of each Member State are themselves responsible for the national protection of fundamental rights outside EU law contexts – so long as they protect the essence of these fundamental rights. If not, indi-

vidual EU citizens have a right to a “European safety parachute of fundamental rights,” according to von Bogdandy. Since the CJEU has not yet adopted this concept, it has to date remained nothing more than a much-discussed academic recommendation.

In 2016, von Bogdandy also founded the “Heidelberg Discussion Group on the Multilevel Cooperation of Constitutional Courts” (“Heidelsberger Gesprächskreis Verfassungsgerichtsverbund”) together with high-ranking individuals such as Andreas Vosskuhle, President of the German Federal Constitutional Court. In this group, scientists debate with constitutional judges and European judges. CJEU President Koen Lenaerts

and the German judge at the European Court of Justice for Human Rights in Strasbourg, Angelika Nussberger, are also members. In 2018, the subject of discussion was “Mutual trust in the European legal space.” This is an opportunity for von Bogdandy to discuss his research results directly with key stakeholders and to present these results to them.

However, what concrete measures can the EU take if there are problems in individual states? Currently, there are four measures in particular that can be considered.

The lowest-level measure is to initiate a dialogue process. This is based on an “EU framework to strengthen the Rule of Law” that was approved by the

» On principle, EU citizenship encompasses an entitlement to a European safety parachute for fundamental rights.



Photos: picture alliance/dpa (left), picture alliance/NurPhoto

A test of strength in Poland: the government of Jarosław Kaczyński (far left) has been attempting to bring the judiciary under its control since 2015. Małgorzata Gersdorf (large image), the President of the Supreme Court, was due to be forcibly retired in July 2018 but refused to give up her seat.



EU Commission in 2014. Such a dialogue encompasses three phases. First, the EU Commission performs an analysis of the situation, in which it defines the problems. It discusses these with the state in confidence. If the problem cannot be solved quietly, the Commission issues public recommendations and sets deadlines by which they must be implemented. During the third phase, the Commission checks whether the recommendations have been followed and draws corresponding conclusions. Apparently, von Bogdandy's ideas were an important inspiration for this dialogue process. However, the procedure does not provide for sanctions.

The EU Treaty (Article 7) for the EU Council of Ministers, the body of the Member States, has more powerful tools at its disposal. With the agreement of 80 percent of its members, the Council can determine a "clear risk of a serious infringement" of EU basic values. This is intended as a type of final warning. In the next step, the Council can determine that there is "a serious and lasting infringement" of EU basic values. This resolution must be unanimous (excluding the state in question). If this hurdle is cleared, certain sanctions such as the loss of voting rights can be initiated provided there is a qualified majority. While harsh sanctions are possible, this procedure is also strongly politicized. As soon as two states agree to close ranks, there is almost no possibility of introducing sanctions.

The third option consists of infringement proceedings, which can in turn be initiated by the EU Commission. The Commission can file a suit against individual Member States at the CJEU. Here, the matter in hand is not the general situation, but individual laws. These procedures are often effective, since states that fail to comply with CJEU ordinances and judgments are threatened with substantial financial penalties. On the other hand, such procedures frequently remain technical and non-political, since they do not openly address the development of authoritarian ruling structures.

As a fourth option, there are procedures at the European Court of Justice that are initiated by national courts. At issue here is whether a court in one state can still collaborate judicially with a problematic Member State. Here, trust in the other state's application of the rule of law plays a key role. Can a citizen be extradited to this state if they are charged with a criminal offense there? This is a tricky question for the CJEU. If it prohibits extradition because treatment according to the rule of law is not guaranteed in the destination state, this might help the person affected but will damage European cooperation in the fight against crime. If it approves the extradition, it is in effect closing its eyes to the problems relating to the rule of law in the country in question.

POLAND AND HUNGARY SUPPORT EACH OTHER

For Armin von Bogdandy, the question of whether or not these measures are effective in the short term is by no means decisive. For him, the main point is that the EU does something and responds to systemic deficiencies. "Here, the vast majority of the EU states can draw a red line and define themselves in the club." In this way, he says, a situation can be prevented whereby the understanding of the rule of law in questionable states comes to be regarded as different but of equal value.

Over the past three years, the struggle for the independence of the Polish courts has intensified. It is now regarded as a litmus test for the ability of the EU to uphold rule of law structures in the Member States. This case can also be seen as an example of what the tools the EU has at its disposal can achieve in practice.

Poland was in fact the first state with which the EU Commission conducted a dialogue over the rule of law. From January 2016 to December 2017, the EU Commission issued four recommendations to Poland, each referring to different laws. However, from the viewpoint of the EU Commission, the recommendations went unheeded. >



Left A speaker in demand: Armin von Bogdandy is also active in eastern European countries with regard to the discussion surrounding the rule of law in the EU. Here, he is seen at a conference in Budapest.

Below Waiting it out together: according to the EU Treaty, the Council of Ministers has the option of determining a “clear risk of a serious infringement” of the EU basic values by Poland. To date, the members have not reached such a conclusion.



» A situation must be prevented whereby the understanding of the rule of law in questionable states is regarded as different but of equal value.

The EU Commission therefore applied to initiate the Article 7 procedure in the fall of 2017. However, the EU Council of Ministers has yet to pass a resolution on this matter. A removal of Poland's voting right appears almost impossible, since Poland and Hungary have assured each other that they would each prevent a unanimous resolution against the other state.

At the same time, the EU Commission has initiated two infringement proceedings due to the reform of the judiciary in Poland. The second legal action filed in September 2018 has attracted particular attention; it pertains to the reduction of the pensionable age for judges on the Polish Supreme Court. This reduction means that 27 of the 72 acting judges could be forced to retire, including President Gersdorf.

At the end of October, the CJEU, on behalf of the Commission, issued an interim injunction against this proposal. As a result, the judges affected were able to return to work. One month later, the Polish parliament, the Sejm, summarily passed a law that largely revoked the reform. The EU thus proved that it has the stronger arm, at least in individual cases.

During 2018, the CJEU also considered the extradition of criminals to Poland. In one case presented by the Irish High Court, the CJEU recommended a two-stage approach. First, national courts should examine whether there is a risk to the independence of the judicial system in Poland as a whole. The Article 7 procedure that has been initiated could provide important information in this context. In the second step, it must be checked whether this risk might have an impact on the specific case. Here, the CJEU takes account of the fact that the risk of an unfair trial is higher in politically controversial cases

than in cases of everyday crime. In this way, the Court of Justice cleverly avoids having to make its own assessment of conformity to the rule of law in Poland by transferring responsibility for the analysis to the national courts.

STRENGTHENING SELF-HEALING POWERS WITHIN THE COUNTRY

Armin von Bogdandy says that he is unable to predict whether or not the efforts made by the EU in Poland will be successful in the long term, and which tools could be the most effective. He says that he is neither a political scientist, nor is he sufficiently familiar with Polish domestic politics.

For the Director of the Max Planck Institute in Heidelberg, it is important not only to research the situation in Hungary and Poland from afar, but also to work with academics and judges from these countries in order to formulate questions and develop assessments. In 2017, for example, he held a conference in Warsaw.


At the same time, however, he warns against regarding the problematic EU states merely as objects of EU measures. "These countries have their own point of view, which we should listen to and assess carefully."

In the case of Poland, for example, the PiS government claims that it is in

fact creating the rule of law by removing judges from the communist era together with corrupt party members from the previous civic government. Poland and Hungary also claim that they are accused of having structures that have never been contentious in other states such as Germany, such as the election of judges by political committees.

Armin von Bogdandy is glad that in such debates there are also independent bodies such as the Venice Commission of the Council of Europe working alongside the EU institutions. This commission is a committee of experts that advises states on constitutional issues and also assesses them. It has explicitly criticized the restructuring of the judicial system in both Hungary and Poland.

However, for von Bogdandy, the purpose is not so much to enforce government compliance from the outside. First and foremost, he wants to strengthen the self-healing powers in the country in question. "If the EU insists on a judicial system that is independent and based on the rule of law, this is certainly acknowledged in the state affected." For him, it is a good sign that at the CJEU, nine judicial referrals are already pending from Poland with issues relating to the Polish judicial reform. ◀

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

SUMMARY

- Through political interventions, Poland and Hungary are threatening to undermine the independence of the judiciary and thus the EU rule of law.
- The EU has several ways of responding to this. The most effective ones appear to be infringement proceedings arising from specific laws that constitute an infringement of EU law.
- In the long term, the EU will only be successful if it strengthens the self-healing powers in the Member States affected.



The Union of disparity

Opinions are divided when it comes to the question of how Europe should progress in the future. On the one side are the Eurosceptics, who wish for stronger nation states. But on the other there are also many advocates of stronger European integration. At the **Max Planck Institute for the Study of Societies** in Cologne, research on Europe by **Martin Höpner** and his group and **Fritz Scharpf** explores to what extent there is any chance for the member states to move closer together, given their significant structural differences.

TEXT **CASPAR DOHMEN**

Photo: shutterstock



Europe will be whatever the Europeans can agree on, or there will be no Europe,” wrote the politicians Hans Eichel (SPD), Roland Koch (CDU), the philosopher Jürgen Habermas, and the economist Bert Rürup in their appeal for more solidarity in Europe in the fall of 2018. They called for more Europe, from an integrated European army to minimum standards of social protection for the unemployed from Portugal to Romania. Other pro-Europeans are demanding a greener Europe, or a more social Europe. There are many good reasons for them to do so. But how likely is it that the 27 EU members remaining after Britain has left can agree on such ambitious steps towards integration?

The researchers at the Max Planck Institute for the Study of Societies (MPIfG) in Cologne have found that the political and economic heterogeneity of the member states has a significant impact on European integration. “Their heterogeneity has a decisive influence on the scope of what is politically possible,” says the political scientist Martin Höpner, leader of the “Political Economy of European Integration” research group at the MPIfG. “It determines what is realistically possible, and what is not.” Given the serious structural differences, the researchers are skeptical. Their perspective is likely to make them seem unduly negative to European visionaries, yet their objective is to identify realistic courses of action.

Worlds apart: in Bulgaria, the poorest member state of the EU, 20 percent of people are so poor that they cannot cover their basic needs. Roma people (left) are the hardest hit. In Luxembourg, the richest EU country, seven percent of citizens are millionaires, and some like to display their wealth.

That might also help to prevent disappointment among citizens when the high-flying plans of the visionaries cannot be realized.

For a long time, there was much to be said for aligning living standards in the EU, in theory. In practice, however, the story of European integration took another course: the differences between the member states increased with each enlargement and, except in the case of Ireland, diminished little over time. >



Record export levels: Germany exported more goods than ever before in 2018. The German economy benefits from the fact that the euro – because of the economically weaker countries of the eurozone – is valued too low by international comparison.

The six founding members of the European Community (Germany, France, Italy, Belgium, the Netherlands, and Luxembourg) were initially a relatively homogeneous group, measured by their economic performance. This first began to change when the southern countries (Spain, Portugal, and Greece) joined in the early 1980s, and then did so very significantly with the wave of accessions of Eastern and Central European countries after the fall of the Berlin Wall. The wealth gap continues to this day: gross domestic product per citizen is more than ten times higher in Luxembourg, the richest member state, than in Bulgaria, the poorest country in the EU. This inequality is also reflected in minimum wages, which are EUR 11.55 per hour in Luxembourg and only EUR 1.57 in Bulgaria.

The MPIfG research group on Europe works in particular with comparative political economy, an approach commonly used by political scientists, sociologists, and economists. With it, researchers examine the structural dif-

ferences between states and find out whether heterogeneity has consequences, for example for the integration of regional economic areas such as in the European Union. Essentially it is concerned with different manifestations of capitalism. This is how the American political scientist Peter A. Hall and the British economist David Soskice differentiate in their classic book *Varieties of Capitalism* between coordinated economies in “core Europe” and liberal market economies such as the U.S. or Great Britain. The Danish sociologist Gøsta Esping-Andersen classifies states according to their social-democratic, conservative, and liberal welfare models. As early as the late 1970s, Fritz Scharpf, an Emeritus Director of the Cologne-based MPIfG and still actively researching today, identified other important variables for determining national differences in economic development: how they control inflation and how they set wages. The impact of these factors became clear with the oil crisis, caus-

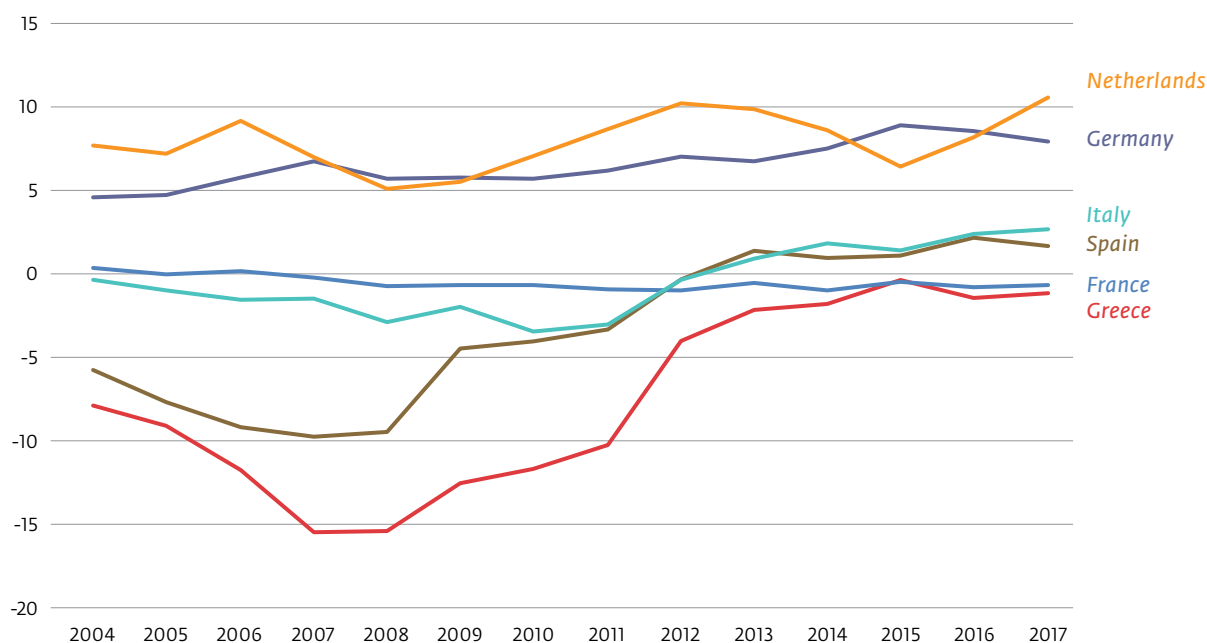
ing countries that were once comparable to drift apart economically during the 1970s.

EUROPEAN CONSENSUS HINDERED BY DIFFERENCES

According to Höpner, there is no definite threshold from which heterogeneity prevents integration. However, in political economy research there is a consensus that “the heterogeneity of the EU member states is enormous.” This is clearly illustrated by factors including minimum wage levels, worker participation arrangements, or methods of taxation. Nevertheless, a large amount of integration has taken place in the EU – in a variety of ways.

In the early 1990s, Fritz Scharpf already distinguished between positive and negative integration which is essential to understanding the approach taken by the Cologne researchers. The terms are used neutrally, merely intended to describe two different ways of achieving “more Europe.” Negative

Current account balance as a percentage of GDP



integration takes place when national trade barriers are removed in the individual countries. The best example of this is the creation of a single European market. The Community banned protectionist measures in all member states, such as customs duties and individual product specifications, so-called non-tariff barriers to trade. This resulted in the liberalization of the EU Single Market.

Negative integration, however, is not only brought about by European legislation. It is also extended by interpretation in the judgments of the European Court of Justice (CJEU). This happens on a regular basis. An example of a landmark judgment of the CJEU is the *Cassis de Dijon* ruling of 1979. The judges ruled that if a product was lawfully marketed in one member state, it was generally permitted for this product to also be sold in all other member states.

Meanwhile, the researchers talk about positive integration if the EU creates policies that are binding for all member states. To this day, such decisions in the EU require a large degree of political consensus among the members. "Owing to the structural econom-

ic differences, however, it is extremely difficult to reach this kind of consensus," Höpner says.

THE EU OFTEN ANNULS STANDARDS BUT DOES NOT CREATE NEW ONES

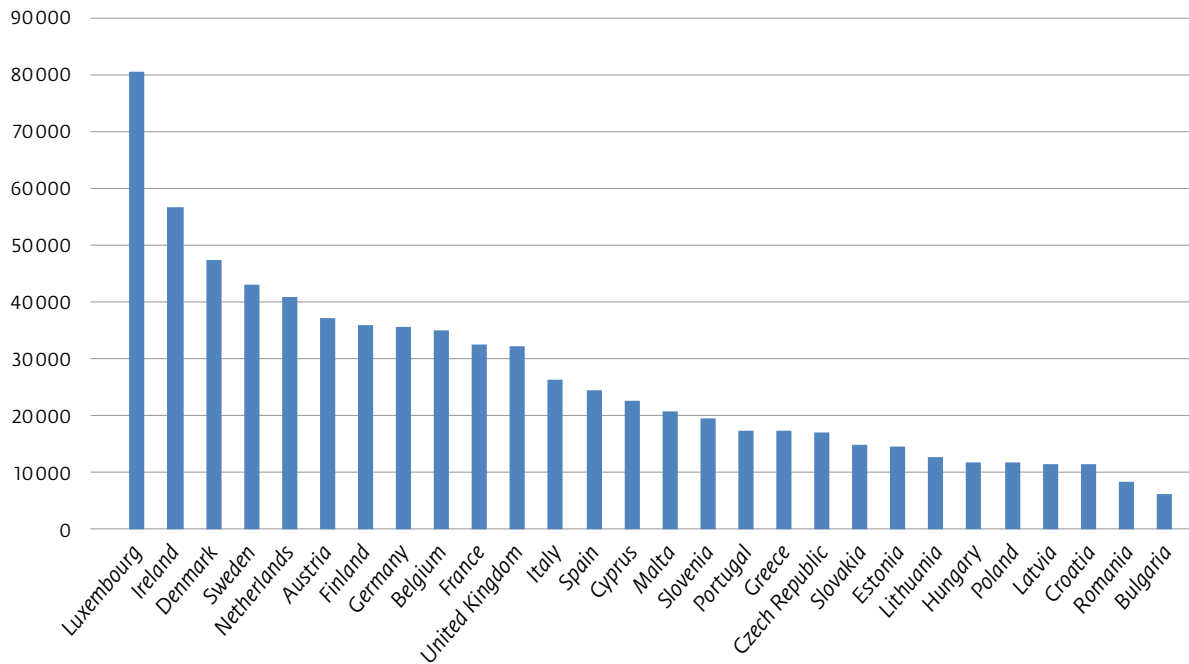
The best example of this is the discussion about tax harmonization. Large EU states have much to lose through tax competition and tend to push for harmonization of tax rates, for example for corporate taxes. Smaller and poorer EU countries are more interested in attracting companies with lower tax rates. "This is a legitimate interest," Höpner points out. Interests also clash when it comes to regulating the employment market, as the *Posting of Workers Directive* shows. Poorer countries are interested in their domestic companies being able to export lower standards and wages to richer countries, at least in part. Meanwhile, the wealthier countries try as far as possible to prevent this. These divergent interests make it very difficult to agree on consistent overriding principles in the Community, whether for social welfare, capital taxes, or worker participation.

Forced harmonization: the current account balance – the difference between the value of exported and the value of imported goods and services – has developed positively in Greece and Spain. However, in order to achieve this, people in these countries have had to suffer significant wage reductions and severe cutbacks in their health and pension systems.

The institutional regulations make it much easier to achieve political progress in the EU by means of negative integration than by positive integration. "This asymmetry is embedded in the European institutional system, and thus in the deep grammar of the EU, so to speak," says Höpner: "Negative integration generates a momentum that positive integration never could."

This has significant consequences, as the two integration mechanisms address different policy areas. Positive integration is usually used to create new regulations and establish standards, for example in the fields of environmental or social policy. Negative integration, on the other hand, often affects the economic policy field. Here national standards are almost always eliminated, which is why negative integration almost always has a liberal-

GDP per capita in euros in 2017



An indicator of inequality: the gross domestic product per capita reflects the disparities in the levels of prosperity. The gap between the EU members is apparent, despite the fact that the figures are slightly distorted by the high number of cross-border commuters in Luxembourg and Ireland's favorable taxation conditions for non-European companies.

izing effect. This theory can be used to explain why so many steps towards liberalization have been taken in the EU but there is little harmonization in the social sphere.

Structural differences have explosive effects in the eurozone of 19 EU countries. According Fritz Scharpf, Emeritus Director of the Institute, they are to a large extent caused by a single factor: differences in the relative size of the export sector and of the non-traded sector where goods and services are produced for domestic demand.

Wage and price increases have a different effect in export-oriented countries such as Germany or the Netherlands than they have in countries depending primarily on domestic demand, such as Italy or Spain. In the export sector rising wages that increase the costs of production may force export-oriented companies to increase the prices of their products or services,

which will put them at a competitive disadvantage compared to their competitors in the international market.

INFLATION PUSHES UP EXPORT PRICES

Of course, there are also exporting companies in countries that focus on their domestic market. For these companies, wage increases are a competitive disadvantage, too. However, increasing wages increases household incomes, causing demand to rise, and this can be far more significant for the development of the national economy. Companies are then able to achieve higher prices at home and can expand production and employment as a result. This may well cause inflation to rise, but inflation in a country with a large domestic sector can have a different significance for its economy than in a country with a large export sector. It may therefore

make sense for central banks in national economies that focus on domestic sales to allow higher inflation.

The common currency is also problematic when it comes to evaluation of the current accounts of domestic-market and export-oriented countries. Economists talk about a negative trade balance if the value of goods and services purchased from abroad by a national economy is higher than that of the goods and services sold abroad. If the opposite is the case, they talk about a positive trade balance. The trade balance is the largest component of the current account. Before the common currency was launched, imbalances between the current accounts of EU member states could be compensated through appreciation or depreciation of the respective national currencies.

Since the introduction of the single currency, adjustments have only been possible through internal devaluation.

» It would take enormous sums to reduce the economic disparity that exists in the eurozone. It makes no sense for everyone to keep the euro.

Economists use this term to refer to a lowering of prices and wages to improve the competitiveness of a national economy. Internal devaluation on a particularly large scale took place in heavily indebted euro member states during the financial crisis – in part under significant pressure from the so-called Troika, the EU Commission, the European Central Bank, and the International Monetary Fund.

WAGES IN GREECE FELL BY A QUARTER

In practice, such measures apply mostly to wage and non-wage labor costs. In Greece, for example, gross wages fell by around one quarter, the tariff system was eroded, and many workers today receive only the minimum wage. These so-called austerity measures are intended to make companies from one national economy more competitive compared to their competitors from other national economies. However, the right economic policy for an export-oriented country may prove counterproductive for those with a focus on domestic sales, as can be seen from the countries hit by the crisis. The strategy has proven successful in the sense that current account deficits and the wage share have decreased, and exports are growing faster than gross domestic product. However, employment has fallen in the crisis countries, and national debt is significantly higher than it was before the crisis. What is more, the already high German export surpluses have increased further, as the euro is undervalued compared to the rest of the world.

“The gap in international competitiveness between northern and southern EU countries still exists. It could

only be closed by further extending and intensifying present austerity policies,” Scharpf explains. Prices and wages in crisis-ridden countries would need to decrease even further, an option he considers to be “politically impossible.”

Trade unions in many EU countries have already been weakened by the austerity policies, for example because wage settlements have been decentralized to plant level. Local works councils are in a weaker negotiating position than trade unions that bargain collective wage agreements for entire industries. Education, health, and pension systems have also been weakened. All of this is not without consequences. “Certain types of social order are hard to create and easy to destroy,” says Höpner: “Liberalization often produces irreversible results.”

So, what political conclusions do the researchers in Cologne draw from their findings? In theory, the economic disparity in the eurozone could be reduced by transfers between richer and poorer countries, much like the fiscal equalization that takes place among the German federal states. This would require enormous sums, likely to overstrain the donor states. Taking the major structural differences into account, however, the MPIfG researchers consider this solution to be highly unlikely anyway. More inflation in the north would ease the burden of adjustment in southern economies, as this would reduce price distortions within the eurozone. But this is easier said than done. Higher inflation cannot be prescribed against the will of those it affects. The only other way to keep the eurozone together would therefore be more austerity, which would cause considerable unrest among the affected citizens. >



Research-active Emeritus: Fritz Scharpf was a Director of the Max Planck Institute for the Study of Societies between 1986 and 2003 and continues to work on issues relating to Europe.



A political scientist with an economic focus: Martin Höpner leads the MPIfG research group on the “Political Economy of European Integration”.


“It makes no sense for everyone to keep the euro,” says Höpner. He believes it would be wise to implement a mechanism in the eurozone that enables states to opt out of the single currency, as well as back in. For this type of reform he also sees major obstacles, however. There is an intense fear of the consequences that dissolving the euro might have, as well as the tendency to associate the euro with a pro-European attitude. As the German Chancellor Angela Merkel succinctly put it before the Bundestag, “If the euro fails, Europe fails.” Höpner considers the “emotional or ideological identification of the euro with Europe [to be] part of the problem, as it prevents a necessary correction of the currency union.” The essence of the researchers’ findings is this: ambitions for the EU should be lowered. This may not produce a United States of Europe, but it could lead to a more functional union of states.

The researchers consider the likelihood of establishing a European welfare state to be “non-existent.” A European welfare state that works in Bulgaria and Denmark at the same time? “It is impossible to imagine, even in theory,” says

Höpner. Scharpf and Höpner nevertheless see realistic chances of social progress, for example in the form of EU assistance to enable poorer member

states to strengthen basic social protection. Höpner considers a voluntary basis for such assistance to be appropriate, which the countries will be hard pressed to refuse given the great benefit to their citizens.

Sober assessments like this may not be as exciting as the dream of a United States of Europe, but they may provide better opportunities for making actual political progress in the EU despite all the structural differences between the member states. ◀

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

SUMMARY

- There are significant differences between the economic structure and performance of the member states of the European Union.
- The resulting conflicts of interests make it almost impossible to reach agreement in certain areas, for example in the case of a common tax policy or EU-wide social standards.
- There are also significant disparities within the eurozone: depending on whether a country’s economy focuses on its domestic market or on exports, policy measures – for example to lower inflation or cut wage costs – can have a positive or negative effect.
- In setting its targets, the EU should pay more attention to the heterogeneity of its members. Euro countries should also be able to temporarily opt out of the common currency.

GLOSSARY

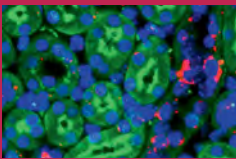
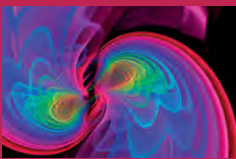
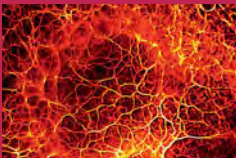
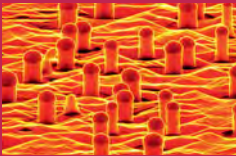
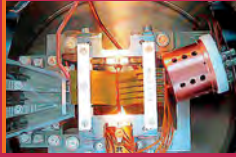
Austerity refers to policies provided pursued by governments in an economic downturn in order to cut spending and make the country more attractive for investors through lower wage and incidental non-wage labor costs.

The trade balance of a country’s economy is a calculation of all exports and imports of goods and services over a certain period. A positive trade balance is where the sum of a country’s exports is higher than that of its imports.

The current account is made up of the trade balance, transfers to and from abroad, and residents’ net income.



Connecting Science and Business.



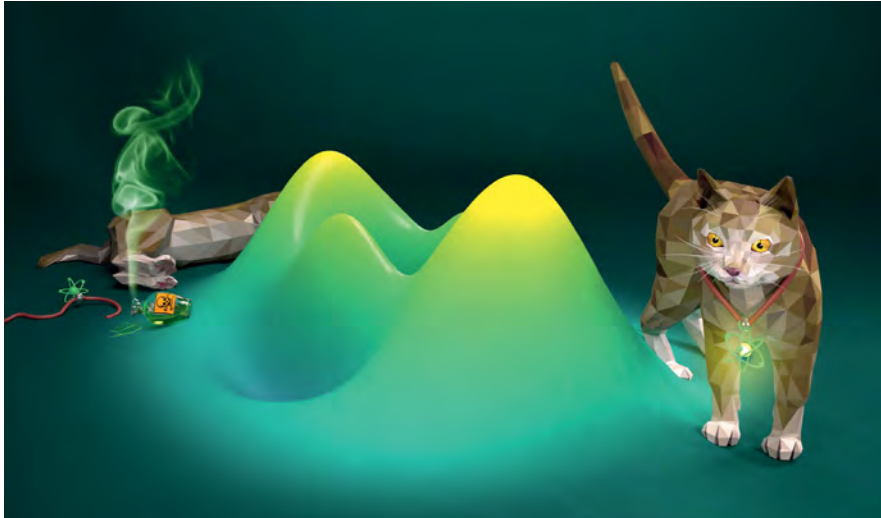
Max Planck Innovation is responsible for the technology transfer of the Max Planck Society and, as such, the link between industry and basic research. With our interdisciplinary team we advise and support scientists in evaluating their inventions, filing patents and founding companies. We offer industry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

Connecting Science and Business



Flying optical cats

An entangled atom-light state raises new prospects for quantum communications



Alive and dead at the same time: Schrödinger's cat is entangled with an atom. If the atom is excited, the cat is alive. If it has decayed, the cat is dead. In this experiment, a pulse of light forms a superposition state of this kind, as represented by the pulse profile in the middle of the image.

allowed a cat to be simultaneously dead and alive in what is known as a superposition state. In this version of the experiment, however, the role of the cat was played by a pulse of light. After bringing an atom into two physical states that existed simultaneously, the researchers caused the light signal to interact with the atom in a resonator – a tiny cavity between two mirrors. This interaction caused the light to adopt a similar state. Using other optical operations, the researchers ultimately caused the pulse of

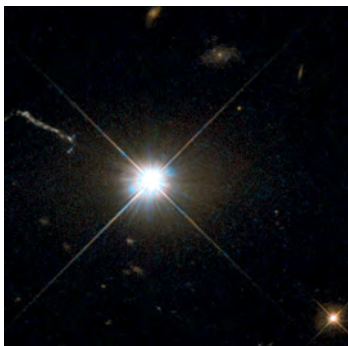
At no point did researchers put a cat's life in jeopardy. Rather, a team led by Gerhard Rempe, Director at the Max Planck Institute of Quantum Optics in Garching, conducted a paradoxical thought experiment in the laboratory. Devised by the quantum physicist Erwin Schrödinger, this experiment

light to continue flying independently of the atom in a superposition state similar to that of Schrödinger's cat. As optical superposition states of this kind can be used to encode quantum information, the experiment raises new possibilities for quantum communication. (www.mpg.de/12651632)

In the whirlpool around a gigantic black hole

Quasars are the turbulent nuclei of galaxies that serve as the home of supermassive black holes. In these cosmic powerhouses, gravitational energy is converted into heat as material falls into the black hole at the center. In the process, the gas glows so brightly that it illuminates the entire galaxy and is visible even from billions of light years away. This brightness complicates the measurement of active black holes, because it is no longer possible to see the stars whose orbits are used to calculate the central mass. However, using the Gravity instrument on the Very Large Telescope at the European Southern Observatory, astronomers from the Max

Planck Institute for Extraterrestrial Physics have peered deep into the heart of the quasar 3C 273 and succeeded in determining its precise mass for the first time based on the swirling motion of the gas clouds that surround the black hole. The distance of 150 light days from the clouds to the center, in combination with their orbital velocity, produced a value of 800 million solar masses. (www.mpg.de/12545668)



A power plant in space: the quasar 3C 273 is located in a gigantic elliptical galaxy in the constellation Virgo, some 2.5 billion light years from Earth. It was the first quasar ever identified as such.

Who lies the most

Meta-analysis synthesizes results of 565 studies on the psychology of dishonesty

Experimental studies have long sought to identify the personal and environmental factors that turn people into liars. Now, scientists from the Max Planck Institute for Human Development have teamed up with Israeli colleagues to synthesize the results of 565 studies as part of a comprehensive meta-analysis. This confirmed the conjecture that men lie more often than women – although the

Preference for underweight bodies

Anorexia nervosa patients prefer extremely slender bodies

Scientists are increasingly relying on the use of virtual reality in order to research how people perceive their bodies. The researchers scan subjects' bodies and create a digital copy using the latest computer technology. This approach is more realistic than, for example, squeezing or stretching photos to simulate variations in body weight. Using the new technique, researchers from the Max Planck Institute for Biological Cybernetics and the Max Planck Institute for Intelligent Systems studied the body perceptions of over 100 people with eating disorders. With the help of a joypad (similar to a Playstation controller), the subjects were asked to vary their avatars until the weight of their virtual alter ego matched their perception of their own weight. The results showed that patients with anorexia nervosa estimated their weight just as accurately as healthy women. Many previous studies suggested that anorexic women suffer from distorted visual self-perception and perceive themselves as too fat, even though they are generally severely underweight. The researchers also investigated what



Personalized avatar of a test subject. Anorexia nervosa patients are just as accurate as healthy women in estimating their real body weight. Unlike healthy women, however, they perceive severely underweight bodies as attractive.

body weight the participants considered desirable and found that women with anorexia nervosa considered severely underweight bodies ideal. For example, they perceive a weight of 43 kg at a height of 1.60 m as beautiful. According to the researchers, the fact that women with anorexia nervosa have a different opinion about what weight is desirable should be at the forefront of future therapies for people suffering from eating disorders. (www.mpg.de/12332536)

Photos and graphic: MPI for Biological Cybernetics/A. Thaler (top), Adobe Stock (bottom)

difference is slight, with 42 percent of men and 38 percent of women lying in the experiments. What is clear is that younger people lie more than older people: the probability of lying is about 47 percent for 20-year-olds and falls to just 36 percent by the age of 60. However, the results also show that the experimental set-up can influence subjects' behavior. In other words, people are not honest or dishonest per se, but rather their behavior depends partly on circumstances. This should be taken into account in future studies. (www.mpg.de/0120194/en)

Geckos walk on water

When it comes to walking, geckos have evolved some extraordinary abilities. For example, tiny hairs allow many of them to walk upside down across a sheet of glass, and some medium-sized species can even walk on water, as researchers led by Ardian Jusufi at the Max Planck Institute for Intelligent Systems in Stuttgart have discovered. To prevent themselves from sinking, the lizards – which weigh around six grams, about the same as a sheet of paper – appear to use a variety of techniques. For example, they exploit the surface tension of water, as do some species of insects, but they are too heavy for this alone to keep them afloat. The reptiles therefore rapidly slap the water with their feet, like ducks and swans during takeoff, to cre-

ate air pockets that support them. In addition, their water-repellent skin appears to allow them to plane across the water. Finally, they use wavelike movements of their tails to create thrust and lift. Based on these findings relating to geckos' ability to walk on water, researchers want to develop robots with similar abilities. (www.mpg.de/0120192/en)



Medium-sized geckos cannot rely on surface tension alone in order to stay afloat.

Reaching into the box of psychological tricks

The degree of willingness of men and women to assert themselves in competitions can be balanced out



Unequal opportunities: women are generally less willing than men to face competition. A psychological method known as priming can be used to iron out behavior differences between genders.

There are significant differences between men's and women's attitudes to competition – and this is one of the key reasons why women are often at a disadvantage in the world of work. This inequality can be reduced considerably using a psychological trick, as demonstrated by Matthias Sutter of the Max

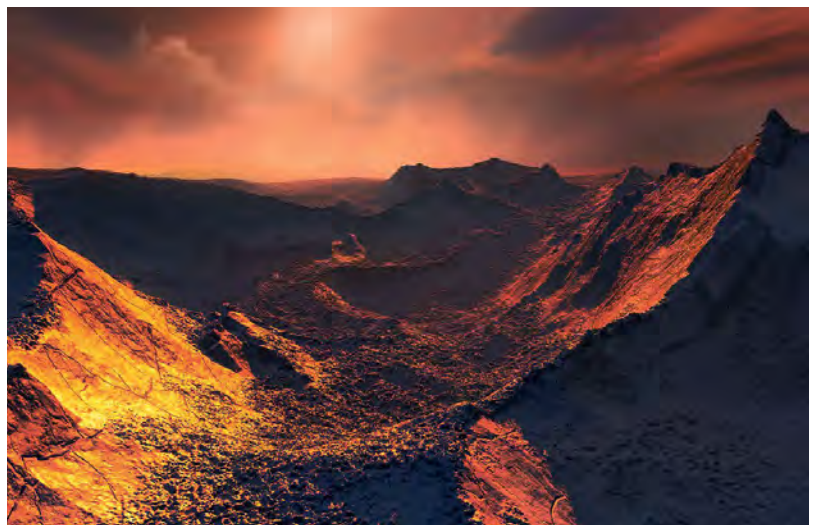
Planck Institute for Research on Collective Goods together with Austrian colleagues. In an experiment, some of the subjects were prepared using a psychological method called priming. This group was asked to remember an event over which they exerted an influence. Another group of subjects went unpre-

pared. When all of the participants subsequently faced a competitive situation, 40 percent of men but only 14 percent of women in the neutral group were willing to enter into competition. Following priming, men in particular behaved differently, with only 28 percent of them choosing to face the competition. On the other hand, a slightly larger proportion of the women – 20 percent – opted for the competitive situation. Remembering an influential situation appears to enable individuals, regardless of their gender, to arrive at a realistic assessment of their own abilities. According to the research team, the method could be applied in the education system and in professional training. (www.mpg.de/12381578)

A cold super-Earth in our neighborhood

Barnard's Star, which is six light years away, is home to an exoplanet

An international group of astronomers, including from the Max Planck Institute for Astronomy, has succeeded in detecting a planet orbiting Barnard's Star, which is only six light years away. The planet has just over three times the mass of Earth and is about as cold as Saturn. The discovery was made by measuring the periodic changes in radial velocity of the parent star – that is, the movement of the star in response to the planet's pull. To do this, the astronomers extracted a signal from 771 individual measurements they had collected over the course of two decades. The celestial body, which has been named "Barnard's Star b", orbits its host star once every 233 days at a distance of around 60 million kilometers. With a temperature of about -170°C , it is probably a hostile, icy desert in which there is no liquid water. (www.mpg.de/12486212)



An alien world: this illustration shows the surface of the planet "Barnard's Star b".

The toolmakers of the bird world

New Caledonian crows combine individual parts to form a long-distance reaching aid

For a long time, tool use appeared to be an exclusively human trait. We now know that tools are widespread in the animal world, although it was thought that only humans and great apes could use complicated objects consisting of multiple components. Now, however, it is clear that this illustrious group of animals also includes crows. Scientists from the Max Planck Institute for Ornithology in Seewiesen and the University of Oxford have discovered that New Caledonian crows can create compound

tools in order to access food that is out of reach. In an experiment, the researchers offered the birds treats that they could not reach, as well as several sticks that were each individually too short. Without any external help or prior training, the crows combined the short pieces to create a stick of sufficient length. One of the birds even made tools out of three and four parts. The results show that crows are among the few animals that can respond flexibly to novel problems. (www.mpg.de/12401947)



New Caledonian crows – from the eponymous archipelago in the South Pacific – are extremely intelligent birds. If necessary, they can combine several elements to create a working tool.

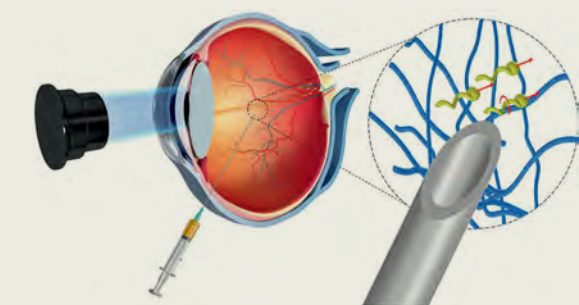
Symbiosis of burying beetles

The animals rely on their gut symbionts in order to transform decaying carcasses into healthy nurseries for their young

Burying beetles bury the cadavers of small animals in soil to use them as a food source for their offspring. However, the nursery decomposes progressively over time, and the resulting toxic substances, microbial pathogens, and nutrient loss are a threat to the beetle larvae. According to scientists from the Max Planck Institute for Chemical Ecology in Jena, the beetles therefore replace harmful microorganisms with their own beneficial gut microbes. Symbiotic yeasts from the beetle's gut thus suppress the soil-associated molds that quickly overgrow a cadaver in normal circumstances. In this way, the parent beetles ensure that their offspring remain healthy and can thrive in the dead body. In cadavers without microbes from the parents' intestinal flora, on the other hand, the larvae remain a significantly smaller size. The burying beetle is therefore another example of how insects can use symbionts to exploit challenging resources. (www.mpg.de/12358349)



A pair of burying beetles of the species *Microphorus vespilloides* attend to their young in a dead mouse. The beetles have preserved the cadaver with microorganisms from their gut.



Corkscrew-shaped nanorobots are injected into the vitreous humor of an eye and steered towards the retina using an external magnetic field.

Nanorobots enter the eye

In the future, nanorobots could perform medical tasks directly on the retina. A team led by Peer Fischer, a scientist at the Max Planck Institute for Intelligent Systems, has moved a step closer to this goal. The researchers steered a corkscrew-shaped nanopropeller through the vitreous humor of a dissected pig's eye. They had incorporated particles of iron into the silica propellers so that they could actively control the movement from the outside using magnetic fields. By applying a coating that was not only hydrophobic but also oleophobic, they ensured that the propeller slipped through the gel-like substance in the vitreous humor. Nanovehicles of this kind could be used to deliver medicines or to perform minor operations. (www.mpg.de/0120193/en)

Illuminating women's role in the creation of medieval manuscripts

Traces of blue paint in dental plaque offer the first clear evidence that women were involved in illustrating manuscripts



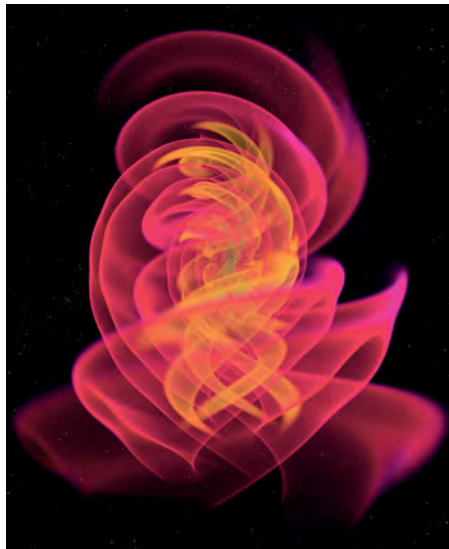
An unspectacular place for an archaeological find: a community of religious women lived in Dalheim, near Paderborn, in the Middle Ages. At least one of them illustrated elaborate manuscripts – a job that, until now, has been attributed solely to men.

Germany was a center of book production in the Middle Ages. As a sign of humility, many medieval scribes and painters of manuscripts did not sign their work – which may explain why illumination was long attributed solely to men. Now, an international team of researchers with significant participation by the Max Planck Institute for the Science of Human History has shed light on women's role in this profession. When analyzing the dental calculus of a woman buried at a small women's monastery near Paderborn in around 1000 AD, the team came across lapis lazuli pigments. Along with gold and silver, this precious blue paint was reserved for illustrating the most luxurious manuscripts, and only people with exceptional skill were entrusted with its use. Based on the distribution of the paint particles in her mouth, the researchers concluded that the woman probably painted with lapis lazuli and repeatedly licked the end of the brush while she worked. (www.mpg.de/12632827)

Four new sources of gravitational waves

The LIGO and Virgo observatories are also publishing their first catalog

Scientists have carried out a closer analysis of previously recorded data from the LIGO and Virgo gravitational wave detectors, tracking down four new signals. All of them originate from the fusion of pairs of black holes, which is accompanied by the release of part of the mass as energy and a distortion of space-time. The masses of the black holes varied widely, from 7.6 to 50.6 solar masses. One of the newly discovered events – known as GW170729 – was attributed to the most massive and distant gravitational-wave source ever observed: in this coalescence, which took place roughly five billion years ago, an amount of energy equivalent to almost five solar masses was converted into gravita-



tional radiation. To coincide with the announcement of the new findings, the scientists presented a catalog of all known gravitational wave detections and candidate events from the first two observing runs, O1 and O2. The catalog describes the characteristics of the merging black hole population. So far, the astronomers have tracked down eleven signals, one of which does not originate from black holes but rather from a collision between two neutron stars. (www.mpg.de/12552357)

Space is moving: this numerical-relativistic simulation reflects the first observed fusion of two black holes, as measured by the Advanced LIGO detectors on 14 September 2015.

Appealing art has a lasting effect

Paintings can trigger reactions in areas of the brain that are normally used for reflection

Based on measurements of brain activity, a team including researchers from the Max Planck Institute for Empirical Aesthetics is studying how our brain reacts when we look at works of art. Cognitive researchers expect primarily sensory brain regions to be active when we look at images, as the focus is – of course – on the outside world. At the same time, there should be a reduction



in brain activity in areas that support reflective processes. However, the researchers observed that aesthetically pleasing images activated the observers' "default mode network" – an area of the brain that allows us to think independently of external stimuli, for example, in the form of daydreams or future plans. When subjects saw an artwork they did not find attractive, however, this effect was not observed. In other words, if – and only if – artworks are aesthetically pleasing, they activate an unusual process in the brain that deals not only with external stimuli but also with mental and emotional responses.

Impressive: the painting *The Starry Night* by the Dutch artist Vincent van Gogh triggers a reflective response in many people even 130 years after it was created.

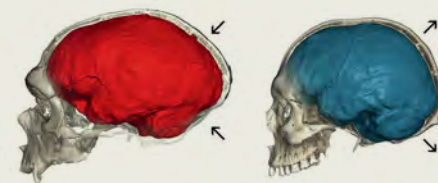
It's an animal!

Traces of organic material in fossils dating back over 550 million years allow classification of the primeval organism Dickinsonia

Dickinsonia was an unusual creature. Examples of this genus are thought to have moved about on the seabed until approximately 550 million years before our time, reaching a size of up to 1.40 meters and bearing no resemblance to present-day organisms. It was hitherto unclear whether the organism was a lichen, an extinct form of large single-celled amoeba, or indeed the earliest known animal on Earth. Now, this question has been answered by an international team including scientists from the Max Planck Institute for Biogeochemistry. The researchers classified Dickinsonia by analyzing traces of

An animal with no modern relatives: Dickinsonia, whose fossils have been found in the White Sea, in Russia, for example, is unlike any present-day organism.

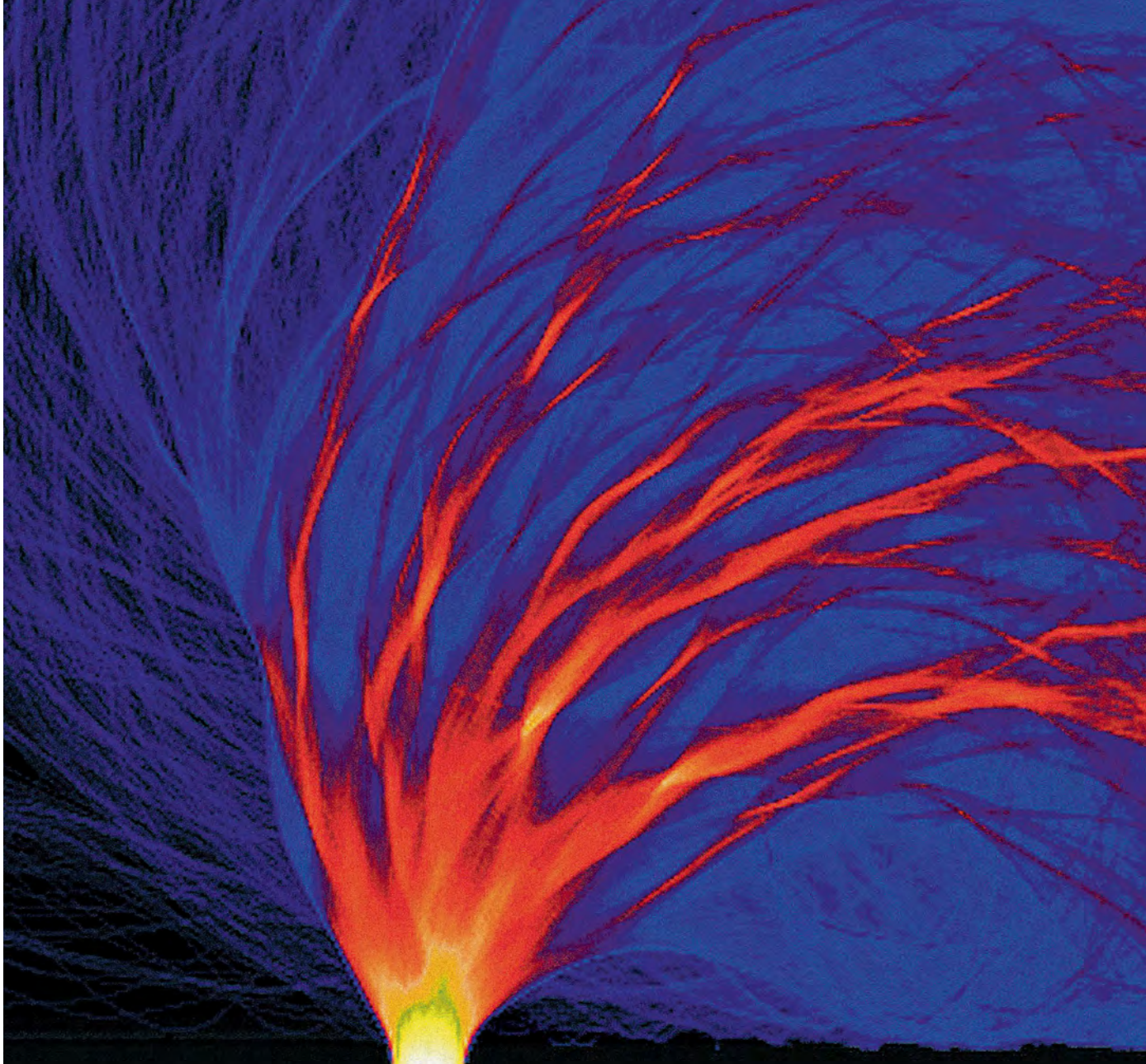
organic material in fossils dating back 558 million years. According to their analyses, the substances are residues of cholesterol molecules that are typically found in animals. Dickinsonia are therefore the earliest known animals on Earth. (www.mpg.de/0120191/en)



Skulls of a Neanderthal (left), with the typical elongated brain shape (red), and a modern human (right), with the typical rounded brain (blue). The arrows point to the enlarged cranial fossa at the back of the skull, which is home to the cerebellum, and the arching of the parietal bones in modern humans.

Neanderthal genes influence the shape of the brain

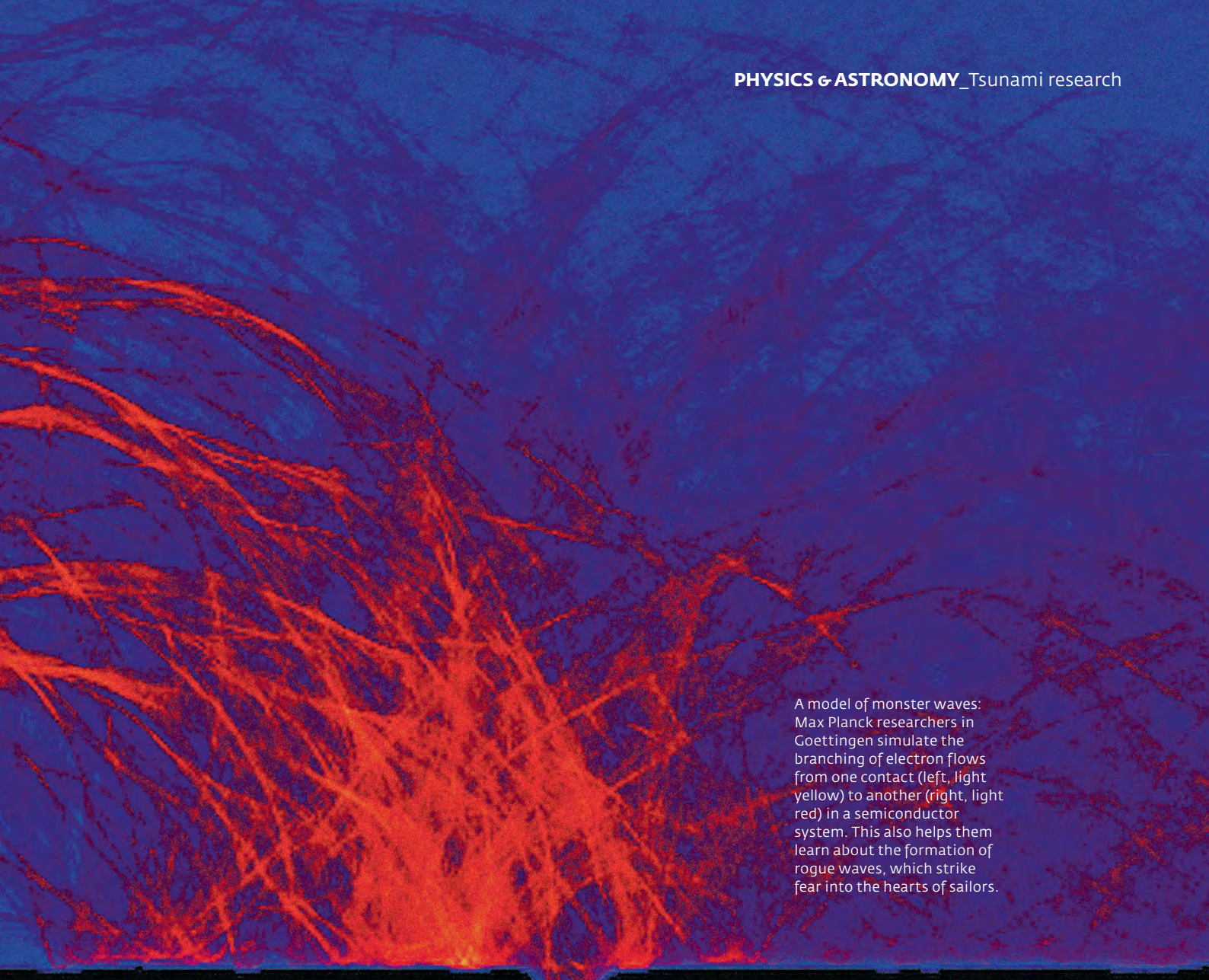
One characteristic feature of modern humans is their unusually round skull and brain in contrast to other forms of human. An international team including scientists from the Max Planck Institutes for Evolutionary Anthropology and Psycholinguistics has now discovered genes that influence the shape of the brain and therefore the skull, in modern humans. The researchers analyzed skulls from Neanderthals and modern humans using an MRI scanner and produced virtual imprints of the inside of the skull. These imprints reflect the shape of the individual's brain but not their intellectual capacity. According to the analyses, significant differences in brain and skull shape are found not only between Neanderthals and modern humans but also between the skulls of some humans who are alive today. A genome analysis showed that humans with more elongated skulls carry Neanderthal DNA on chromosomes 1 and 18. These fragments alter the activity of two genes involved in brain development and the formation of nerve cells. However, brain shape is probably not affected solely by these two genes, but rather results from the combined effect of many different genetic variants. (www.mpg.de/12565720)



Atoms make waves

For **Ragnar Fleischmann**, it was a surprising discovery: in simulations depicting the flow of electrons in semiconductors, he observed behavior resembling that of tsunamis and rogue waves on the open sea. Today, his team at the **Max Planck Institute for Dynamics and Self-Organization** in Goettingen is researching electronic processes with a view to improving forecasts of destructive waves.

TEXT **KLAUS JACOB**



A model of monster waves: Max Planck researchers in Goettingen simulate the branching of electron flows from one contact (left, light yellow) to another (right, light red) in a semiconductor system. This also helps them learn about the formation of rogue waves, which strike fear into the hearts of sailors.

For anyone who was still unaware of it, the destructive force of tsunamis became abundantly clear over Christmas in 2004. A powerful earthquake struck off the coast of Indonesia, triggering a wave that raced halfway around the world and killed in excess of 200,000 people. The tsunami traveled for hours before slamming into distant coastlines, claiming the lives of unsuspecting beachgoers even thousands of kilometers away.

Since then, German scientists have installed an early warning system in the Indian Ocean. This is based on the principle that seismic waves move much faster through rock than water waves can cross the ocean, meaning there are

often several hours in which to issue a warning. From the seismic waves, scientists can determine not only the strength of the earthquake but also its epicenter – that is, the place from which the wave originates. Based on this information, software is used to model the path of the tsunami and to calculate when it is expected to arrive at the various coasts. People on the ground are then warned via radio announcements, sirens, or other signals.

But the modeling of the wave's course can be misleading, as demonstrated by Ragnar Fleischmann and his team at the Max Planck Institute for Dynamics and Self-Organization in Goettingen. According to their calculations, these monster waves are even

more deceptive than previously assumed. To understand this, we must turn our attention away from the great ocean for the time being and instead consider the world of tiny nanostructures, which can only be accessed using highly sensitive techniques such as atomic scanning probe microscopy.

A MOMENTOUS DISCOVERY IN SEMICONDUCTOR SYSTEMS

Indeed, Fleischmann is not an oceanographer but rather a theoretical physicist, and his research focuses primarily on complex dynamics and quantum phenomena, such as those in electronic semiconductor structures. While he was studying systems of this kind as a

postdoc with the physicist Eric Heller in Harvard 18 years ago, he and two colleagues made a discovery with far-reaching consequences. They were seeking to explain an experiment that delivered beautiful images but that is also difficult for non-experts to understand. It concerned how electrons move in a two-dimensional electrical conductor.

A conductor of this kind is formed at the interface between two different semiconductors – a semiconductor heterostructure. Here, electrons are trapped in a “potential well”, rather like water in a trough. Their freedom of movement is therefore limited to the two dimensions parallel to the interface.

IMPURITY ATOMS FORCE ELECTRONS ONTO NEW PATHS

Two tiny metal contacts on the surface of the crystal are separated from one another by a narrow slit, forming a bottleneck that the electrons have to squeeze through. This is known as a quantum point contact. Since the semiconductor material used in the experiment was highly pure, the scientists expected the electrons to fan out from the quantum point contact in all directions like light from a streetlamp.

After all, the particles should be able to move freely and have only negligible obstacles to overcome: the adjacent semiconductor is doped with impurity atoms that affect the flow of current. However, because these impurities are relatively far from the interface, they should only deflect the electrons slightly, and their effect should be barely noticeable – or so the researchers assumed.

Instead, the experiment produced a completely different result. The image from the atomic scanning probe microscope showed that the electrons did not fan out evenly, but rather were focused into filaments. What the researchers saw was more reminiscent of a “cat o’ nine tails” than a uniform beam of light. “At first, we feared that the mea-



Photo: dpa



Photo: Ragnar Fleischmann

asuring technique was at fault,” says Fleischmann. However, he and his colleagues produced detailed models showing that the method worked perfectly, except that physicists had considerably underestimated the influence of the imperfections. Although the impurity atoms were not located on the interface between the two semiconductors, they were forcing the electrons onto new paths.

Together, the many small imperfections created a focusing effect, which led to the flow branching that the researchers observed under the microscope. The structures of these focusing patterns have long been known to science and go by the technical term “caustics”. The term comes from the study of optics, where it is used for specific aberrations produced by lenses.

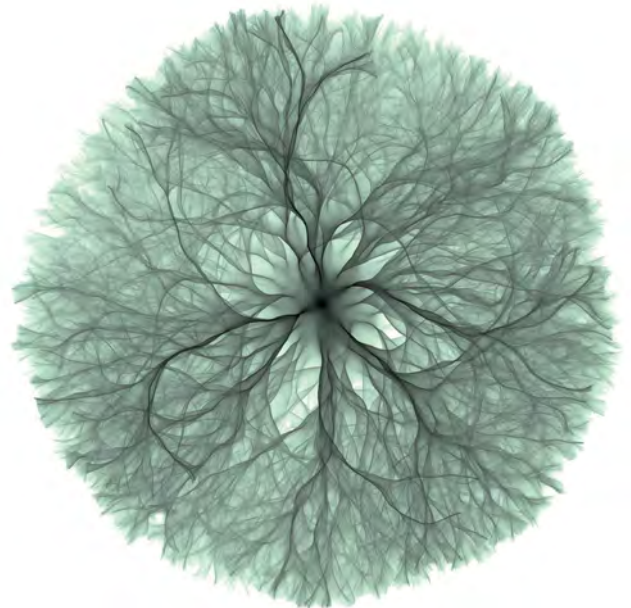
Caustics can be observed in many everyday situations. For example, when the sun shines on the surface of an outdoor swimming pool, you often see a grid of bright lines on the bottom of the pool. Here, the sunlight is being fo-

cused into caustics, which are also known as focal lines. With their calculations, Fleischmann and his colleagues showed that even minimal imperfections are enough to produce this phenomenon. In other words, small causes can have a big effect – this had simply been overlooked so far.

This brings us back to tsunamis, and more precisely to the catastrophic tsunami of 11 March 2011, which destroyed several nuclear power plants in Japan and ultimately spelled the end of nuclear power in Germany. Scientists from the NOAA Center for Tsunami Research reconstructed how the wave spread across the Pacific and how its height varied. For this, they used data from sensors that had recorded the wave height at a number of locations in the open ocean. When they adapted this measurement data to the modeled course of the tsunami, the resulting pattern was astonishingly similar to that of the electrons in the semiconductor. Ragnar Fleischmann immediately thought to himself: “The two

Left The tsunami of 2004 completely destroyed this part of the city of Banda Aceh, in northern Indonesia. Here we compare two aerial photographs: one taken six months before the disaster (top) and one taken two days after (bottom).

Right Electrons radiating from a point source can be used to simulate how seabed relief focuses waves that were originally triggered by sea-quakes. Small defects in the conducting layer concentrate the flow of charge carriers into small branches.



things might be related.” Here too, there was no homogeneous wavefront, and the wave energy was instead concentrated in individual bands that branched out – as Fleischmann had observed in the nanostructures. The wave reached a far greater height in the bands than in the surrounding area. Although the values only differed by a few decimeters, this can eventually have major consequences in the case of a tsunami.

SEABED RELIEF INFLUENCES TSUNAMIS

After all, a tsunami is a highly unusual wave. It is rarely more than a meter high in the open ocean, but it is also incredibly long, with successive wave troughs often separated by a distance of several hundred kilometers. Its shape is more like a gently sloping plane than a steep hill and is best imagined as a tidal bulge instead of wind waves. Indeed, ships’ crews generally don’t even notice when they pass over a tsunami. The ship just gently rises and falls.

Experts call this a shallow water wave, because the wavelength is much larger than the water depth. To put it another way: for the tsunami, the sea is nothing more than a puddle. The key thing to note is that shallow water waves have completely different properties from those of the short waves whipped up by the wind. Their character is essentially determined by the seabed.

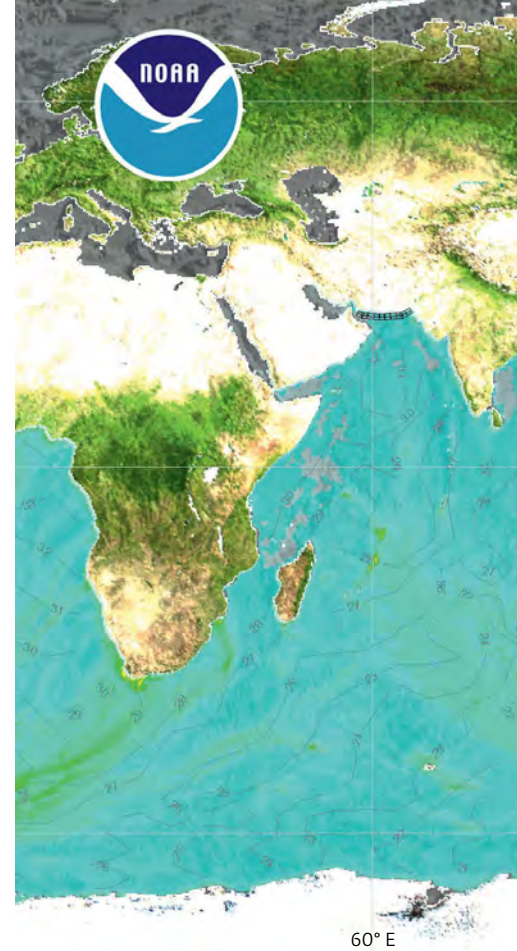
For a start, the speed at which a tsunami rolls across the ocean depends solely on the water depth: at a water depth of 5,000 meters, a tsunami reaches speeds of around 800 kilometers an hour – as fast as a jet aircraft. At a depth of 3,000 meters, it still travels at approximately 600 kilometers an

hour. Only when it reaches the coast does the wave undergo rapid deceleration, rising steeply to reach catastrophic proportions. At this point, the few-decimeter height difference in a tsunami moving across the open sea grows to many meters.

However, seabed relief not only determines the wave’s speed but also its course and shape. For example, an underwater mountain acts like a converging lens and focuses the energy, whereas depressions act like diverging lenses and long trenches behave like guide rails. Islands also leave their mark on the wavefront, and experts take all of this into account when modeling the path of a tsunami. Until now, however, they had only considered larger structures. Smaller disturbances with elevations of just 100 or 200 meters were not included in the calculations – which potentially leads to significant errors, as Fleischmann and his colleagues have now demonstrated.

They selected a 1,500-kilometer square of the Indian Ocean with no interfering islands or major underwater mountains. The depth was around 4,000 meters plus or minus seven percent, and the seabed relief was taken from the official data pool. Based on this, they used a computer to model how a tsunami – triggered by a fictitious event – passed over the relief in order to observe how the wave changed in response to the seabed.

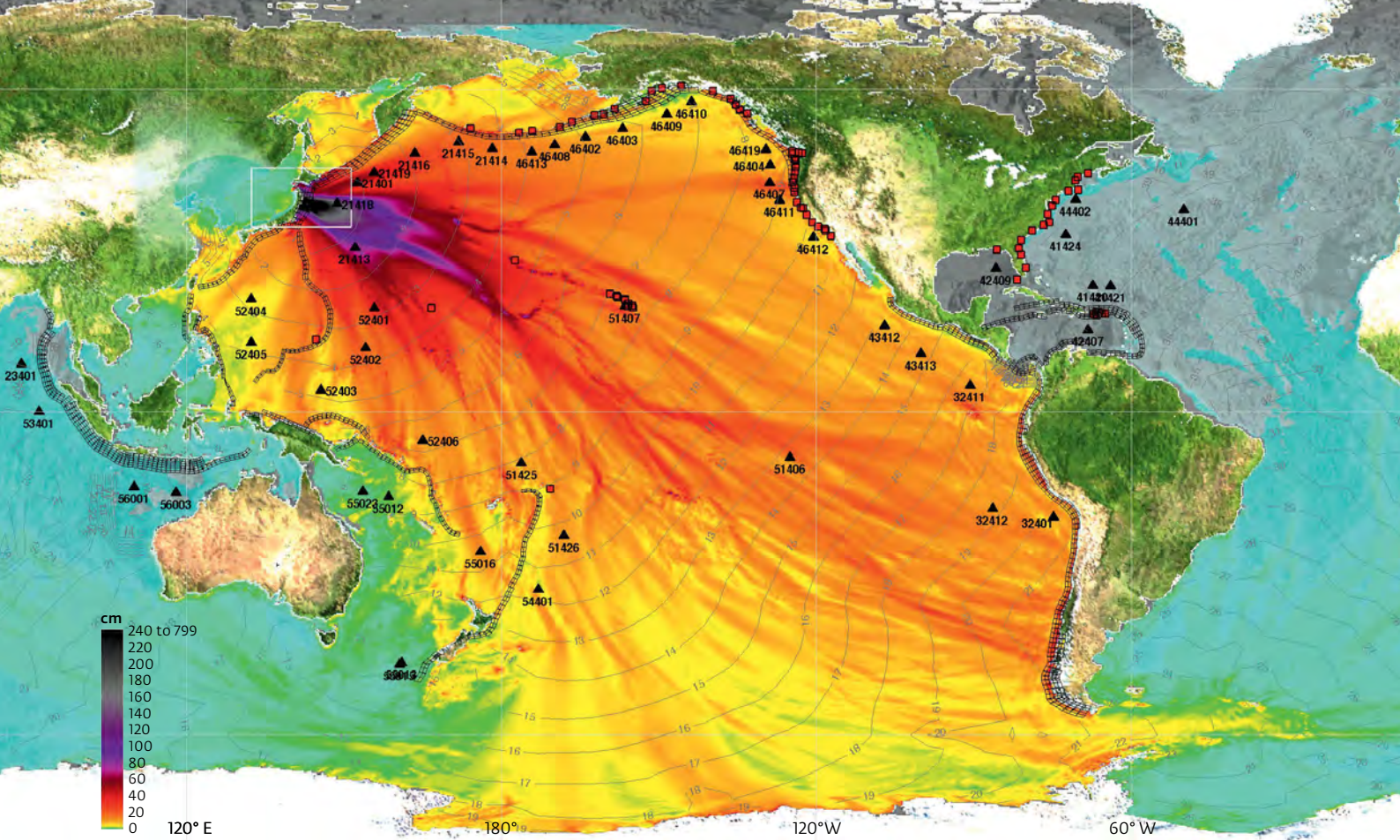
In a second run, they varied the seabed relief slightly. Small changes should not make a great deal of difference. After all, the existing data is anything but exact, providing depth measurements that are accurate to within a few hundred meters. The researchers therefore incorporated a few hills whose heights were less than the error tolerance. This



Top The tsunami formed in 2011 following a quake off the coast of Japan raced across the Pacific and exhibited significant differences in height. At some points, the wave stood just 20 centimeters above mean sea level (yellow), while at others it reached a height of 8 meters (black).

Bottom When electrons from a point source flow through the boundary layer between two semiconductors, they are focused by impurity atoms in the material, as this simulation demonstrates. These so-called caustics can also be observed on the open sea, where currents can focus waves to reach over double the height of the waves around them.





second relief therefore still corresponded to the real topography. Again, they simulated a tsunami moving across it – but this time they obtained a completely different pattern. At some points, the wave energy differed by a factor of ten between the two calculations – and a power of ten results in enormous height variations that could mean the difference between life and death. As with the semiconductor mentioned earlier, small causes can have a big effect.

But what does this finding mean for tsunami forecasts? Unfortunately, it won't be possible to predict caustics reliably until accurate maps exist of the ocean floor. Whether we like it or not, the models are still imperfect. "But we have to realize that this effect exists," says Fleischmann. For example, warning services could examine how their calculations are affected by small depth variations to get a better idea of the reliability of their forecasts.

Of course, these services also have a completely different set of problems to deal with. Above all, they must ensure that their warnings reach even the smallest fishing villages and that they are actually taken seriously once they get there. False alarms undermine their

efforts because they desensitize people. Anyone who has sought refuge unnecessarily three times simply won't bother when the fourth warning comes. The problem is that not every earthquake produces a tsunami; it is only when the sea floor moves in a vertical direction that it causes the water to surge.

MANY EXAMPLES INVOLVING THE SAME MECHANISM

These two phenomena – a tsunami that races halfway around the world and the electron flow in a semiconductor – are separated by about twelve orders of magnitude, but they both involve the same mechanism. Indeed, the relationships that Fleischmann identified in the semiconductor are universally applicable. Wherever a wave propagates through a disordered medium, small imperfections can have major consequences, focusing the energy into branched structures.

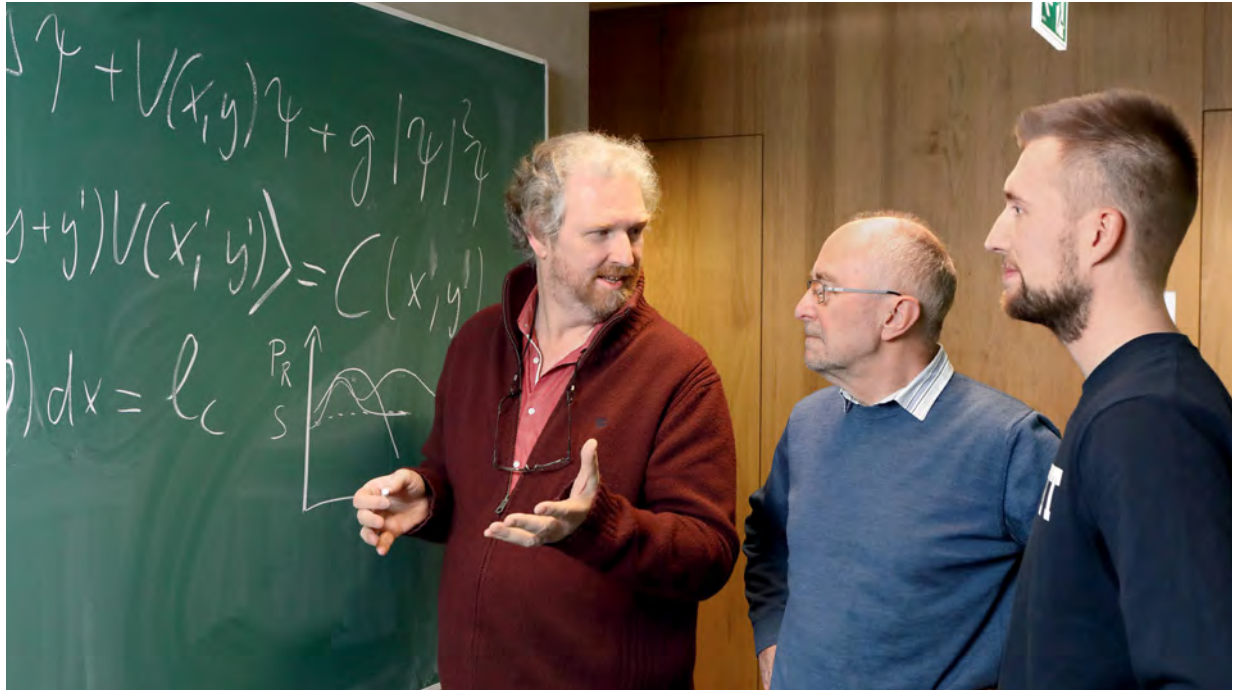
Of course, this is subject to certain prerequisites. Firstly, the medium must only cause relatively weak deflection in the waves. The effect would not occur if every encounter with an imperfection scattered the waves in every di-

rection. Secondly, the medium must be disordered, because a sea floor structured as regularly as an egg carton would have no impact on a wave. That being said, landscapes with an irregular distribution of elevations and depressions represent the rule rather than the exception.

It is no wonder, then, that there are many other examples involving this mechanism, such as the twinkling of stars. Of course, stars do not twinkle in reality – but they appear to do so if you look at them for a long time. This is also due to caustics: before the light reaches our eyes, it must pass through the atmosphere, which is littered with small disturbances that produce a focusing of the light. For the observer, the starlight therefore seems to vary in intensity. When a caustic reaches the eye, it resembles a small flash of light – the star appears to twinkle. This also explains why stars twinkle particularly strongly when there is turbulence in the atmosphere.

One particularly impressive example of this are monster waves, which are also referred to as rogue or freak waves. These actually have nothing to do with tsunamis – they are just unusually high,

Photos: Ragnar Fleischmann (left); NOAA (top)



wind-driven waves that suddenly tower up in the middle of the ocean. They are at least twice as high as surrounding waves and are said to have engulfed many a ship over the years. Until a few decades ago, however, these stories were dismissed as seamen's yarns.

CURRENTS CAN FOCUS WIND WAVES INTO ROGUES

Our knowledge has advanced since then – or at least we now give credence to the observations of seafarers. In fact, they actually know several categories of monster waves: in addition to the unusually high wave, there is also the “white wall”, which rises at an especially steep angle and lights up due to its covering of foam. Sailors have also learned to fear the “three sisters” – three giant waves in quick succession that slow ships down so sharply that they can no longer climb the final crest.

If these eerie encounters far out at sea are no longer dismissed as myths, it is partly because shipping traffic has increased enormously and almost no section of the sea remains unobserved. Oil platforms also record wave movements, and some satellites are able to

detect these gigantic breakers. In February 1995, a laser system on the Draupner drilling platform in the North Sea recorded a 26-meter surge, and in November 2007, a 21-meter wall of water rushed toward the Ekofisk platform, also in the North Sea. This is said to be the steepest wave ever measured. At the time, it was only a force-nine storm, and the wave simply appeared out of nowhere.

Every year, ships are lost with no explanation – many of them presumably due to an encounter with a killer wave. In 2001, the cruise liner MS Bremen had a lucky escape off the east coast of Argentina when it was caught by a breaker reportedly measuring 35 meters in height. The force of the impact smashed windows on the bridge, which normally towers high above the waves. As water rushed in, the resulting short-circuit caused the engines to cut out, leaving the ship in a precarious situation, listing parallel to the wavefront. It took the crew half an hour to start the auxiliary diesel engine.

Science has taken a serious interest in monster waves for around 20 years, but it has yet to provide a convincing explanation of how they are formed.

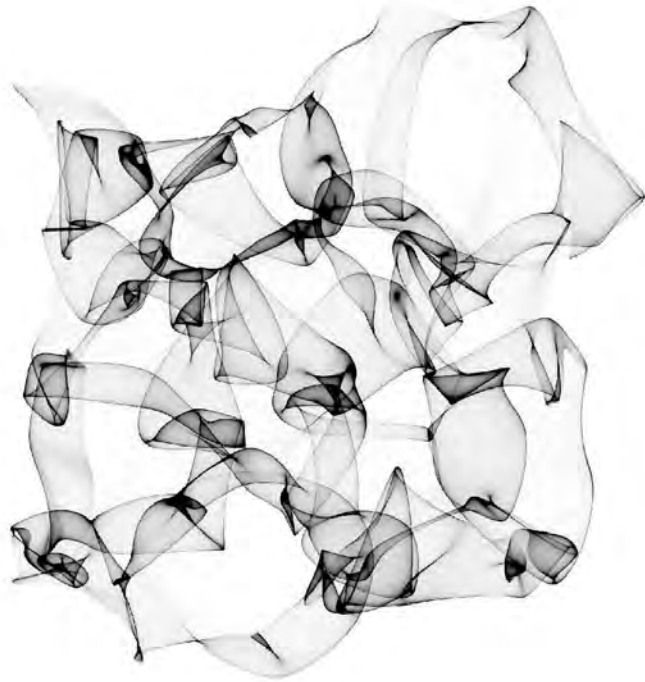
According to basic wave models, they shouldn't even exist. But what does all of this have to do with caustics and experiments on semiconductors? The answer becomes clear when you enter the mouth of a river on a ship. The river's current alters the waves rolling in from the sea and can cause them to build up into dangerous breakers.

The current therefore corresponds to the impurity atoms in the semiconductor, or to the underwater hills affecting a tsunami. It influences the wave and changes its course, focusing the energy at certain locations. This effect, which is clearly visible in river estuaries, also occurs on the open sea. After all, the water is moving in every direction – if you plotted the near-surface currents on a map, they would produce a disordered pattern of spirals.

The greatest danger arises where currents intersect. This can also produce a focusing of the wave energy, causing a vast wave to appear out of nowhere. Eric Heller, the scientist with whom Fleischmann once modeled the electron experiment, has undertaken a particularly intensive study of monster waves. His conclusion is that if you take account of branches in wave flow due

Left Ragnar Fleischmann talks to Max Planck Director Theo Geisel and doctoral student Gerrit Green (from left to right) about mathematical laws that apply to both electron dynamics and ocean waves.

Right Ragnar Fleischmann's team simulated how water with a moving surface focuses light into a web of caustics. The researchers created an inverted image of the effect, representing the bright focal lines as areas of dark shading.



to currents, the number of freak waves is 50 times higher than without this assumption. That sounds feasible, especially since other studies have now confirmed that rogue waves are far more numerous than once assumed.

USING TWO THEORIES TO MAKE REALISTIC PREDICTIONS

However, there is another theory of how freak waves are formed. This is based on special properties of the wave equation, so-called nonlinearities, which are used to describe water waves. Fleischmann is convinced that only a combination of the two theories will permit realistic statistical forecasts of freak waves. This is therefore one of the research projects he is currently working on.

In addition, he is particularly committed to gaining a deeper understanding of branched flows and to producing a statistical description of this phenomenon, as caustics are merely its most striking feature. Indeed, a branched flow contains a complex interplay of chaotic stretching, compression, and folding of wavefronts, creating not only caustics but also interference phe-

nomena. Only by understanding the interaction between these factors can scientists make reliable forecasts of how

often monster waves occur and where tsunamis will deliver their greatest destructive force. ◀

SUMMARY

- Impurity atoms in tiny semiconducting structures cause an electron flow to branch out as it passes through the system. By analogy, Max Planck physicists draw conclusions as to why tsunamis hit different sections of coastline with varying degrees of force. In the same way as impurity atoms alter the course of electrons, these destructive waves are focused by irregularities in the seabed.
- By analyzing nanosystems, researchers can gain a better understanding of why monster waves repeatedly occur on the open sea, where waves are whipped up by the wind before being focused by ocean currents.
- These findings could help improve early warning systems for tsunamis and allow more accurate statistical forecasts of how often ships might encounter rogue waves.

GLOSSARY

Branched flow: The flow of electrons or water waves can be focused by disturbances.

Caustic: In this effect, which is known from the field of optics, light is focused into lines – for example, when it passes through moving water. In a similar way, electrons and water waves can also be focused into caustics.

Monster wave: Ocean currents can focus wind-driven waves, causing them to grow to over twice the height of surrounding waves. Monster waves are also referred to as rogue waves.

Quantum point contact: A nanoscopic constriction in a conductor. When electrons flow through a bottleneck of this kind, quantum effects occur that are not observed in ordinary conductors.

Tsunami: A wave triggered by a seaquake.

A fast-paced life

Silvia Cappello's life is all about movement: at the **Max Planck Institute of Psychiatry**, she performs research into the way in which different types of neurons migrate to the correct position in the cerebral cortex, during embryonic development of the brain. In her free time, the passionate athlete rarely stands still either.

TEXT **ELKE MAIER**

Walking up the stairs with Silvia Cappello to her fourth floor office in the Max Planck Institute of Psychiatry, you may well get out of breath. "I like to use this walk for exercise," the scientist explains. Since April 2015 she has been the leader of an independent Max Planck Research Group in the field of "Developmental Neurobiology".

Already when looking at the Institute's website, it is obvious that she is very sporty. There is one picture of her astride a wooden sled wearing an anorak, a woolen hat and a big smile. Another picture shows her just after a running competition. The caption reads: "Silvia Cappello, who is now officially the third fastest female boss in Munich!" Talking to her it soon becomes apparent that she enjoys a wide range of sporting disciplines: the list includes running, cycling, climbing, swimming, skiing, snowboarding and surfing, and she also used to do boxing and judo. "I am kind of hyperactive," she says, "and I use exercise to compensate for that. I rarely sit

still, except when I am working on the computer. I also tend to try and do too many things at the same time!"

FINDING THE RIGHT PLACE AMONG BILLIONS OF CELLS

Silvia Cappello's office is colorful and homey: a bright yellow sofa is paired with a black rug with white dots. The walls are decorated with radiantly colored images of neurons. There is a shelf filled with a harmonious mix of specialist literature, an Asian lucky cat, children's artwork and photos of family and friends. By the window there are houseplants she has adopted from former doctoral students: "They always remind me of them. I like being surrounded by everyone I care about!"

In our meeting, the scientist comes across as easy-going and approachable. The kind of person you may like to go out with to have a beer. Or to go on a mountain hike at the weekend. Wearing jeans, a t-shirt and trainers, she leans back in her desk chair as she talks about science as well as her personal

life. She speaks English with a hint of a Mediterranean accent, and she talks at the fast pace you would expect from her: taking notes of our conversation soon becomes a challenge, owing to my lack of shorthand skills.

Silvia Cappello's area of expertise is the embryonic development of the brain. With her team of seven researchers, she examines the processes that ensure that each individual cell takes the correct place in which it is able to fulfill its function, within the complex network that consists of billions of cells.

The scientist pulls a sheet of paper showing two magnetic resonance images of human brains from a stack of documents, to illustrate her research topic. Using a pen she points out an area in the picture on the right: "This gray layer should normally not be here," she explains, "these cells should have moved further on to the outside, towards the edge."

The outer cerebral cortex of around three percent of all human beings features malformations, caused by incorrectly positioned neurons. The effects of



Thinking on the run: running not only keeps Silvia Cappello physically fit, it also helps her to put her thoughts in order. The scientist often has new ideas during her runs.



this vary, depending on the cells and the area affected: “Some people are completely unaware of it, others suffer from severe epilepsy,” says Silvia Cappello. “There may also be links to autism.”

WHY CELLS SOMETIMES GO ASTRAY

But why do brain cells migrate in the first place? “During embryonic development, neurons are formed from neural stem cells in the neural tube,” the researcher explains. “From here they migrate to their respective destinations in the different layers of the cerebral cortex.”

Along the way, the young neurons specialize, developing for example into visual or olfactory cells. However, sometimes cells settle in the wrong place – researchers refer to this as heterotopia. The electrical signals they fire from there can disrupt the complex circuits in the brain and as a result cause conditions such as epilepsy. Silvia Cappello and her team would like to find out, why it is that neurons sometimes go astray.

The scientist speaks about her work passionately: “Just try to imagine this: each cell has to move to one particular place to be able to carry out its function. How does this work? How do the cells know where they need to go? It is a great mystery. And even the smallest of mistakes may have disastrous consequences!” However, what Cappello is

A strong position in science: Silvia Cappello has been a Research Group Leader at the Max Planck Institute of Psychiatry in Munich since 2015. She appreciates not only the working environment, but also the close proximity to the Alps and her home country Italy.

»» Each cell has to move to one particular place to be able to carry out its function. It is a great mystery, how the cells know where to go.

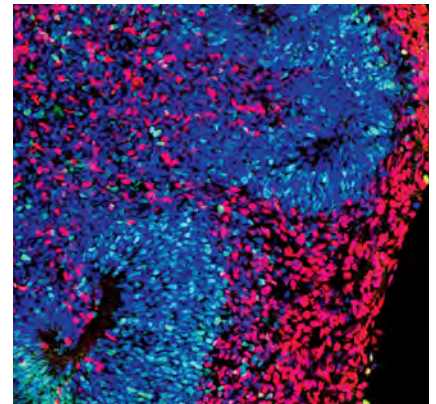
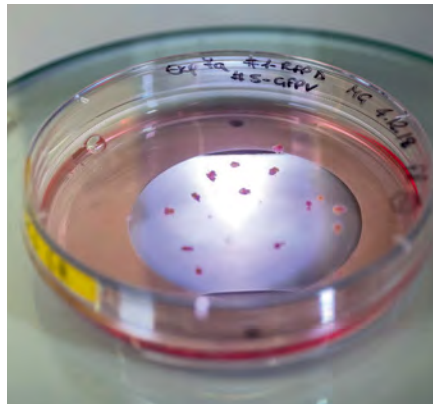
fascinated by the most, is that in most cases everything goes well, despite the high degree of complexity: “This doesn’t only require precise spatial coordination, but also temporal coordination, as the stem cells that give rise to the different cell types divide at varying times.”

So far, researchers have only begun to understand how all of this is coordinated: “We know that young neurons are guided by chemical signals, but also by the appearance of cells in their environment.” Silvia Cappello and her team are conducting research into the migration of cells using a range of different model systems, such as neurons in petri dishes and the brains of mice.

They also work with brain organoids – pinhead sized cell clusters (see *MAXPLANCKRESEARCH* 3/18, p. 54) that are grown from human neural stem cells.

This method is still relatively new: “The first publications about brain organoids came out in 2013. We tried the protocols right away and we were lucky: it worked right from the start!” The unremarkable looking cell clusters live in a reddish nutrient solution and they thrive in culture dishes in the incubator at a pleasant temperature of 37 degree Celsius. A slow vibrator keeps the organoids in constant motion. This prevents them from sticking to the bottom, and it ensures that they receive an ideal supply of oxygen and nutrients. After about ten days, the young organoids are ready for the researchers to start working with them. The cell clusters can survive in the laboratory for up to a year.

“The organoids represent a revolution for research,” says Silvia Cappello. “They resemble a human brain at a very early stage of development. This means that we have access to a cell cul-



Small yet revolutionary: to study cell migration, Silvia Cappello and her team use pinhead sized brain organoids that they grow in the laboratory (left). Fluorescent dyes enable the researchers to make the different types of cells visible (right): the cores of all cells are marked in blue, the neural stem cells are green, and particular neurons are highlighted in red.

ture system in which we are able to watch cells in three-dimensional tissue.” The researchers are able to monitor the movement of individual cells under the microscope. Organoids featuring mutations in their genetic material provide clues of the effects that these genetic changes have on cell migration.

MIGRATION IS DISRUPTED DUE TO GENETIC CHANGES

In the first step it is important to identify mutations that have an impact on migration. “There are a wide range of different genetic causes for malformations of the cerebral cortex,” the scientist explains. “In order to find a starting point for future treatments, we need to find out what the various disease patterns have in common.”

To this end, Silvia Cappello cooperates with peers from Germany and abroad, such as Barbara Treutlein from

the Max Planck Institute for Evolutionary Anthropology in Leipzig. Stephen Robertson, human geneticist at the University of Otago in New Zealand is another important cooperation partner. The scientists work together, searching the genetic material of patients for tiny changes. Meanwhile they are aware of quite a few mutations that affect migration behavior of neurons, and they continue to examine their effects.

After all those years Silvia Cappello still thinks of the brain as “the most fascinating of all research objects.” But how did it all begin? Being very versatile, she was not fixed on this subject to begin with.

The scientist, who is the second child in a family of lawyers, grew up in Bologna. In school she studied the classics: Greek, Latin, philosophy. She played the piano and the violin in her youth. “I would have loved to become a violinist,” says Cappello, “but I wasn’t

good enough.” Instead she played the violin in a punk rock band with old friends from school, until she graduated from university. Sports already played an important role for her, when she was still in school.

TRAVEL BRINGS CLARITY FOR DECISION-MAKING

However, it was in the biology lessons in her final years of secondary school that her course was determined: “I was fascinated by the subject of genetics, and desperate to learn more about it.” So instead of following in her family’s track – many of whom are lawyers – she opted to study biotechnology. This was never an issue for her parents: “They always allowed me complete freedom and encouraged me to trust my instincts.” Her way was also smoothed by her brother, who is three years older than her: “He is a biophysicist and lives in France.”

During her third year at university, the young woman came in touch with her future research object for the first time: “We looked at neurons under the microscope, and I fell in love with them right away. They look so different from all the other cells, it is simply fascinating!” Once more she followed her instincts, and wrote her degree thesis about neurotrophins and about the impact these endogenous signaling substances have on neural activity.

After this, she had to decide: should she write a doctoral thesis? And if so, which topic should it be about? “Whenever I need to make an important decision, I go on a trip,” says Silvia Cappello. “And I go on my own.” She flew to Ireland and spent three months backpack-

ing across the island. During this trip she made up her mind: after her return she started working on a doctoral thesis at the University of Bologna. However, she was not particularly excited here. Perhaps she should transfer to Germany? So she packed her bags once again and went to Australia for three months. Upon her return she knew for sure: she would go to Magdalena Götz, the leader of the laboratory for stem cell research at the Helmholtz center in Munich.

“This was the most important decision of my life,” Silvia Cappello says without hesitation. “Magdalena is one of the most inspiring scientists I know.” Her decision also proved to be very fortunate when it comes to her personal life: in Götz’s working group, she met her future husband. She also met one of her best friends, who she goes climbing with once or twice a week to this day, a doctoral student in the laboratory next door.

After conferral of their doctorates, the couple decided to go to New York together, to Columbia University. “For us this was not only about science, we also wanted it to be an important experience in our lives.” Working as a postdoc with Richard Vallee at Columbia University, she went on to perform research about the genetic foundation of lissencephaly, a rare malformation of the human brain. The brain surface of affected individuals is smooth rather than convoluted, and this is caused by a disruption of neural migration.

She had found her ideal area of research. The young scientist loved her work and the atmosphere at the Institute: “Working next door to Nobel Prize winners is pretty special. And New York

is really exciting, too!” She visited the Museum of Modern Art every week, as she enjoys contemporary art, especially Kandinsky. The city also had much to offer when it came to sports: the researcher regularly participated in charity runs that are very popular in the U.S.: “I love running for a good cause!”

However, she and her partner did not want to live in New York permanently: “We wanted a family and I could not imagine raising children there. I think the city is too big and too hectic for that.” Munich seemed to be better suited for this purpose: “The mountains, the Isar, the way of life – it is a big city, but a very relaxed one.”

And last but not least: it is close to Italy. She would be able to spend weekends and vacations with her family and her mother from Bologna at her apartment in the Italian Brenta mountains – climbing, hiking, skiing or snowboarding, depending on the time of year.

FAMILY, RESEARCH, SPORTS – ORGANIZATION IS KEY

Cappello gave Magdalena Götz a call and was offered a position at her former place of work. Just before their first son was born, the couple returned to Germany. Four years later, Silvia Cappello received a Max Planck scholarship and became the leader of an independent Research Group at the Max Planck Institute of Psychiatry. Nowadays she is a mother of two sons, aged five and nine.

Reconciling the demands of family-life, research and sports is mostly “a matter of organization” for Silvia Cappello. This is what she also tells her female students, to show them that



Discussing the situation: Silvia Cappello discusses the latest experiments and next steps with her doctoral students Isabel Buchsbaum and Fabrizia Pipicelli.

they do not have to choose between a family or a career in research: “You can do both!” She finds it unfortunate that there are still so few role models in the scientific community.

Her family life was chaotic to begin with, but she and her husband are now handling the situation very well – “not least thanks to our Google calendar that we use to coordinate our appointments.” Another great help is their Italian nanny: “She picks the little one up from kindergarten and looks after him until one of us comes home. This means that I am able to calmly finish my work, without having to rush.”

Unwinding after a long day at work is not an issue for the Max Planck researcher: “The kids make me think of other things right away.” She is also able to relax while cooking. Dishes from her home country are her favorites: “Food is very important to me. I guess I am a typical Italian in that respect!” Science is never discussed during dinner: “When my husband and I used to work at the same Institute, we had the arrangement that talk about work was

only permitted on our way home, and not afterwards. Today we can manage without this kind of rule.” Her husband works for a pharmaceutical company these days.

ALWAYS COMPETING AGAINST HERSELF

Nevertheless, spending a cozy night on the sofa is not an option for Silvia Cappello: three nights a week she goes for a ten or fifteen kilometer run, as soon as the kids are in bed. “I do my best thinking while I run!” Being in excellent shape, she regularly takes part in

half-marathons. She even used to train for a marathon, but had to give up shortly before the run, due to a knee injury. In competitions, she does not strive to do better than others: “I only compete against myself. It annoys me, if I do worse than the time before!”

She does not believe in competitive thinking in science, either. During our conversation she offers a lot of praise for her colleagues, and some of her cooperation partners are among her personal friends. The atmosphere in her team is easy-going and friendly too: “It is my first working group and everyone is excellent. I am very happy!” ◀

GLOSSARY

Neural stem cells: They give rise to different types of neural and glial cells. They exist in large numbers in the embryonic brain, but are rare in the adult brain.

Neural tube: Embryonic structure during early pregnancy that develops into the central nervous system, the spinal cord and the brain.

Heterotopia [from Greek hetero = different, topos = place] refers to tissue or organs that are located in unusual places. In neurology this term means that the gray matter that consists mostly of neural cell bodies is positioned in the wrong location.



Material mix from the food processor

Valerio Molinari and his team at the **Max Planck Institute of Colloids and Interfaces** in Potsdam have equipped their laboratory with a pasta machine, pizza oven and mixer. What's more, the scientists often use waste from the forestry or food industries in their experiments. They can use these simple resources to manufacture wood-based materials, bioplastics and biofuels.

TEXT **PETER HERGERSBERG**

It was a cookery contest with scientific implications. “My boss and I had a discussion about what goes into a proper ragù,” says Valerio Molinari from Italy, adding with mock disgust, “In Germany they call it bolognese sauce – heresy!” In consequence, the researcher, who was doing his doctorate at the Max Planck Institute of Colloids and Interfaces at the time, and his Director Markus Antonietti set up an Italian cookery contest. In the Department’s small kitchenette, the two scientists each cooked for around 20 colleagues using their own recipes. No vote was planned; if necessary, the contest could have been decided by the number of half-full plates left at the end of the evening.

In the end, both variations turned out to be very popular despite their differences. “As a good scientist, Markus Antonietti is keen on experimenting – he calls his style ‘fusion’,” says Valerio

Molinari. “For my part, I cook the sauce just like my grandmother did.”

While the culinary results of the contest soon disappeared, the researchers were left with an idea that had first been put on the table that evening: the idea of practicing technical chemistry with kitchen equipment and ingredients.

ONE INCENTIVE: MATERIALS THAT ARE EASY TO MAKE

This idea actually came quite naturally: after all, chemistry is always happening in saucepans, frying pans and baking tins. Nearly 30 years ago, some chefs made quite a fuss about enhancing their creations using methods employed in chemical labs – this was known as molecular gastronomy. But how would this work in reverse? A pizza oven, a pasta machine, or even a fancy utensil like a sous vide cooker on the lab bench? And semolina, vanilla or egg

whites to create materials made from renewable sources? Valerio Molinari and Markus Antonietti had never heard of such a thing, even though chemists often talk about cooking in connection with their experiments.

“It goes without saying that kitchen utensils can’t set the temperature as precisely or be programed as flexibly as a lab device that mixes and heats substances for chemical reactions,” explains Molinari. “In principle, though, they do the same thing at a fraction of the cost.” This is one of the main motivations behind the kitchen lab, which Molinari – now as the leader of a small research group – constructed about four years ago.

“The chemical industry often reacts sceptically to developments in academic research,” he says. The developments that scientists present so proudly work well with expensive laboratory equipment and the extremely pure chemicals normally used for research purposes. However, it is often impossible to use these great innovations in industrial

An indigestible baking mixture: researchers in Potsdam kneading a dough made of waste from the paper and food industries; this turns into a durable wood-based material when baked in the oven.

production facilities. “By using kitchen equipment and natural ingredients, we are demonstrating that our materials are easy to make.”

Despite being inedible, the Potsdam-based researchers’ creations could be a mouthwatering prospect for furniture manufacturers, the cosmetics industry or biofuel producers – not least because Valerio Molinari and his team have been relying heavily on renewable

resources ever since the start. They even purchase some of the ingredients for their recipes in the supermarket.

RemixWood®, for example, is a special product developed in the lab. Valerio Molinari developed this material together with former Group Leader Nina Fechner, who now works at the Charité, Berlin’s university hospital. This material has many of the properties of wood but is more durable and

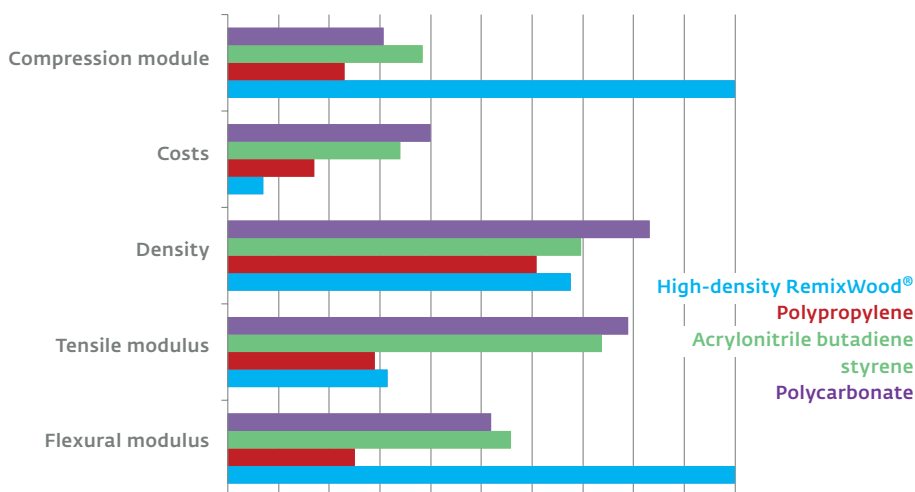
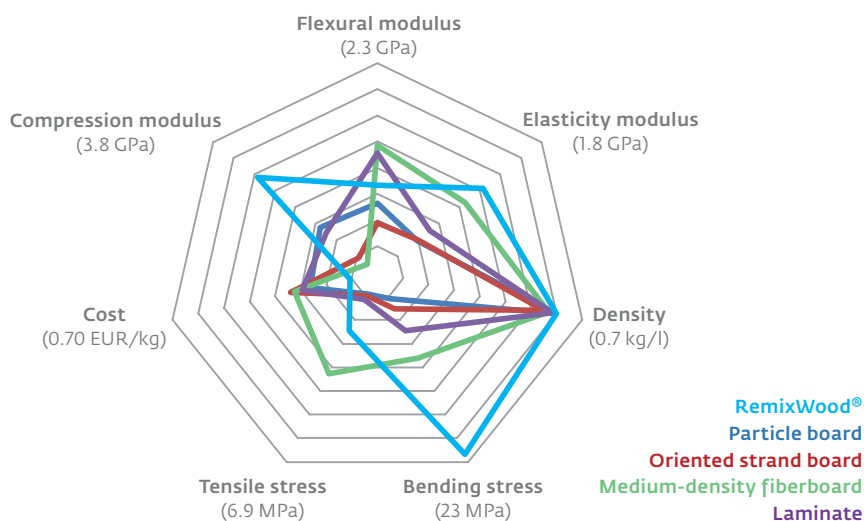
can be processed into almost any shape. It could therefore be used instead of particle board when manufacturing furniture, for example. Another advantage of the material is that it could be an alternative to plastic, as it is more rigid, less prone to warp and cheaper than some widely used plastics. Some of the sustainable components it contains were even formerly classified as waste. “What’s more, our RemixWood® – unlike a lot of particle boards – doesn’t release formaldehyde, because this isn’t needed during processing,” says Molinari.

A WOOD-BASED MATERIAL MADE OF INDUSTRIAL WASTE

Molinari and Shekova are accelerating the process of developing the material. Shekova is testing the ideas put forward by Molinari and his colleagues by performing systematic experiments. “She’s much more organized than I am,” says Molinari, while the lab technician prepares various pastes: RemixWood® and some of its predecessors in their raw state. For this, she starts by weighing a plastic bowl full of cellulose, which is stored in the lab in a large plastic bucket. “We use inferior cellulose left over from paper production,” explains Molinari. “You could say that it’s the framework on which our materials are built.”

Above The researchers in Potsdam compared the costs and mechanical properties of RemixWood® and other wood-based materials with the same density. Their reasonably priced material has outstanding compression and elasticity moduli. The modulus measures the force required to deform a material in a specific way, e.g. by compression. RemixWood® can also withstand considerable bending stress before it breaks.

Below RemixWood® compares favorably to various plastics due to its low cost and high compression and flexural moduli.





Photos: Valerio Molinari / MPI of Colloids and Interfaces (2)

Versatile material: Irina Shekova makes RemixWood® with various degrees of density by submitting the paste to varying amounts of pressure. One of the material's components is lignin, which comes from the woody parts of plants, i.e. from nutshells or bamboo (below).

Next, Irina Shekova spoons yellow powder from another bucket into the mixture: this is gluten, which mills remove from certain flours because it clogs some people's intestines, as a result of which they are no longer able to digest food. Despite being life-threatening for some, this property is exactly what Molinari finds so interesting about gluten. Gluten is a mixture of various proteins that are brittle when dry but become tough and sticky when wet.

Shekova and Molinari mix cellulose and gluten with various other ingredients to create assorted pastes. They spread the mixtures in square tins reminiscent of Christmas cookie molds, although they don't leave a design in the dough. The material is baked in a device that is unlikely to be found in any kitchen: a combination of oven and press that is reminiscent of one of the grim-looking nutcrackers from Germany's Ore Mountains. Molinari puts the paste-filled tins into the heatable jaws of the hydraulic press and uses the lever to compress them under ten tons of weight. This makes the material very firm and dense. If the researchers wish to manufacture a lighter material, less pressure is used.

The compressed pastes are then baked at 135 degrees Celsius. An appetizing aroma spreads throughout the lab while they are cooking. This is because Molinari added vanilla to one of the mixtures as an additional adhesive, as gluten alone does not bind the chain molecules in the cellulose sufficiently. The researchers have also tested turmeric for this purpose. This gives the paste an intensive yellow color and a spicy



note. “We started by using vanilla and turmeric, because these substances – like ordinary adhesives – contain a chemical group called phenol,” explains Molinari.

However, neither of these substances yielded optimum results. Vanilla produced a usable material, but this spice is relatively difficult to manufacture and is consequently more suitable for vanilla cookies than for furniture. Turmeric was also a contender for use as a binding agent in RemixWood®; however, the product it yielded was crumbly. “We finally hit on the idea of using lignin, which also contains plenty of phenol groups,” says Molinari. Lignin makes straw and wood rigid and is left as waste when cellulose and hemicellulose are extracted from lignocellulose, e.g. while being made into paper.

FLAME-RETARDANT INTERIOR

Before using the biopolymer in their wood-based material, the researchers treat it chemically to make it bond better with other components. The prepared lignin, cellulose and gluten are kneaded into a dark brown dough that looks just like an appetizing dark bread. However, once it is baked, the mixture becomes harder than particle board – you could easily break your teeth on it. With its long, widely branching chain molecules, lignin not only makes the material particularly stable but is also cheap and plentiful, being as it is a waste product from the paper industry. The fact that two of the components come from wood inspired Nina Fechner to create the name RemixWood®.

The material not only scores points for being stable and sustainable, it can also be furnished with various extras. “Using powders to manufacture RemixWood® means that we can also give it a variety of properties,” says Molinari.

Normally, wood-based materials can only be treated on the outside, for example with flame retardants or fungicides. As soon as the product becomes worn, it loses its protective layer. “These properties are also found in the interior of our material,” says Molinari. It can also be dyed all the way through or even turned into a wooden magnet by adding magnetic particles.

Due to its many advantages, Nina Fechner and Valerio Molinari believe that RemixWood® will be a market success. “We are hoping that a company will pick up on this material and find practical applications for it, for example as a substitute for particle board in furniture or for conventional plastics,” says Valerio Molinari.

Nikki Man is also working on an alternative to plastics made from fossil resources; this consists of bioplastic sheets. She too is mixing various pastes to demonstrate the properties of various compounds. For this, she is mixing gluten glycerol, which when dry is less brittle than ordinary gluten, with other components such as lignin. However, she is also working on a mixture containing chitosan, a nitrogenous polysaccharide extracted from the chitin found in the exoskeletons of shrimp. The chemist mixes the pastes thoroughly and forms them into spheres the size of marzipan balls. She then flattens these spheres between two metal plates, puts them in the nutcracker oven and compresses them to the thickness of foil. While the mixtures melt to form bioplastics, Nikki Man talks about another project.

“We want to produce stable emulsions, for example for cosmetic production and the pharmaceutical industry,” explains the chemist. Many emulsions consist of oil droplets finely dispersed in a watery medium – however, without some kind of agent, they will not

usually stay this way for long. Oil and vinegar in salad dressing, for example, separate quickly unless the dressing is stabilized by adding mustard. Cosmetic and pharmaceutical creams are often stabilized by adding microplastics, which at some point contaminate water supplies and can also end up in the human food chain.

AN EMULSION IS STABILIZED IN THE SOUS VIDE COOKER

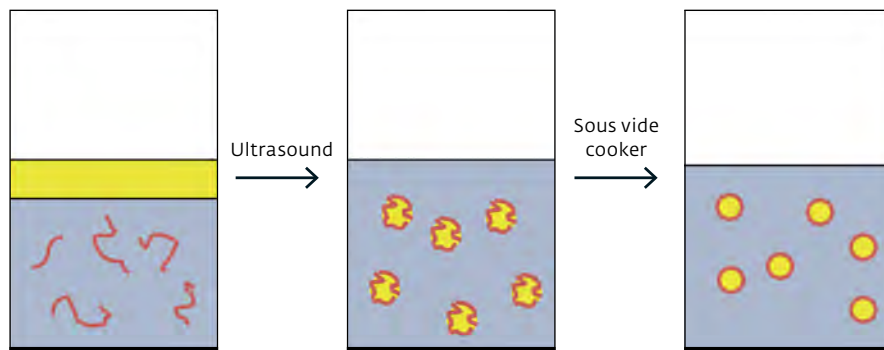
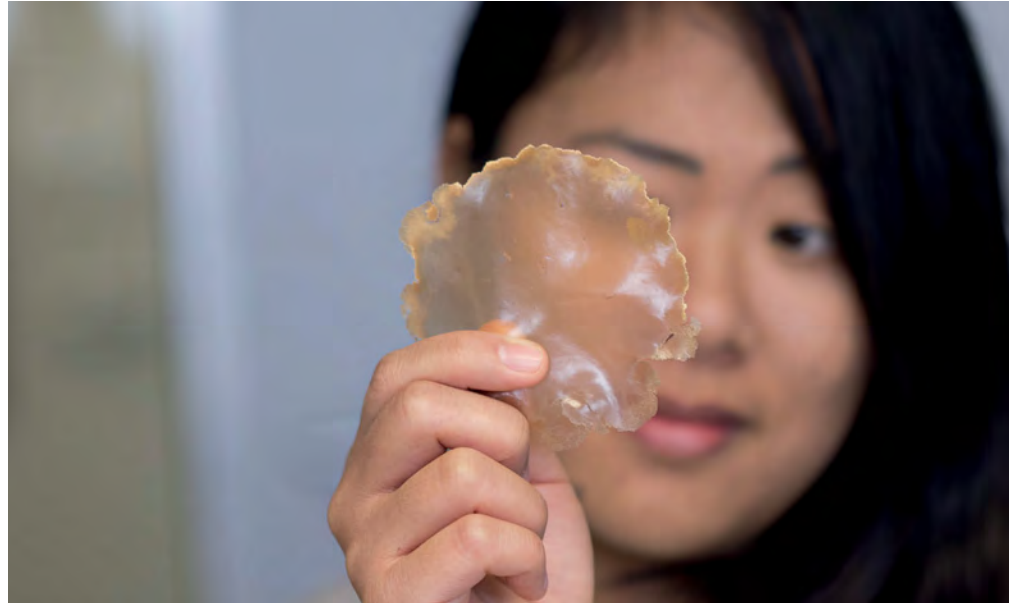
In her search for an alternative to environmentally harmful plastic particles, Nikki Man combines laboratory chemistry with culinary techniques and also borrows ideas from mayonnaise. This mixture of oil and vinegar or lemon juice gets its wonderfully creamy texture from the lecithin and proteins found in egg yolk. The chemist also utilizes the stabilizing effects of proteins in her oil-in-water emulsions by adding the protein albumin, extracted from cattle serum, to her mixtures. She then dips an ultrasonic wand of the type used in laboratories into her mixtures to make the emulsions particularly homogeneous. The fine, inaudible shock waves break up the oil into microdroplets or even nanodroplets that are coated in protein molecules and are all roughly the same size.

Now the emulsion has to undergo one more procedure which Nikki Man borrowed from the kitchen. “This is our sous vide cooker,” says the researcher proudly, pointing to a wand suspended in water-filled glass basin the size of a microwave oven. Such devices were first used by French chefs to prepare vacuum-sealed meat in order to make it particularly tender at temperatures of less than 100 degrees Celsius. Nikki Man uses the moderately warm water to convert the protein coating of her emulsified oil droplets

Plastic made from renewable resources: Nikki Man mixes various ingredients to make bioplastic sheets. Gluten and glycerol yield a transparent material.

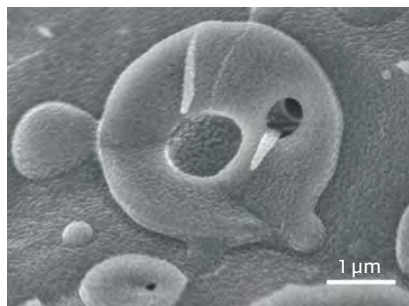
into stable shells, thus making the emulsion more durable. There are lab devices that can keep water baths at a constant, precise temperature, but these are many times more expensive than the kitchen version.

While the researcher explains how her emulsions are prepared in the sous vide cooker and shows computer images of the oil-filled protein spheres taken by a scanning electron microscope, the bioplastic finishes cooking in the oven press. The gluten glycerol and lignin sheet, ocher yellow in color and sprinkled with dark dots, can only be removed from the carrier plate with difficulty and shatters at the first



● Oil ● Water ● Protein

An ultrasonic wand is inserted in a mixture of oil, water and protein to produce uniformly sized oil droplets coated in protein. The moderate heat of the sous vide cooker then stabilizes the protein coatings and consequently the entire emulsion. The size of the oil droplets depends on the quantity of oil in the mixture. An image taken by a scanning electron microscope (right) shows an oil droplet in a mixture containing 30 percent oil.



attempt to bend it. The transparent, reddish brown version containing chitosan fares somewhat better, but is still not flexible enough for tear-resistant packaging. “We now want to test a chemically modified form of lignin, which mixes better with other components and should therefore contain fewer predetermined breaking points,” says Nikki Man.

If the plan succeeds, the researchers will have found a way to produce a flexible variety of RemixWood®. This wood-based material is itself inflexible, as Valerio Molinari and Marius Bäuml found out. “We got a pasta machine especially for testing purposes,” says Molinari. They used the machine to make spaghetti, tagliatelle and penne out of the paste. These noodles are also easy to shape when raw; Molinari even used them to weave a braid. Unfortunately, the material was no longer as elastic when it came out



Catalytic pasta: Valerio Molinari (top left) and Marius Bäümel turn a dough containing a large quantity of wheat semolina into thick spaghetti. After cutting it up, they roast it to obtain highly porous pellets (right). These serve as carrier material for a catalyst that facilitates the efficient production of the biofuel DMF.



of the oven; under gentle pressure, the braid simply crumbled away.

However, this vital piece of Italian kitchen equipment still turned out to be a good investment, since the researchers have now found a pasta recipe with a promising application. They call their creation catalytic pasta. It can be used as a chemical moderator, for example in the production of biofuels and other bioproducts manufactured by the chemicals industry.

Molinari hit on the idea of using catalytic pasta for the production of

biofuel in cooperation with his office neighbor Majd Al-Naji. He too leads a working group at the Max Planck Institute of Colloids and Interfaces, where he is seeking ways to do chemistry with renewable resources. "We want to convert agricultural and forestry waste into fuel and source materials for the chemicals industry," says the chemist.

Dimethylfuran, DMF for short, is one of the possible candidates for the biofuel of tomorrow. The energy density of this substance is almost 50 percent higher than that of ethanol; moreover,

it has an octane rating that makes it even better suited for use in combustion engines than ordinary gasoline. DMF can be obtained from lignocellulose, which is found for example in plant waste. However, chemists need a suitable catalyst to extract lignocellulose from this bioresource, as it is not very susceptible to chemical changes.

Fortunately chemists have already known for a long time that nickel nanoparticles in a suitable carrier material are very good at catalyzing the formation of DMF. A structure consist-

ing of carbon and nitrogen has proven to be a good base for the nickel particles; the larger the area it provides for the reaction, the better. This means a substance with countless fine pores is needed; this substance must be available in the form of pellets the size of pharmaceutical capsules. “Manufacturing large quantities of these pellets is a very complex process,” says Molinari. He and Marius Bäümel have found a remedy in the form of an unconventional pasta recipe.

AN EFFICIENT CATALYST FOR BIOFUEL PRODUCTION

For the pasta dough, the researchers mix durum wheat semolina with glucose and urea. These ingredients then bond to form a carbon and nitrogen structure, with the carbon being primarily derived from the semolina. The researchers had this specially sent from Italy. “A specific dough consistency is essential for production in the pasta machine,” says Marius Bäümel. “Original durum wheat semolina simply has the best properties and makes the perfect dough.”

Zinc oxide nanopowder is added to the mixture together with fine salt – ordinary table salt is perfectly adequate. These two substances serve as placeholders for the pores and are washed or steamed out of the finished pasta. The researchers use the pasta machine to press out the dough in the form of thick, light-colored spaghetti that looks quite appetizing. However, all this changes when Molinari and Bäümel process it further.

They start by cutting the long strips of dough into short stumps, then put them into the oven to roast. When Marius Bäümel takes the sheet with the pasta pieces out of the oven several hours later, they are coal black and look

as if they would be much more at home in the boiler of a biorefinery than on a plate. As soon as the chemists have removed the zinc oxide and salt from the pores, they soak the catalytic pasta in a nickel salt solution, with which it reacts chemically to form the nickel nanoparticles. “Because it’s so porous, the pasta provides a surface area of 700 square meters per gram,” says Marius Bäümel. “This means that ten grams have the surface area of a football pitch, which is more than most industrial catalysts can manage.”

Studies performed by Al-Naji’s team have shown that this large surface area also makes a difference in the production of DMF. The catalyst is extremely efficient and significantly cheaper than competing products produced commercially. “Producing the catalyst in the form of pasta is consequently also a

promising approach for industrial companies,” says Majd Al-Naji. In the next step, the scientists wish to set up a pilot facility to test the large-scale production of DMF. If the catalyst pellets also prove their worth in this situation, this will mean that another step has been taken toward the competitive industrial production of biofuel.

The fact that the catalyst is easy to manufacture is sure to be another point in its favor. This advantage could also stimulate the appetite of other chemicals companies. If so, the production of catalytic pasta may no longer be limited to the kitchen lab. The research carried out by Molinari’s team could inspire other chemists to experiment with kitchen equipment and renewable materials instead of using expensive laboratory equipment and fossil resources. ◀

SUMMARY

- In the kitchen lab, Max Planck researchers in Potsdam are experimenting with kitchen equipment and renewable raw materials, including waste from industrial processes.
- They are using cellulose, gluten and lignin to make RemixWood®, a cheap, durable wood-based material. Similar mixtures are used to produce bioplastics.
- Proteins could replace microplastics for stabilizing cosmetic products.
- With catalytic pasta, the scientists have found an efficient catalyst for the production of biofuel that is also easy to manufacture.

GLOSSARY

Cellulose: This polysaccharide, which consists entirely of glucose, is an important component of the cell walls of plants; it is used to make paper.

Gluten: The protein compound found in grains is sticky and elastic when wet; this is what makes dough kneadable.

Hemicellulose: Polysaccharide which consists of various sugars and is also found in the cell walls of plants.

Catalyst: A substance that accelerates chemical reactions or guides them in a specific direction without being consumed.

Lignin: A biopolymer critical for the stability of wood cells.

Buses on demand

It is extremely difficult to get around in rural areas without a car of your own, either due to a lack of public transport or because scheduled buses are infrequent. That is why a team led by physicist **Stephan Herminghaus**, Director at the **Max Planck Institute for Dynamics and Self-Organization** in Goettingen, have developed the EcoBus, a system that lets customers order a bus directly to their front door. The special thing about it is that, unlike other on-call systems, rather than poaching customers, the EcoBus will augment existing public transport services.

TEXT **TIM SCHRÖDER**

Oh man, I've really hit the jackpot today," exclaims the young man who boards the bus at the outskirts of Clausthal, "I only had to wait three minutes!" His car is currently in the workshop, so for the past few days he has been catching the EcoBus to work at a kiosk in town each morning. "I always see the bus pass by," he says during the journey, "and thought I'd give it a try." It is really great, he goes on to say, that the bus takes him directly to the door for just EUR 2.70.

The little bus wends its way down the steep road into Clausthal. The young man continues: "Back home in Turkey you get little buses like this everywhere. It's pretty funny that they've only just come up with the idea here." However, whilst these buses, known as Dolmus in Turkey, can be flagged down anywhere, they only follow fixed routes and cannot be ordered in ad-

vance, unlike the EcoBus. Anyway, the kiosk owner only spends a few minutes on board until the bus comes to a stop right in front of his kiosk in the town below. As he gets off, he bids the driver, Torsten Keck, a cheery "have a nice day."

THE BUS TRAVELS TO WHEREVER IT IS NEEDED

Torsten Keck continues through the streets, with their pretty half-timbered houses, to his next stop. He has no fixed timetable and glances at the tablet mounted in a holder to the right of the gear lever to see where his next pick-up point is. "Ah, okay," he says, "the next passenger is getting on just behind the market church."

Every few minutes the tablet emits a quiet "ping" whenever a new customer sends a request to be picked up anywhere between Clausthal, Goslar and Osterode. The pick-up requests are

sent to the driver's tablet from a central server via the cell-phone network. "This is the list of the next few stops," he says, tapping the screen. "The system inserts the new customers somewhere along the route I'll be taking in the next few minutes."

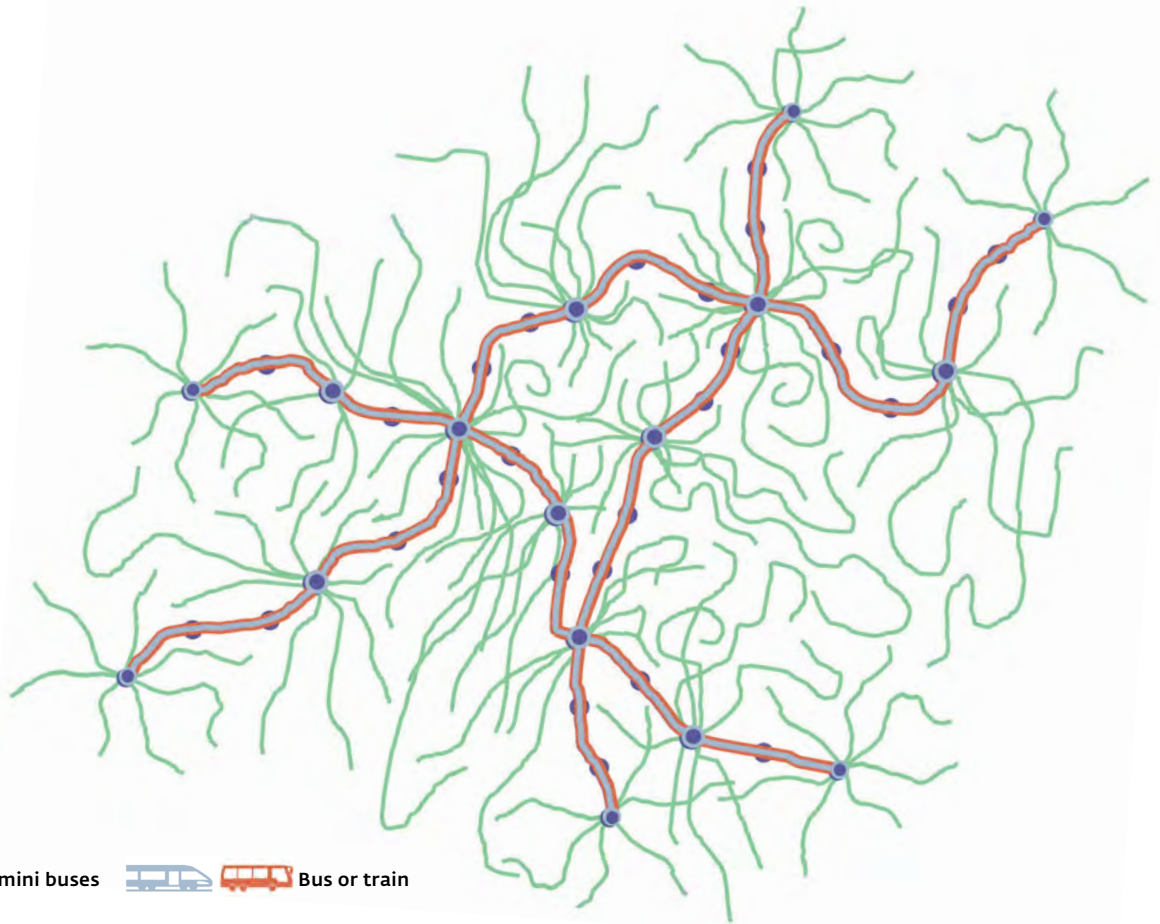
The EcoBuses have been operating in the Harz region since the middle of August. There are currently eight of them, each with eight passenger seats. Some of them even have space for wheelchairs. "We've already got a few regulars, mostly elderly folks." Says Torsten: "A lot of younger people use the service on Fridays and Saturdays." The buses stay out till two in the morning on those nights. He once had a group of young men who brought all sorts of barbecue equipment and provisions on board. He drove them to a barbecue cabin in the country. By the end of 2018, the EcoBus had some 6500 registered users – more than ten per cent of the population within the pilot area. Cus-



"You are the bus stop!" True to this slogan, the EcoBus picks passengers up wherever they like – even at some points along a country road.

tomers can to book the service by phone or using a smartphone app via the website www.ecobus.jetzt (in German). The EcoBus is still just a pilot project launched by researchers at the Max Planck Institute for Dynamics and Self-Organization. The buses are operated by project partners Regionalbus Braunschweig (a subsidiary of Deutsche Bahn), the Zweckverband Verkehrsverbund Süd-Niedersachsen (Administrative Union for the Integrated Transport System of Southern Lower Saxony) and the Regionalverband Grossraum Braunschweig (Greater Braunschweig Regional Association), who have also employed the drivers.

The buses' sliding side doors bear the witty slogan: "You are the bus stop!" which neatly sums up the concept: rather than walking to a traditional bus stop to wait for a service bus, you call the bus to where it is needed. And because most modern smartphones are equipped with a GPS function, the bus can even



be called to remote places such as hikers' car parks, tourist cafés or, for that matter, barbecue cabins far off the beaten track.

"Ultimately," says Stephan Herminghaus, physicist and Director at the Max Planck Institute for Dynamics and Self-Organization, "we want the EcoBus to contribute towards the reduction of private cars on the road by enabling several people to share their journeys." The EcoBus project was his idea. "The basic concept is that passengers board the bus along its route. But, unlike with car sharing, it is the ride that is being shared, not the car. We call it ride sharing."

Of course, as Herminghaus admits, the concept of ride sharing is nothing new. On-demand bus services that operate on a similar principle, picking up passengers along the way, have been around for a considerable time, he says. And, he continues, with modern transport services, such as Uber or Volkswagen's Moia, vehicles can be booked by smartphone at any time and any place.

"The problem," says Herminghaus, "is that all of these services put more ve-

hicles on the roads, which, ultimately, does nothing to reduce road traffic." On the contrary: "Services such as these take passengers from the environmentally-friendly public transport systems and distribute them among many cars." Stephan Herminghaus is familiar with the extreme side effects that can result from this from his own experiences in the Indian metropolis, Bangalore, where for some time now a significant part of the road traffic load has been due to empty trips by cars driving for Uber or Ola, its Indian counterpart. "These are mostly drivers on their way to their next customers, but that is precisely what the future should not look like."

LOCAL TRAFFIC IS INCREASING

The EcoBus is designed to achieve the opposite by getting people out of their cars and onto the public transport services. Its buses have often been an unattractive option to date, as some villages are not even connected to the public service routes or else the buses

are very infrequent. As a result, many people prefer the car, so many large intercity buses currently only carry a handful of passengers. They are referred to in the sector as "ghost buses" and tend to cost the public transport companies money to operate. "The EcoBus that I book to come to a particular spot at a time of my choosing will be able to fill this gap in future," says Herminghaus. "Last but not least, it also provides a shuttle service to the established public transport network – to the train station or the nearest bus stop. This strengthens public transport rather than weakening it." That is why the EcoBus is also being supported by public transport companies themselves in Southern Lower Saxony. It augments the existing network.

At first glance, the EcoBus project has very little to do with the research carried out at the Goettingen-based Institute, where scientists conduct research into flows, self-organizing networks of living cells and dynamic networks such as the electrical grid of the future.

Left-hand page In the traffic concept represented by the EcoBus, such flexible shuttle buses transport passengers to boarding points for regular bus or train services.

This page Stephan Herminghaus and the concept of ride sharing: rather than sharing cars as in the car sharing concept, people share journeys.



“Yet, in the final analysis,” says Stephan Herminghaus, “road traffic is also a flow – a special kind of flow,” whereas that is not the case with traffic. It is true, he says, that in this case too there is a certain flow in a particular direction, but, of course, vehicles can diverge from this main direction. “In this context we talk in terms of active fluids in which particles have proper motion,” Herminghaus explains. “It’s like with plankton organisms. Whilst they are transported in a certain direction by powerful water currents, they can use a rowing motion to change direction.” Thus, the complex phenomenon of road traffic is nothing new to flow researcher Herminghaus.

The idea for the EcoBus project occurred to him several years ago at a time when he had to cross the Reinhaeuser Landstrasse, one of the large multilane arterial roads out of Goettingen, whilst cycling to the Institute each day. “Sitting in almost every car there during rush hour is a single person. I asked myself how we could change that; how

people could be coaxed out of their cars and onto the buses and trains.” The EcoBus is his answer: pick people up in places where there had previously been hardly any alternative to the car.

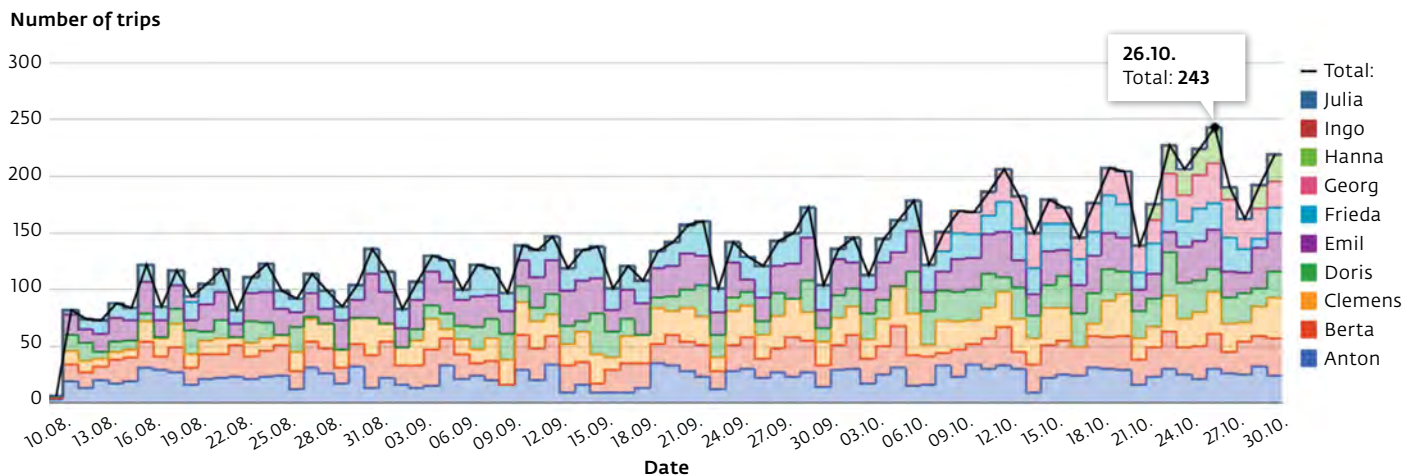
EIGHT BUSES WITH THE TRAVELING SALESMAN PROBLEM

The technology behind this service is so complex that Herminghaus had to assemble a dedicated team of engineers and physicists. This is because to send an EcoBus out on its rounds means mastering several challenges. For example, the EcoBus concept relates to a classic mathematical problem. Called the “traveling salesman problem” it has been known since the 1930s and involves finding the shortest route between several towns that a traveling salesman wants to visit. Yet, the more towns there are, the greater the number of alternative routes: the 15 biggest cities in Germany, for example, can be connected via 43 billion different route combinations! There are now a pletho-

ra of algorithms that produce solutions to this optimization task. They are used in Satnav systems among other things.

“But our work goes quite a bit further than this routing problem” says Tariq Baig-Meininghaus, who worked intensively on a route finding solution within the EcoBus project. “We’re not dealing with a traveling salesman, but with many passengers who want to be picked up and dropped off again. In addition to that, at present, we need to coordinate the routes of eight buses.” For example, a bus that is currently traveling in the direction of Clausthal-Zellerfeld should not pick up passengers whose destination is Goslar in the opposite direction – and vice versa. And another thing: the routes change continuously because new guest are always submitting their shuttle requests.

It took Tariq Baig-Meininghaus and his colleagues a good two years to reconcile all of these requirements, and, although there are already various software solutions on the market, a lot



Increasingly popular: of the ten buses with names such as Julia, Frieda and Anton, up to eight are in operation every day, whereby the number of trips has increased since the start of the pilot project.

of manual work was still needed. So whilst many research groups have published routing algorithms in the past, the majority of them are too slow for the EcoBus. “If a customer requests a bus then they want to know within seconds when one will be free and when it will arrive,” says Baig-Mein- inghaus. “An offer has to be made within twelve to 15 seconds or the system would feel too slow.”

He and his colleagues solved the problem in such a way that the EcoBus system really does provide an initial response to the customer request within a few seconds whilst the algorithms continue to work in the background to optimize the route and coordinate the many customer requests, which takes them a bit longer. The customer has no inkling of this. The researchers also made the system faster by dividing the entire EcoBus region into sub- units, for which detailed calculations

are first performed. Finally, the software synchronizes the individual areas and interim results to produce an overall solution.

FURTHER STEPS TOWARDS A RELIABLE TIME OF ARRIVAL

Coordinating all buses and customers or timing – there were many parameters that the researchers had to tweak for their EcoBus system. In particular, this also includes placing customer requests in a practical sequence to avoid the excessive prolongation of individual passengers’ journey times. Bus driver Torsten Keck knows why: “I recently had a passenger who spent almost an hour in the bus because other passengers, whose pick-up points were along the route, had booked the service. The trip then got longer and longer due to the short detours – and at some point the passenger let it be known that he’d like to get home in the not too distant future.”

The experts did program a maximum journey time per passenger into their system, but, because there are currently only eight buses in operation in

the pilot project, a trip can simply take up to an hour on occasion. In other cases, the customers still have to wait quite a long time till the next free bus comes their way. “I once had to wait an hour and a half for the bus,” says the young kiosk owner from Clausthal. But the more buses in operation in future, the faster the service should be.

The EcoBus is therefore by no means a hundred per cent plannable for the customers at this time, not least because the buses do not always arrive at their destinations to the exact minute. For project leader Stephan Herminghaus, that is the next step. He wants to further develop the system over the coming months so that it can give the passengers a reliable time of arrival – for example to get them to the station in Goslar on time for them to catch their connecting train.

But, even then, a precise departure time from the front door will not be possible. “Such complete flexibility will not be achievable with ten buses – the area between the three towns with its 63,000 residents is simply too big,” says Herminghaus. “So, the way it’ll work initially is that we’ll be able to give the

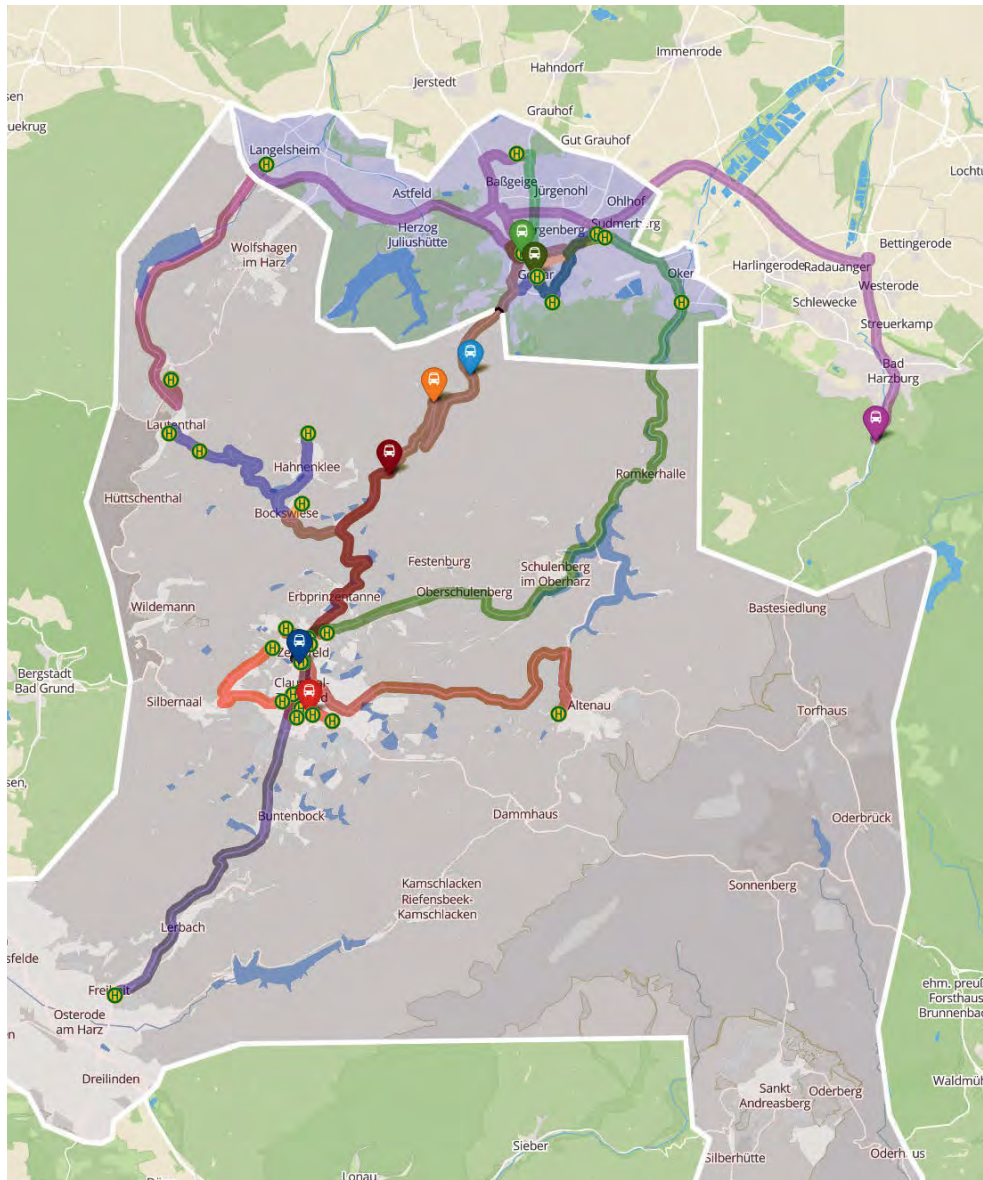
Flexible routes: the EcoBus also operates in rural districts in which there are no public transport services. The map shows an example of the routes traveled by the various mini buses on a particular day. During these trips, they stopped to pick up passengers at all the points marked by the bus stop symbol.

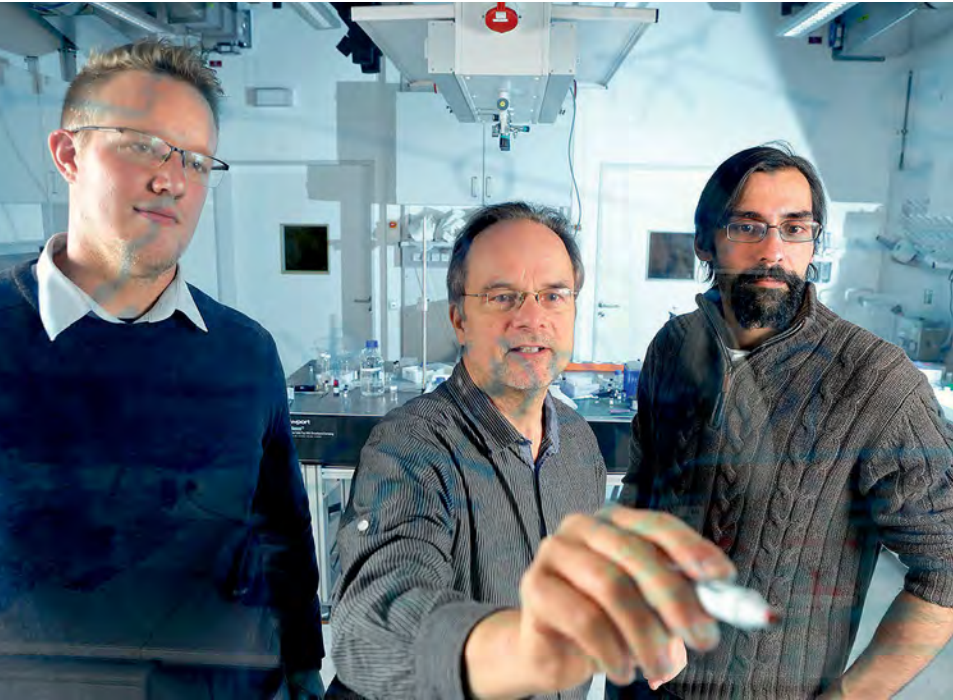


passenger an accurate time of arrival and a period during which we'll pick them up – that's achievable." Alternatively, a cooperation agreement with taxi firms would be feasible. Customers in a rush could be collected by taxi and transferred to an EcoBus somewhere along the way that would take them the rest of the way to the train station.

SIMPLIFYING THE SYSTEM WITH PUBLIC PARTICIPATION

However, the EcoBus project involves more than just the software that works in the background to synchronize all bus movements and customer requests; it also includes the visible elements. "We developed everything ourselves," says electrical engineer Christoph Brügge, "The app and the website through which you can book a trip as well as the Satnav system used by the bus drivers." To this end, Brügge and his colleagues also organized public events during which they asked locals about their expectations of such a system. "We wanted to keep the system as simple as possible so that older people, in particular, would be able to use it." >





Tailor-made mobility: Christoph Brügge, Stephan Herminghaus and Tariq Baig-Meininghaus (from left) are members of the team that developed and continue to improve the EcoBus. A next step is to be able to provide passengers with reliable arrival times.

Because the buses are operated by the public transport companies themselves, the tariffs are easy to understand – and the tickets can be transferred. The fares are the same as for the public service buses: a trip through Goslar costs the usual EUR 2.70 and the route from Clausthal to Goslar costs EUR 4.00. Among other things, passengers can also purchase a Deutsche Bahn Niedersachsensenticket (Lower Saxony Ticket) to enable them to use public transport throughout the state. “We initially found integrating the public transport ticket printers within our system to be an additional level of complexity,” says Stephan Herminghaus. “However, we’ve come to realize that this is an additional benefit to our customers because it integrates the bus directly into the transport associations’ tariff systems.”

Herminghaus emphasizes the fact that he is not trying to reinvent the wheel with the EcoBus: “I’m pretty certain that companies such as Uber use very similar algorithms – all developers use similar tools, after all,” says the researcher. “But, unfortunately, private companies keep their cards close to their chests so that, in the end, we did have to set up a system of our own after all.”

OTHER TOWNS AND CITIES ARE ENQUIRING ABOUT THE ECOBUS

This is a system with evident appeal, as the public transport companies are very interested. One member of the team is currently developing an EcoBus solution for the Leipzig transport services, with which the goal of precise passen-

ger arrival times should shortly be realized. Initially, two EcoBuses will be deployed in Leipzig for this purpose. The test is intended to demonstrate that the bus can interact perfectly with the regular bus and train timetables.

“Other municipalities have enquired about when we’ll finally be launching the EcoBus as a product and service on the market,” says Herminghaus. In the meantime, he continues, he has already developed an appropriate business model in conjunction with his colleagues from Max Planck Innovation, the Max Planck Society’s central technology transfer hub. “The concept is attractive because we would bear the risk. Our goal is to operate the call system as a service at our own cost and to fund it via small fees to be paid with each booking,” the researcher explains. But he is not yet able to say precisely when the EcoBus service will be on sale.

However, the pilot project in the Harz region has already demonstrated that the service works, and the researchers learned a lot from it: “Especially that interacting with the real world sometimes looks very different to the way a physicist imagines it will in theory,” says Tariq Baig-Meininghaus with a smile. “The passenger can certainly point the cursor at the exact spot on the map in the app where they want to be picked up – but, it’s still sometimes hard for drivers to find people, which can delay the departure time – you need to take account of this kind of thing in the system.” And the researchers encountered another stumbling block during the pilot project in the Harz region: dead zones!

On the route from Goslar to Clausthal-Zellerfeld Torsten Keck steers his bus through tight bends and serpentine. The bus dives down into a thickly forested river valley – no chance of cell phone reception. The tablet only comes back to life as the bus drives into Goslar: Ping! Ping! Ping! Ping! “We’re

back online,” says Torsten. “Now all the new customer requests will come rolling in.” And suddenly his route plan looks completely different. The EcoBus server has already arranged the requests in the correct sequence. “That’s the nice thing about this job: you’re always driving different routes. And, I’ve already discovered a few little places that I hadn’t even known existed before.” There is no doubt the EcoBus is opening up new prospects, not just for drivers like Torsten Keck, but especially for the customers and rural districts such as the Harz region, in which people still find themselves sitting in ghost buses much too often. ◀

SUMMARY

- Rural bus services are rare if they exist at all. Because many people prefer to use their cars all the time, those buses that are in service are extremely underutilized.
- That is why researchers at the Max Planck Institute for Dynamics and Self-Organization developed the EcoBus to make public transport more flexible, whereby, among other things, they had to solve an especially difficult route finding problem. Public transport companies in Lower Saxony are currently testing the system between Goslar, Clausthal-Zellerfeld and Osterode am Harz.
- The EcoBus picks people up where they want to get on and takes them right to where they want to go. Although the system is not yet able to specify precise departure and arrival times, because the route is changes continuously in response to new requests, it should soon be able to provide reliable arrival times – not least to enable customers to catch their connecting buses and trains on time.
- By contrast with other on-demand bus service systems, the point of the EcoBus is to reduce the number of vehicles on the roads, because as part of the public transport services, it augments service buses and trains.

Sunrise!

The Foundation funded a 130-meter Helium balloon for the Max Planck Institute for Solar System Research, enabling one of the world’s largest solar telescopes to get off the ground.

Sami Solanki’s SUNRISE telescope observed the sun’s magnetic fields in high resolution. As a result, research on how the sun influences the earth system can now be carried out more effectively.



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The umbrella algae's **crazy caps**

Acetabularia is several centimeters long – and consists of a single cell. Joachim Hämmerring from the Kaiser Wilhelm Institute for Biology in Berlin-Dahlem and Hans-Georg Schweiger from the Max Planck Institute for Cell Biology in Ladenburg dedicated most of their research life to the umbrella algae. One of their goals was to find out about the role of the nucleus.

TEXT **ELKE MAIER**

Berlin-Dahlem in 1931. It was a rather peculiar little plant that the biologist Joachim Hämmerring was contemplating. It did not really look like a plant at all, but more like an umbrella or a small mushroom. A thin stalk the length of a finger was equipped with a flat, ribbed cap on one end, and a root-like holdfast on the other end which the plant used to anchor itself to the substrate in the surf zone of the sea.

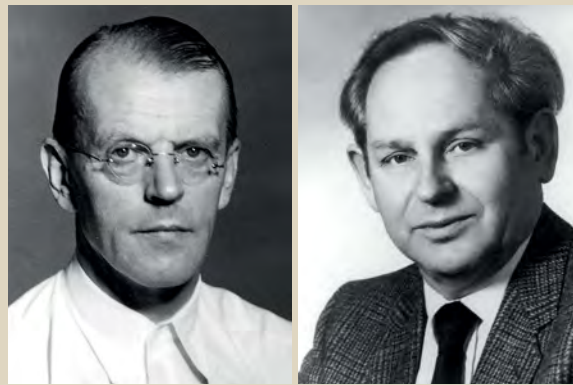
Hämmerring's object of study was a type of umbrella algae known as *Acetabularia mediterranea*. From a research trip to the Mediterranean Sea, Max Hartmann, the Director of the Kaiser Wilhelm Institute for Biology in Berlin, had brought back a number of specimens of these algae that grow to a length of up to six centimeters. His postdoc Joachim Hämmerring was now supposed to find out how the algae reproduced.

It was especially the fact that the entire organism consists of a single cell that made *Acetabularia* interesting for scientists. In the course of his studies, Hämmerring discovered that the gigantic cell also contains just one nucleus throughout its entire growth period, and that this nucleus is bigger than in most other organisms and is always located in the holdfast. Hämmerring recognized the marine plant's great potential for cellbiological research.

In multicellular organisms, the individual cells differentiate and take over different functions. But how does a gigantic cell like this organize itself and manage to reproduce? How does it ensure that the cap is formed at one end, and the holdfast at the other?

Hämmerring was unwilling to believe in the assumption that was popular at the time, according to which appearance was determined by mysterious life forces. He was convinced that material information carriers were behind all this. To prove his theory, he began to systematically cut umbrella algae into pieces. Thanks to their large size, he did not even need any special instruments – scissors and a pair of tweezers were enough.

The algae survive, even when they are cut apart repeatedly: provided that the nucleus remains intact, the cut off top section



Pioneers of cell biology: Joachim Hämmerring (left) and Hans-Georg Schweiger.

is regenerated time and time again. The nucleus can be isolated and transferred into another *Acetabularia* fragment, even a foreign one, without losing its functionality. The little plant was the perfect model organism to tackle fundamental questions of cell biology.

In order to find out more about the function of the nucleus, Hämmerring removed the nucleus of a young specimen that had not yet formed a cap. And lo and behold: against all expectations the plant did not die – quite the contrary. Without a nucleus it even lived for longer than with a nucleus; however,

it lived life on the back burner. The specimen remained in its development stadium at the time, and it never reproduced. It appeared to be the case that the nucleus transmits information that is vital to a normal life.

Hämmerring continued to conduct countless experiments in which he cut up umbrella algae, removed their nuclei and replaced them with foreign ones. In this context he also experimented with exchanging nuclei across different species of *Acetabularia*. This caused the cell to produce the form of cap typical of the species the nucleus came from. If Hämmerring placed nuclei of two species inside the same cell fragment without a nucleus, he could even create mixed cap designs.

However, he made his most astonishing discovery when he removed first the cap and a week later also the nucleus of a cell: the cut off side was able to form a new cap, even though the nucleus was gone! It had to be the case that the building instructions for the cap had moved from the nucleus to the cell plasma and survived there.

Through his experiments, Joachim Hämmerring gained fundamental insights into the interaction between the nucleus and the cell plasma. He recognized that shaping is controlled by the nucleus by transmitting “morphogenetic” (relating to formation) substances to the plasma. Nowadays, it is known that these substances are messenger ribonucleic acids – transcripts of the ge-

netic code that are channeled from the nucleus into the plasma, where they are used as instructions for protein production.

“Hämmerling succeeded in showing with simple means that properties such as outer appearance are determined by the nucleus, before people even knew about the genetic material DNA that is located inside the nucleus,” says Horst Bannwarth, a former *Acetabularia* researcher of the Max Planck Institute for Cell Biology in Ladenburg near Heidelberg, who now holds a professorship at the University of Cologne. “It was not until 1944 that the Canadian Oswald Theodore Avery demonstrated that information about hereditary characteristics is stored in the DNA.”

Hämmerling’s classic experiments paved the way for the umbrella algae to enter the laboratories. Scientists around the world were soon examining the processes inside the gigantic cell. The medical expert Hans-Georg Schweiger worked with the giant algae at the Max Planck Institute for Cell Biology. Schweiger had previously conducted research on red blood cells with and without nuclei. He used new and refined methods to examine the umbrella algae that can be easily manipulated and gained many new insights into the interrelations between the nucleus and the cell plasma. In this research work, he was particularly interested in biological rhythms.

Whether it be behavior or metabolic processes – there are many vital processes that are characterized by specific regularities. Photosynthesis in *Acetabularia* follows a daily rhythm, with large amounts of oxygen being produced during the day and smaller amounts at night. The algae maintain this rhythm, even when exposed to permanent lighting. This means that there must be an internal clock. But where is it? And how does it work?

To find out, Schweiger and his staff members once again took the cells apart. The researchers measured oxygen production in

AUGSBURGER ALLGEMEINE newspaper on 14 September 1977



The algae that the local Italian lagoon dwellers lovingly refer to as “umbrellas”, and that were introduced as research objects 50 years ago by Professor Joachim Hämmerling, who is meanwhile retired, have attracted a lot of attention for a long time now.

individual cells and cell fragments to determine photosynthetic activity. They found that the “sense of time” exists across all parts of the plant, and that the clock must therefore be located somewhere in the cell plasma rather than in the nucleus. What was interesting, however, was that an *Acetabularia* specimen whose nucleus had been removed adopted the rhythm of a foreign cell whose core was implanted into it and that had been modified to follow a different schedule by means of artificial lighting. Here, too, the nucleus therefore played an important part.

The methods had meanwhile become much more sophisticated than had been the case when Hämmerling was a postdoc. The researchers were now able to use specific inhibiting substances



Model plant: the umbrella algae *Acetabularia mediterranea* are at home in many places in the Mediterranean Sea, and they gave rise to fundamental insights into the interior of cells.

to block either transcription – the copying of the genetic code – or subsequent translation – the synthesizing of proteins based on the code. The internal clock would stop whenever the scientists interfered on the translation level. The clock must therefore be controlled by one or multiple substances that are produced in this process – by specific proteins.

Schweiger and his team were able to identify a protein called P230 as a key element of the internal clock. In *Acetabularia* it is located in the chloroplasts, and it controls the circadian rhythm of photosynthesis. Together with his brother Manfred Schweiger, who held a professorship in biochemistry at the University of Innsbruck at the time, Hans-Georg Schweiger published the so-called coupled translation-membrane model in 1977, which explains the underlying mechanism and can also be applied to other organisms.

This work made Hans-Georg Schweiger one of the pioneers of chronobiology – a field of research that has gained significant momentum over the past few decades: in 2017, three Americans – Jeffrey C. Hall, Michael Rosbash and Michael W. Young – received the Nobel Prize for researching the period gene that controls the circadian rhythm in the fruit fly *Drosophila*.

Following the publication of his model, Hans-Georg Schweiger set about examining the protein P230 more closely. However, he died suddenly in 1986. His mentor Joachim Hämmerling had died six years earlier. The international *Acetabularia* community had thus lost two extraordinary scientists.

The giant algae gradually disappeared from the laboratories in the 1990s. Their cultivation is an elaborate process, and even under ideal conditions their life cycle takes several months, and without bacteria colonizing their cell walls, they remain rather frail. They cannot compete against model organisms such as baker’s yeast, roundworms or thale cress. This is particularly true in our contemporary fast-paced world, where scientists are expected to present results as quickly as possible.

The possibility of a comeback cannot be excluded, though: *Acetabularia* belongs to the order of *Dasycladales* that have existed on earth for close to 600 million years. “There are now only 19 living species,” says Sigrid Berger-Seidel, Professor at the University of Heidelberg, and a former staff member of Hämmerling and Schweiger. “It would be interesting to compare species of different evolutionary ages, and to use new methods to examine the relationship between the nucleus and the organelles.” So it is quite possible that the primitive giant algae will return to the laboratories one day.

“I was simply relieved”

Gerard Meijer, Director at the FHI, talks about the DEAL project and negotiating with Wiley

He played a leading role in bringing the negotiations between the DEAL project and publishing company Wiley to a successful conclusion: Gerard Meijer, Director at the Fritz-Haber-Institut in Berlin since 2017, has long been an advocate of Open Access. The Dutch scientist gave our interviewer a look behind the scenes of the three-year negotiating marathon.

DEAL project spokesperson Horst Hippler described the conclusion of the agreement on January 15, 2019 as “a milestone.” How did you feel that day?

Gerard Meijer: I was simply relieved. The weeks before the deal was closed cost a lot of time and nervous energy. I remember saying to my wife, “If this doesn’t work out, all the work I’ve done over the last two months will have been a waste of time.” But once the deal was done, everything was forgotten (laughs).

So you were afraid that the deal with Wiley might fall through right up until the agreement was about to be signed?

Yes, we wrangled over details right up to the finish. After all, this was the first agreement of its kind in Germany – and there was a lot of money involved. We didn’t manage to conclude the negotiations before Christmas. After that, Brian Napack, President and CEO of Wiley, and I were of one mind: “We have to set ourselves a deadline no matter what. Either the deal will be done by January 11 – or it will all be over.”

How did you manage to turn things around?

During the week before January 11, Brian Napack flew over from the U.S., especially

so that he could sit in on the negotiations. For two days, we sat at the negotiating table discussing the details right up until midnight – nine hours on one day and 15 hours on the other.

Two days of marathon negotiations...

Yes, we really got down to brass tacks. But the results were worth the effort. After the second day, it was clear that we had done it. On January 11, I had a very pleasant phone conversation with Brian Napack, in which we both said, “Now everything’s fine!”

Let us take another look back. The MPG delegated you to start negotiations at the beginning of 2017. How did that happen?

Well, it wasn’t my first time at the negotiating table. Before I came back to Germany in 2017, I was involved in similar negotiations at home, in the Netherlands, as President of the Radboud University in Nijmegen.

That means you’re probably the first scientist to take part in negotiations for a national license in two different countries.

How far did this contribute to your success? That was a clear advantage. In the past, the large publishing companies had things all their own way. They increased their prices by about five percent every year. Nobody knew exactly how much was paid in the other countries and why. Negotiations didn’t take place on an equal footing for a long time.

In what respect?

The publishing companies always send the same people to the negotiating table no matter where they are in Europe – or possibly even the world. They are really tough



Gerard Meijer

negotiators and know exactly what’s happening in each country. The academics, on the other hand, have a different negotiating team in every country. That’s what made it all the more important to exchange experiences with other countries over those three years.

Three years of negotiations – what took so long?

The agreement with Wiley broke completely new ground. There had never been a national license of this kind in Germany before. We had to get to know each other, build mutual trust, learn to respect the other side’s ideas. That takes time and was the only way to establish a true partnership from which both sides would benefit. This is something else that the last three years have shown: publishing companies and academics need each other if they are to move towards Open Access.

What was the highlight of those three years for you personally?

Without a doubt the birth of MPDL Services GmbH. It was already clear by the beginning of September 2018 that we’d agreed all the most important details with Wiley. A consensus had also been reached within the DEAL negotiating group.

That sounds like a big “but”...

Yes, although we had come a long way in terms of content, we found that we didn’t have the structure necessary to actually conclude a contract. We had no idea which of the people involved in the DEAL project had the mandate to sign the agreement.

What happened next?

I emailed an urgent appeal to President Stratmann and Secretary General Willems

The most important points agreed by DEAL and Wiley

- For an annual fee, all institutions represented by DEAL will have access to all the scientific journals published by Wiley as far back as 1997.
- Researchers at these institutions can also publish their articles in Wiley’s journals as Open Access publications.
- The authors will retain the copyright rather than ceding it to the publisher, as was previously the case.

that same evening: "If the Max-Planck-Gesellschaft doesn't intervene, the DEAL project will be a disaster. The MPG has to save it – for DEAL and for the whole of Germany."

The birth of MPDL Services GmbH ...

Yes, although it wasn't an easy process. The MPG's funds are meant for basic research – not for founding limited liability companies. For that reason, we needed the consent of the Federal Ministry of Education and Research (BMBF) and the Joint Science Conference (GWK). Because things had to move quickly, our request was fast forwarded through the GWK – for the first time in 15 years.

So in the end, the agreement came into being because all the cogs fit together.

Yes, and thanks to the tremendous personal commitment of the staff members at the MPG: Stratmann, Willems, Prugger, Schleier and with him the entire Legal Department, MPDL – all of them pulled together! And the dedication shown by Ralf Schimmer and Frank Sander can't be commended highly enough. Sanders took over the management of MPDL Services GmbH and signed the agreement on January 15. All in all, a great example of what the MPG can achieve!

So the first deal has been done. Where do things go from here?

I hope that the contract will have a signal effect and encourage the other major publishing companies to get on board. We also want to conclude national agreements with the smaller publishers. What's more, we will be setting up an interdisciplinary Open Access journal in cooperation with Wiley. Closing the deal is one thing, but making Open Access public is at least equally important!

Interview: Petra Maaß

Public access to the full agreement is available online:
www.projekt-deal.de/about-deal

Cyber Valley reaches the next level

Cyber Valley is continuing to take shape. Most of the leadership positions in the ten research groups set up as part of the business and science initiative have now been filled. This is one of the central goals of the research alliance, which aims to advance the development of artificial intelligence (AI). The cooperative venture set up by the MPG, the state of Baden-Wuerttemberg with the Universities of Stuttgart and Tuebingen and the industrial partners aims to facilitate the establishment of start-up companies in Cyber Valley.

With this in mind, the partners have now signed contracts that lay down rules for dealing with issues such as intellectual property. "Scientists from academic research facilities are invariably permitted to use inventions developed while working on the Cyber Valley project for new spin-offs before they are used for anything else," says Linda Behringer, press officer for the MPI for Intelligent Systems.

Meanwhile, all five Research Group Leaders at the MPI for Intelligent Systems and their three colleagues at the University of Tuebingen have now started work. The two remaining Research Group Leaders at the University of Stuttgart are currently being selected. Moreover, Matthias Hein and Philipp Hennig have taken two of the professorships additionally created in Cyber Valley.

Meanwhile, numerous events such as forums, lecture series and a science slam have been organized in Tuebingen and Stuttgart with the aim of engaging the public in dialog on AI research and the Cyber Valley initiative in particular. These events are the researchers' response to the criticisms of Cyber Valley expressed in public, for example with regard to possible military applications of AI. "But it goes without saying that no weapons research is conducted in Cyber Valley!" says Linda Behringer. Many of the scientists in Cyber Valley are against autonomous weapons.

There are also reservations about collaborative endeavors with commercial organizations such as Amazon. "Both sides can benefit from the dialog between application-oriented industrial research and curiosity-driven basic research," says Bernhard Schölkopf. The Director at the MPI for Intelligent Systems is also



Breathing life into avatars: researchers in Tuebingen are developing ways of creating realistic, animated 3D models of the body.

working as an Amazon Scholar within the 20 percent timeframe allowed for researchers to perform ancillary activities. Collaboration with commercial partners promotes the translation of basic research into applications, while academic researchers gain insight into the problems that companies are trying to solve besides obtaining inspiration for their work.

The commitment of Amazon in particular has helped Cyber Valley achieve great international visibility, as a result of which the initiative now attracts talented AI experts from all over the world – a central goal for Schölkopf. "It is a matter of personal importance to me that the Cyber Valley region remains a leading European and global center in the field of artificial intelligence."



Wolfgang Gass and Leonhard Schilbach in the documentary series "Ich, einfach unvermittelbar?". Wolfgang Gass passed all the cognitive tests with flying colors (left to right).

When your colleague is a little different

People with autism often have astonishing abilities from which companies can benefit

Patients with a diagnosis of autism usually have difficulties finding a job. The Day Clinic for Disorders of Social Interaction at the MPI for Psychiatry helps them look for work – and adopts unconventional methods in doing so.

A timetable written on an enormous whiteboard: blood tests, morning rounds, various individual and group therapies – all the details are noted clearly and concisely. This timetable serves as orientation and provides support and structure, from 8 am to 4 pm, Mondays to Fridays for a period of six weeks.

At the day clinic in Munich, adults with high-functioning autism learn to deal with the challenges of the working world, which often seem to them to be beyond their control. "From the application process to getting started in the new company and making small talk: our job-oriented training helps them get started or find their way back to work," says social worker Sabine Kieseewetter. Interpersonal communication in particular is an obstacle for many autistic people. Greeting, brief conversations in passing, maintaining eye contact during interviews – they practice all this during individual coaching sessions.

"People with autism perceive their world in great detail but find it difficult to intuitively interpret the emotions of the people around them," explains Leonhard Schilbach. The psychiatrist is the Director of the Outpatient and Day Clinic for Disorders of Social Interaction at the MPI for Psychiatry in Munich. Imprecisely formulated work instructions can easily give rise to misunderstandings at work. As an example, Schilbach tells the story of a patient on work experience who, after printing a set of documents and being asked by his superior to print another set ("And now the same in green!"), printed them out in the color green. These job seekers rarely lack intelligence; their difficulties are with the unwritten rules of society. Many of them have an exceptional eye for detail, a gift for recognizing patterns and are excellent logical thinkers.

Like Wolfgang Gass (46), who completed his Master's degree with an average grade of 1.9, studied electronics and

trained as a mechanical engineer. Despite all this, the highly gifted Gass was unable to find a job. "Why am I in this world if nobody wants me and my skills and talents are useless?" he asked in the Vox TV series "Ich, einfach unvermittelbar?" ("Unemployable Me?"). During the series, which was broadcast at the end of 2018 and was nominated for the Deutscher Fernsehpreis (German Television Awards) and the Grimme Award, people with diagnoses such as autism and Tourette syndrome got to know their true strengths by undergoing specialized diagnostic procedures. Gass now works near Zurich.

While the series was being filmed, he made the acquaintance of Leonhard Schilbach – "a pleasant, busy man," as Gass describes him. The psychiatrist had also been cast for the series but took a long time to decide whether he should take part. "Although the MPI for Psychiatry was already forging unconventional paths in its cooperation with employees such as Auticon and BMW, appearance in a television series is not really one of the tasks of a doctor and scientist." However, it was the opportunity to lift the taboo on the diagnosis of autism that finally persuaded Schilbach to take part in this experiment. His task was to find out the strengths of the autistic protagonists.

The psychiatrist soon realized that Wolfgang Gass had great potential. "He knows a lot about his autism, is open about it and has remarkable intellectual abilities." Schilbach was therefore delighted when Gass was offered a job with a spin-off of the Goethe University in Frankfurt before the series came to an end. The two men are still in contact.

Most former patients do not stay in contact with clinic staff after spending time at the day clinic in Munich. And yet touching scenes still happen, as assistant physician Judith Gollmitzer explains: "Most of our patients have years of suffering behind them. Here they notice that they are not alone with their problems." This is an experience that can have a lasting impact on the patients – on their way towards a more satisfactory working and private life.

Research Establishments

- Institute / research center
- Sub-institute / external branch
- Other research establishments
- Associated research organizations

The Netherlands

- Nijmegen

Italy

- Rome
- Florence

USA

- Jupiter, Florida

Brazil

- Manaus

Luxembourg

- Luxembourg



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