



Jülich researcher
Martin Riese investigates
climate processes in the
stratosphere.

A climate of change?

The facts are on the table – now it's the politicians' turn

TIDY

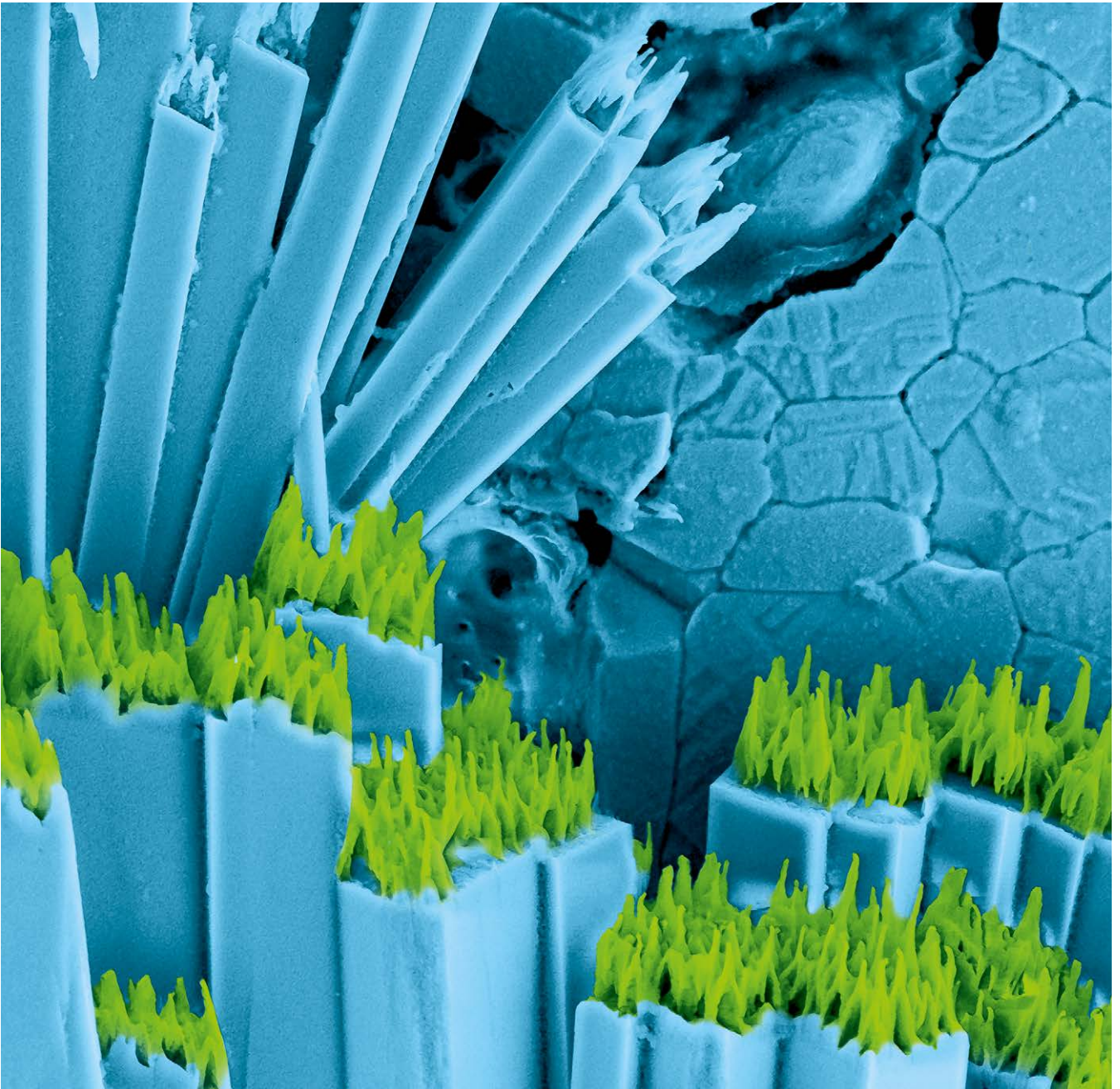
Living cells
clean themselves

BUSY

What our brain and roads
have in common

MESSY

Crystals don't
have to be perfect



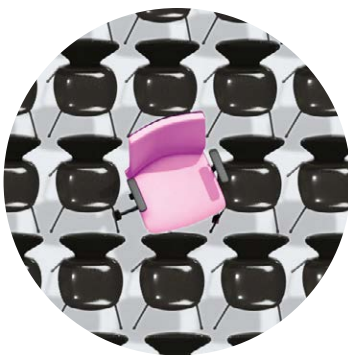
A filter for oxygen

A snowy landscape with spruces and jagged rocks? No. The picture shows a 15 x 15 micrometre section of a ceramic material from the perovskite group – imaged with an electron microscope. Jülich researchers from the Institute of Energy and Climate Research investigate these ceramics, for example to separate oxygen from the ambient air. This is only possible so far using a great deal of energy. One potential application is the oxyfuel process, which is one way of reducing the emissions of conventional power plants – ideally to water and CO₂.

The latter could then be separated and stored or reused.

NEWS IN BRIEF**5****COVER STORY****Small glimmers of hope**

Researchers provide scientific basis for decisions on international climate policy.

8**RESEARCH****All in good (dis)order**

In crystals, flaws can be useful.

14**Rush hour in the brain**

Information flows in our heads like in an extensive road network.

16**Home improvement for the worse**

Viruses modify bacteria to suit their own needs.

18**Measuring with Thor's hammer**

Magnetic resonance spectrometers don't have to be large and expensive.

20**Massive difference**

Roots, leaves, and stem – how plants distribute their biomass.

22**Learning from mistakes**

A measuring error shows how cell membranes oscillate.

23**Staying clean**

Cells have their own garbage disposal system.

24**SECTIONS****Editorial**

4

Publication details

4

What's your research all about?

19

2.2 plus

26

Thumbs up

27

Research in a tweet

28

One Nobel Prize isn't enough



↑ Want to read *effzett* on your tablet? Either scan the QR code with your tablet or visit our website:
www.fz-juelich.de/effzett



You could easily miss it – the Peace Nobel Prize certificate. In a modest blue frame, it hangs in the office of Jülich climate researcher Prof. Andreas Wahner. It pertains to the Intergovernmental Panel on Climate Change (IPCC). The organization received the prize in 2007 together with former US Vice President Al Gore for their commitment to raising public awareness of climate change and its consequences. Wahner, like other Jülich researchers, has contributed to several IPCC reports on the world's climate.

But what is broad consensus in science does not seem to be generally accepted everywhere: 6% of Germans deny that human activities have any noteworthy influence on our climate. In the USA, only one in two people believes that humanity is mainly responsible for the current climate change. For years, the international community has been struggling to establish binding measures for climate protection. Turn to page 8 to read why Jülich climate researchers see tiny glimmers of hope in spite of this.

We wish you enlightening reading!

Your *effzett* editorial team

Impressum

effzett Forschungszentrum Jülich's magazine, ISSN 2364-2327

Published by: Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

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Translation: Language Services, Forschungszentrum Jülich

Graphics and layout: SeitenPlan GmbH, Corporate Publishing Dortmund, Germany

Images: Forschungszentrum Jülich (6 top, 7 top), Forschungszentrum Jülich/HHU Düsseldorf (5 bottom), Forschungszentrum Jülich/Sascha Kreklau (Cover, 3 top centre, 7 bottom, 8-9, 11 top, 19, 20), Forschungszentrum Jülich/Ralf-Uwe Limbach (3 right, 16, 18 top, 23, 24 left, 28), Forschungszentrum Jülich/Wilhelm-Peter Schneider (24 centre and right), A-R-T/Shutterstock (4), Arthimedes/Shutterstock (15 top [small people]), René Borowski (27), Designua/Shutterstock (18 bottom), © German Climate

Consortium, klimafakten.de/illustrations: Climate Media Factory, (12-13 [infographics]), focal point/Shutterstock (6 bottom), Kateryna Kon/Shutterstock (25), Lebendkulturen.de/Shutterstock (25), Tsvetkov Maxim/Shutterstock (25), molekuel.be/Shutterstock (15 bottom), nobeastsofierce/Shutterstock (25), Dr. Goran Pecanac/Forschungszentrum Jülich (2), photosync/Shutterstock (25 [rubbish bin]), Gisela Preuß (5 top), SeitenPlan (3 left, 14-15 [graphic], 17), Roman Sotola/Shutterstock (25), Triff/Shutterstock (21), Videologia/Shutterstock (25)

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BIOLOGY

Fungal splendour

It lustres like silk, frizzes like candy floss, and yet it's only ice. Hair ice, to be precise. On cold winter days, the delicate glory sprouts from dead branches of deciduous trees – but only if the fungus *Exidiopsis effusa* has settled in the wood, as was shown by Jülich and Swiss researchers. The fungus degrades the wood. During this process, the constituent materials lignin and tannin, dissolved in water, find their way out of the branches through pores. They then serve as crystallization nuclei for the formation of ice.

– INSTITUTE OF BIO- AND GEOSCIENCES –

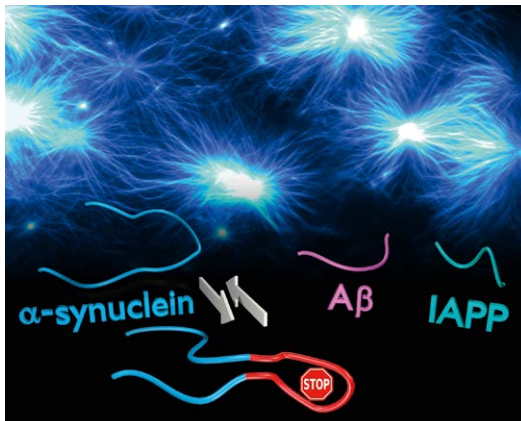


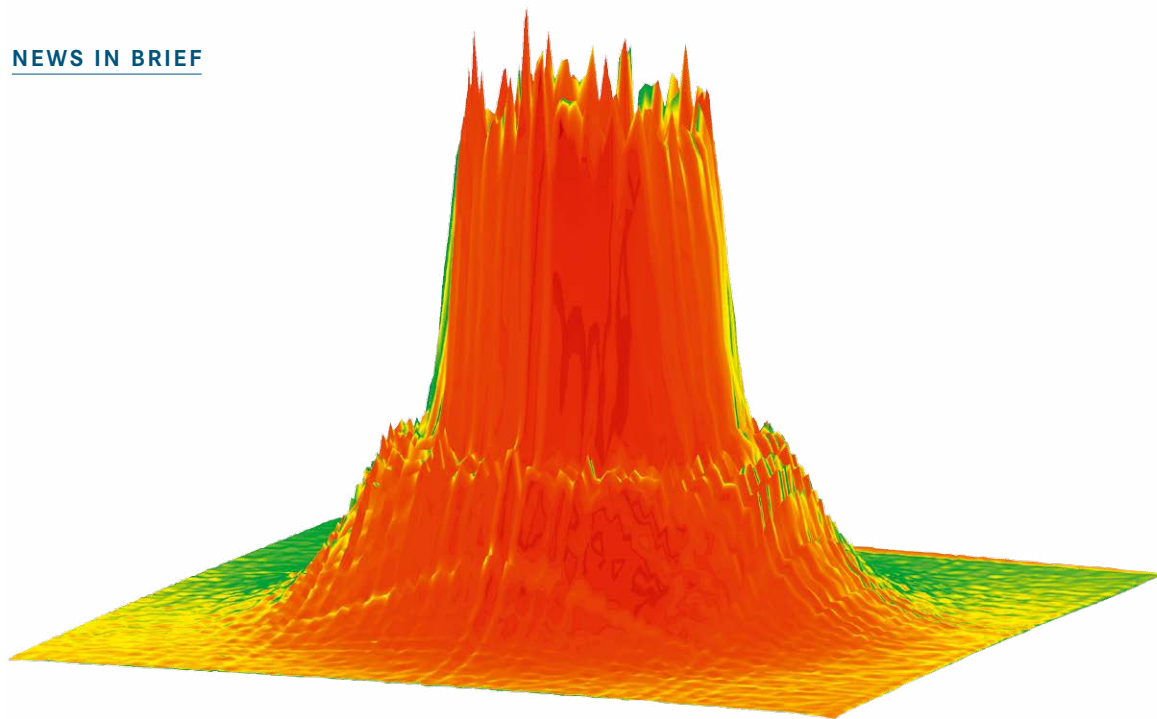
PARKINSON'S DISEASE

Blocked connection

Clumps, known as aggregates, of the protein α -synuclein in the brain are believed to be a cause of Parkinson's disease. A targeted modification to the molecular structure of this protein inhibits the formation of such aggregates, as Jülich and Düsseldorf scientists observed. They blocked two segments of the protein in such a way that they could no longer form bonds with other proteins. The researchers hope to develop new approaches to therapies – not only for Parkinson's disease but also for Alzheimer's and type II diabetes.

– INSTITUTE OF COMPLEX SYSTEMS –





Colloids made easy

Colloids are tiny particles or droplets made up of protein or plastic molecules. They occur in cells and are used in cosmetics and dispersion paints, for example to determine their flow properties. Jülich researchers were part of an international team who developed a model system with which the flow properties of soft colloids can be predicted on the basis of the atomic structures of these particles. Colloids can thus be tailored to the needs of various applications.

- JÜLICH CENTRE FOR NEUTRON SCIENCE -

SURFACE PHYSICS

Benzene knows no difference

It's not only in sports that gold is the measure of all things: at the commodities exchanges, it's worth more than the other two coinage metals silver and copper. Organic molecules don't seem to see the difference.

Researchers from Berlin, Heidelberg, and Jülich found out that the hydrocarbon benzene bonds with all three metals with an exactly equal strength, in spite of their different electronic properties. The scientists believe that an as yet unknown law is behind the phenomenon.

- PETER GRÜNBERG INSTITUTE -

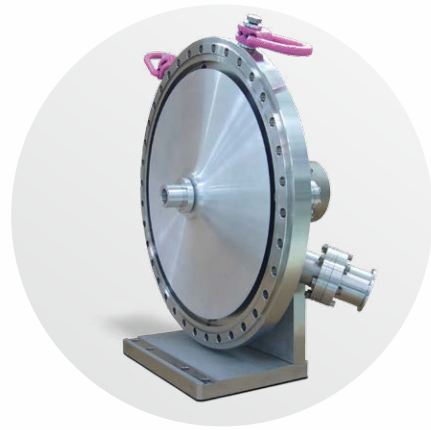


NANORESEARCH

Closer look at charge

Electric fields provide information on the distribution of charges in atoms or molecules. Jülich physicists headed by Dr. Christian Wagner (pictured below) have developed an ultrahigh-resolution three-dimensional microscopy technique which images such fields with previously unachievable precision: scanning quantum dot microscopy. The researchers make use of a scanning force microscope to which they added a sensor comprising an individual molecule. The technique permits the examination of nanostructures such as semiconductor materials or biomolecules.

– PETER GRÜNBERG INSTITUTE –



1,000

metres ...

... per second – or, to put it another way: three times the speed of sound – is the velocity achieved by a rotating disc which is part of a new filter co-developed and co-manufactured by Forschungszentrum Jülich for the Berlin electron storage ring BESSY II. The disc filters individual X-ray pulses. BESSY II's electron beam generates 400 of these pulses per circulation in the storage ring. For certain experiments, however, especially in materials research, scientists require individual pulses. Previously, usage of the storage ring had to be limited for other users for this purpose. This is no longer necessary with the new X-ray filter.

– CENTRAL INSTITUTE OF ENGINEERING,
ELECTRONICS AND ANALYTICS –

ARRIVAL OF THE HEAVY-WEIGHTS

The first dipole magnets for the high-energy storage ring HESR have arrived at Jülich. Until 2018, 44 of the 34-tonne devices are expected. Coordinated by Jülich, HESR is being constructed at the Darmstadt accelerator complex FAIR to permit novel experiments with antiprotons and other charged particles.

INVITATION TO RESEARCH

Together with five other Helmholtz centres, Forschungszentrum Jülich is establishing a new laboratory platform, the Helmholtz Energy Materials Foundry (HEMF). Complementing laboratories worth € 46 million in total will be set up so that researchers from Germany and abroad can develop materials for energy conversion and storage.

JUMP STARTING START-UPS

Jülich researchers Vitali Weißbecker and Andreas Schulze Lohoff won first prize at the AC² competition for new start-up companies. They plan to market their invention, which reduces the weight of fuel cells by 70% by means of their own company. The prize money of € 10,000 will flow into the founding of the company.

Glimmers of hope



Every few years, everything we know about climate change is laid bare. But what use have the five reports published by the IPCC been so far? Not much, it seems. This November will see the 21st United Nations Climate Change Conference take place in Paris. It could end just like most of its 20 predecessors: without any profound measures for climate protection. So does compiling these reports even make sense? Absolutely, say Jülich climate researchers.



The findings are beyond dispute: glaciers are melting, permafrost soil thawing, sea levels rising. To sum up the results of the Intergovernmental Panel on Climate Change (IPCC): our climate is changing. “It is virtually certain that globally the troposphere has warmed since the mid-20th century,” states the latest IPCC report from 2013/2014. But for the first time, the researchers went one step further: in their view, the facts allow no other conclusion than that the exceptionally fast warming since the beginning of the 20th century is not simply a climate “slip”, but that it’s “extremely likely” that human influence is the dominant cause.

“The report summarizes the findings of global climate research. The latest edition is the most comprehensive collection to date,” says climate researcher Prof. Andreas Wahner. “Compared to the fourth report from 2007, the results are based on more than twice as many climate models and a much larger number of simulations.” Wahner is an expert for the lower area of the atmosphere, which is directly above the Earth’s surface, and is known as the troposphere. He has been working at Forschungszentrum Jülich since 1988 – the same year that the IPCC was founded. Two years later, the first IPCC report was published. “During the 1980s, changes in the climate became more apparent, but politicians needed an objective source of information on the causes and potential consequences,” Wahner recollects.

“In the reports, the knowledge of the day is compiled. They represent the basis for political action,” adds Wahner’s colleague Prof. Martin Riese, climate researcher for the next highest level of the atmosphere, the stratosphere. “They reveal options for action and their possible consequences – but it’s policy makers who have to decide,” Riese stresses. The fact that the international community can act quickly as a result of research findings is demonstrated by one prominent example:

the ozone hole. Especially in the atmosphere above the Antarctic, researchers had observed a pronounced thinning of the ozone layer since the mid-1980s. Chlorofluorocarbons (CFCs) were responsible for this. Since 1987, the Montreal Protocol and its follow-up protocols have almost eliminated the use of CFCs. New data and simulations – including some from Martin Riese’s institute – verify a declining trend in the destruction of ozone in certain layers of the atmosphere, although the ozone hole is so far unchanged.



FEWER CFCs – SMALLER GREENHOUSE

“Without the Montreal Protocol and the tightening of measures, the ozone layer would be much thinner today from the tropics right to the polar regions,” says Riese. “In addition, banning CFCs reduced the greenhouse effect caused by humanity.” He and his team are involved as authors and reviewers in the report on the ozone layer situation, which the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) publish every four years. “However, CFCs were a comparatively simple problem for politics,” adds Riese. “It was about only one group of substances, and ultimately only a few companies were affected by the ban.” In the case of carbon dioxide, the problem is far more complex. For a long time, primarily the industrialized countries bore the responsibility, from major corporations down to individual consumers. That picture has changed of late: apart from the USA, newly industrialized countries such as China or India are now among the major polluters, causing large-scale CO₂ emissions. But to counter global warming, the emission of all greenhouse gases must be considerably lowered. “This includes more than just CO₂: other greenhouse gases such as methane or nitrous oxide also contribute to the effect,” says Andreas Wahner.

Compelling all nations to reduce their emissions by means of laws appears almost impossible. Therefore, even the “small” successes of the climate reports provide glimmers of hope: without the knowledge of the first IPCC report from 1990, for example, the United Nations’ Framework Convention on Climate Change in Rio in 1992 would not have taken place. It’s an agreement obligating all partners to regularly publish facts on current greenhouse gas emissions. The follow-up report from 1995 provided the scientific basis for the negotiations for the 1997 Kyoto Protocol. It stipulates binding limits for the emission of greenhouse gases in industrialized countries and entered into force in 2005. The emissions trading scheme in the European Union is also based on it.

Raising awareness is another objective of the reports, says Wahner. According to him, it’s the only way for political decisions that must be sustained over several government terms to be generally accepted. A good example for this is the 2020 climate target in Germany, which aims to reduce the emission of greenhouse gases by 40% compared to 1990.

But the report is also important to research itself. “It shows us where we’re at, where there are gaps to be bridged – and where we have to correct ourselves,” says Prof. Astrid Kiendler-Scharr, expert for aerosols. These are tiny particles in the air which play an important role for the chemistry of the atmosphere and for the climate system. The influence of clouds and these aerosols is one of those gaps, and it’s currently being bridged. “Both aspects are still great unknowns in climate models,” stresses Kiendler-Scharr. The formation of aerosols and their role in climatic processes are complex issues. “Together with my team, I’m working on better understanding the details. That is one precondition to, for example, better estimate how rising temperatures affect these processes,” says the researcher. In her view, global field observations and laboratory experiments are needed to create the basis for improved models.

There are already new basic principles for improved models of the self-cleansing ability of the atmosphere. Measurement campaigns conducted by Wahner and Kiendler-Scharr using the Zeppelin NT provided new data in the past few years. They show that the conventional concepts must be corrected – and, therefore, so do the models.



EVER MORE PRECISE PROGNoses

“It’s decisive that we understand the scientific basis of climate and of climate change. This will allow our simulations to become better and better – and our prognoses more and more precise,” Kiendler-Scharr is convinced. Prognoses which show, among other things, what might happen if humanity simply carries on as before, unchecked. But they also show that it’s possible to limit global warming to two degrees Celsius compared to the pre-industrial age. An ambitious aim, which can only be reached by reducing greenhouse gas emissions radically – but also a glimmer of hope. To what extent has the awareness of the dangers of climate change among politicians been raised? This will be shown by the Climate Change Conference in Paris in late November and the decisions taken there. But whatever politics decides – research must go on. “We are as yet far from understanding all processes in the climate system. The IPCC report shows the scientific community the direction in which research must be steered,” says Andreas Wahner.



↑ Prof. Astrid Kiendler-Scharr, director at the Institute of Energy and Climate Research – Troposphere (IEK-8)

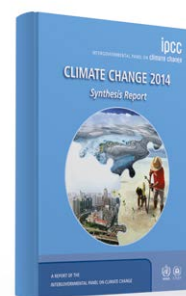
↑ Prof. Martin Riese, director at the Institute of Energy and Climate Research – Stratosphere (IEK-7)

↑ Prof. Andreas Wahner, director at the Institute of Energy and Climate Research – Troposphere (IEK-8)

Research – learn – act!

Jülich researchers have been involved in the IPCC reporting marathon right from the start. They are reviewers or authors and furnish hard facts and figures. In 2014 alone, more than 220 scientific publications from the fields of atmosphere, geoscience, and plant research were published from inside Jülich's laboratories. Each on its own represents progress: with each publication, other scientists worldwide learn something new. Often, it's a little piece of the puzzle of climatic processes, but sometimes it's a big deal, ending up in *Science* or *Nature* – or in the IPCC's reports.

Researching and learning is one side of the coin. Acting is the other. Jülich scientists consider it as their duty to directly talk to politicians and people responsible, to inform them, and thus encourage them to act. This happens in the laboratories and during the measurement campaigns of Forschungszentrum Jülich, as well as in direct talks in Germany and throughout the world. In concrete terms, it has led to buses finally being introduced in Bad Homburg which vent less fine dust and nitrogen oxides into the air. At several industry locations in China, the air pollution was reduced considerably with the aid of Jülich measuring techniques and intensive advising of local actors by a Jülich research team. "Our research has the greatest impact when we offer solutions and these are then immediately implemented," stresses Prof. Andreas Wahner. The researchers agree, however, that in complex structures, such as the atmosphere and politics, there is usually no single solution for all requirements. "In addition to the emissions, there are also economic components to be considered by politics," Prof. Astrid Kiendler-Scharr points out. She is therefore all the more delighted when she meets politicians or journalists who can handle scientific issues which can't be explained in two sentences.

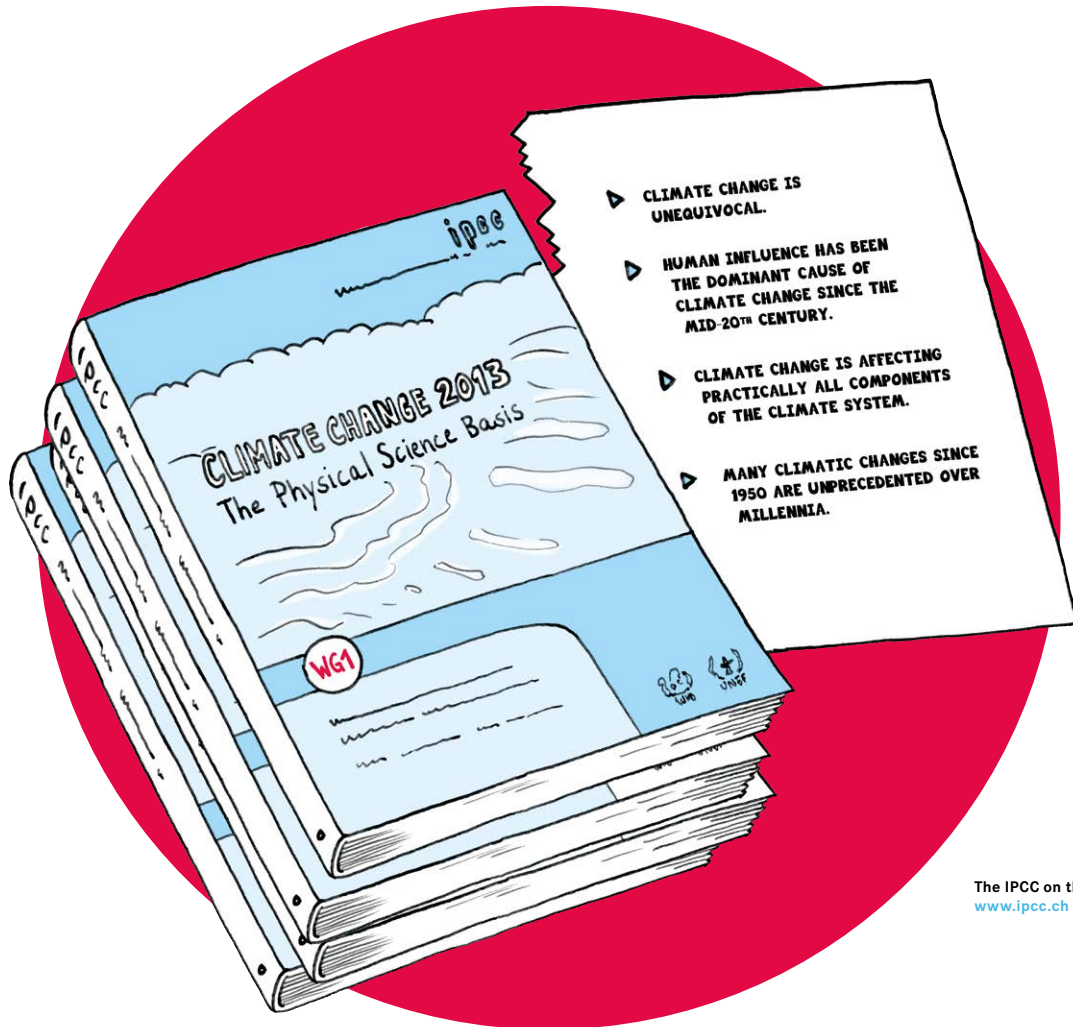


168

pages is the length of the summary of the 5th climate report from 2013/2014.

The current report on the world's climate

What's in it and who writes it



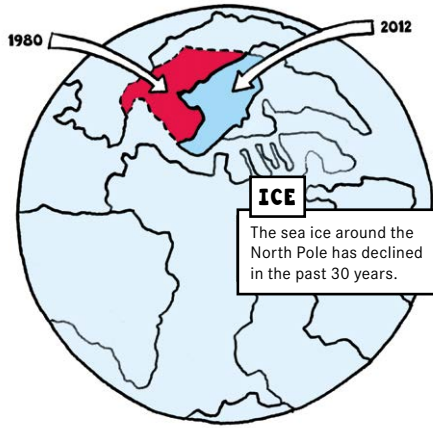
The IPCC on the Internet:
www.ipcc.ch

The World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) set up the Intergovernmental Panel on Climate Change (IPCC) in 1988. Hundreds of scientists from all over the world have since contributed to the five Assessment Reports as authors or reviewers. Among them are the two Jülich researchers Dr. Martina Krämer and Dr. Rolf Müller, who worked on the latest report from 2013 and 2014.

The IPCC currently has 195 member states. The scientists and the Chairs work in an honorary capacity, while the rest of the IPCC is financed mainly by the industrialized countries. On

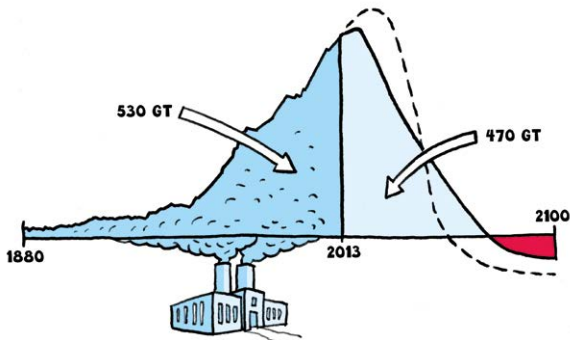
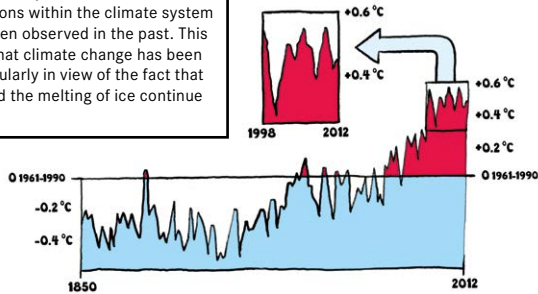
the IPCC's behalf, experts from all over the world compile scientific, technical, and socioeconomic knowledge on our climate. As many as 830 lead authors worked on the latest IPCC report, among them 40 from Germany. The report is divided into three sections: the first part looks at the physical science basis of climate change. The second part is concerned with the consequences of climate change on ecosystems, economy, and health, and the third part outlines political and technological measures which could mitigate climate change.

Summaries of roughly 30 pages for each part provide policy-makers with the means to make science-based deci-



TEMPERATURE

For the past 15 years, the surface temperature has remained at a high level. Such short-term phenomena are mainly due to natural and internal fluctuations within the climate system and have also been observed in the past. This does not mean that climate change has been mitigated, particularly in view of the fact that sea-level rise and the melting of ice continue unabated.



1,000 GIGATONNES

For the first time, the internationally recognized two-degree limit has been linked to a concrete threshold for greenhouse gas emissions: in order to stay below the two-degree limit with a probability of 66%, greenhouse gas emissions may not exceed the equivalent of approximately 1,000 gigatonnes of carbon. So far, just over half of that amount has already been released by human activities.

In North America and Europe, severe precipitation events have become more frequent and more intensive.



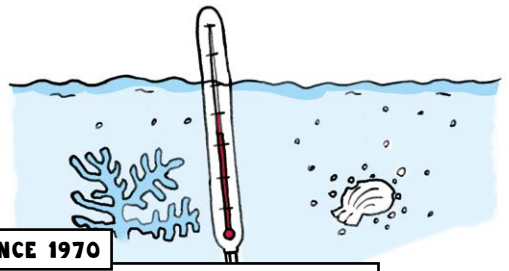
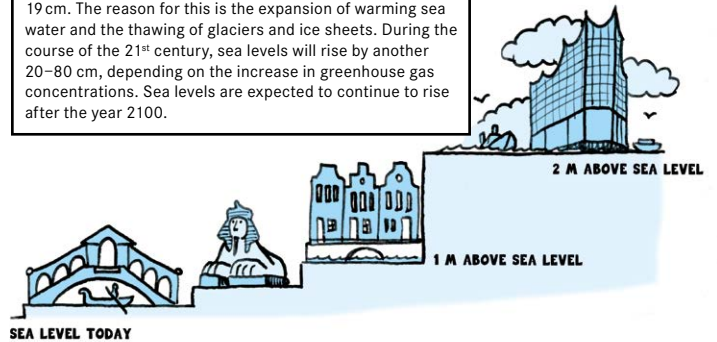
PRECIPITATION

Between 1951 and 2010, the amount of precipitation in the mid-latitudes of the northern hemisphere increased. Progressing global warming will amplify the difference between wet and dry regions.

The number of hot days and nights has risen on a global scale.

SEA LEVEL

Between 1901 and 2010, the mean global sea level rose by 19 cm. The reason for this is the expansion of warming sea water and the thawing of glaciers and ice sheets. During the course of the 21st century, sea levels will rise by another 20–80 cm, depending on the increase in greenhouse gas concentrations. Sea levels are expected to continue to rise after the year 2100.

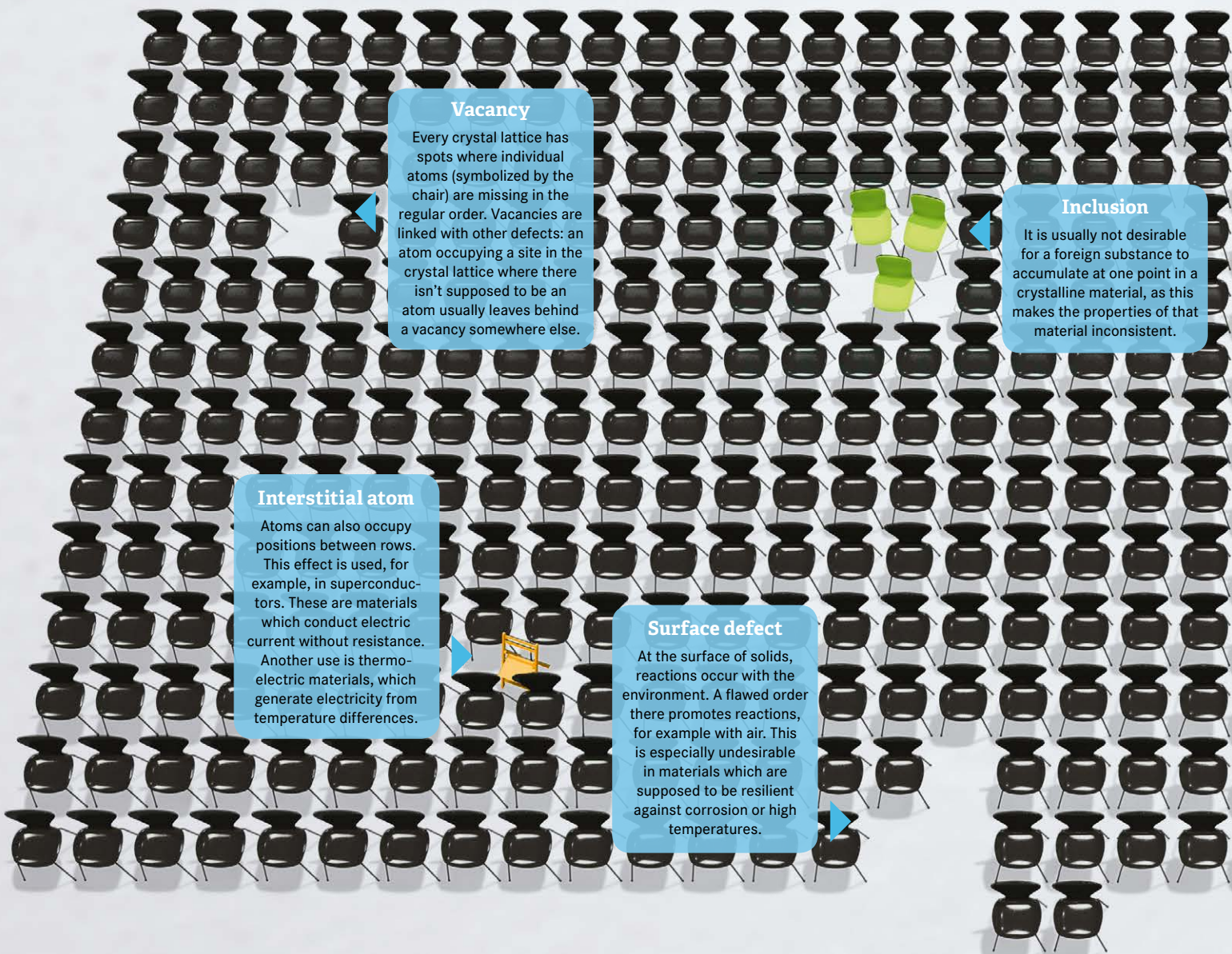


+0.3 °C SINCE 1970

The temperature of the world's oceans has risen considerably since approximately 1970. They have absorbed more than 90% of the energy that has remained within the Earth's system due to the additional greenhouse effect. The oceans also absorb a large part of the CO₂ emissions caused by humans. This has led to their water becoming more acidic.

sions. These summaries are approved sentence by sentence by government representatives and scientists during several days of negotiations. The statements contained in them must be comprehensive and understandable. The scientists have the right to veto formulations if they do not correspond to the content of the report. The government representatives must subsequently approve the summaries and the entire report, acknowledging the scientific content of the IPCC report.

All in good (dis)order



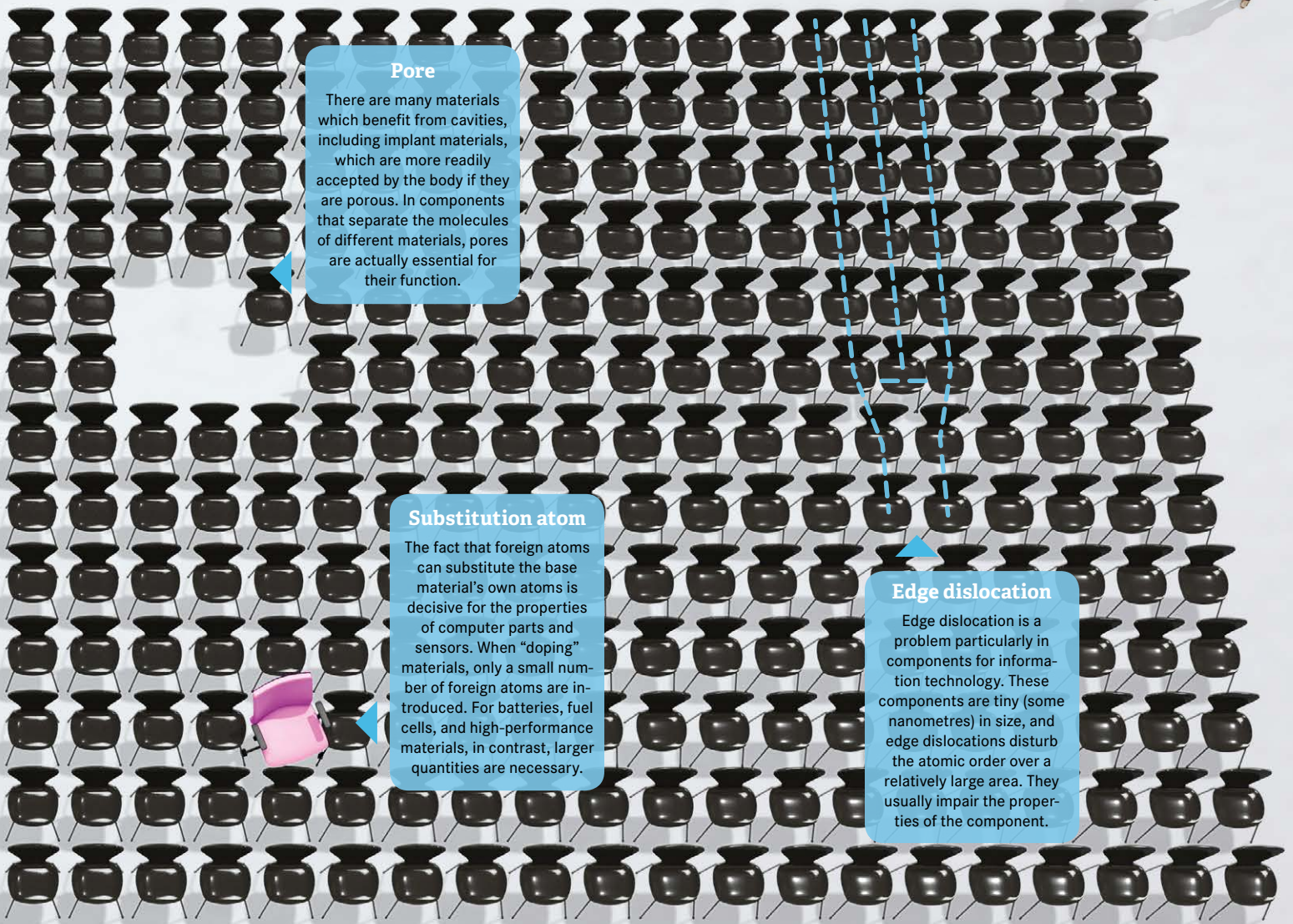
Jülich researchers work with defects

The fact that atoms in crystalline solids can be “disorderly” is important for the work of many Jülich researchers:

- At the Peter Grünberg Institute, the materials for the information technology of the future are investigated.
- At the Institute of Energy and Climate Research, the scientists are concerned with solids for batteries, fuel cells, solar cells, and power plants.
- Research units at the Institute for Advanced Simulation investigate and design materials with the aid of computer simulations.

Are there materials in which each and every atom occupies the right spot with absolute orderliness? No. A law of nature prevents this, making empty spots unavoidable.

But often, materials researchers don't even want to suppress vacancies and other defects – on the contrary. They even introduce defects on purpose in order to tailor the electronic and magnetic properties of materials to the needs of information technology, or to increase the mobility of charged particles in solid matter – which is important for more powerful batteries and other energy technologies.



Pore

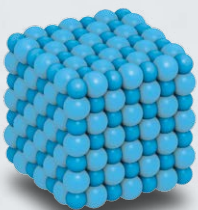
There are many materials which benefit from cavities, including implant materials, which are more readily accepted by the body if they are porous. In components that separate the molecules of different materials, pores are actually essential for their function.

Substitution atom

The fact that foreign atoms can substitute the base material's own atoms is decisive for the properties of computer parts and sensors. When "doping" materials, only a small number of foreign atoms are introduced. For batteries, fuel cells, and high-performance materials, in contrast, larger quantities are necessary.

Edge dislocation

Edge dislocation is a problem particularly in components for information technology. These components are tiny (some nanometres) in size, and edge dislocations disturb the atomic order over a relatively large area. They usually impair the properties of the component.



CRYSTAL LATTICE

If you cut right through the middle of a crystalline solid and look at it with a special microscope, you can see atoms – lined up like chairs in an assembly hall. But there is one difference: the chairs are placed on a surface, the floor, and there are none on top or underneath. The atoms, on the other hand, which you can see at the surface of the crystal, are only the topmost specimens in a stack of atoms. After all, the crystal is a three-dimensional – spatial – object.

Rush hour in the brain

**What do road traffic and our brain have in common?
More than you'd think, according to Jülich brain researchers.**



↑ Prof. Markus Diesmann, director at the Institute of Neuroscience and Medicine (INM-6) and the Institute for Advanced Simulation (IAS-6)



↑ Prof. Moritz Helias, group leader of the Helmholtz Young Investigators Group "Theory of multi-scale neuronal networks" at INM-6 and IAS-6



↑ Dr. Sacha van Albada, research scientist in Prof. Diesmann's working group

What goes on in our heads is similar to traffic on a highway: by way of numerous connections, information speeds back and forth between nerve cells. In order to gather data on road traffic, the authorities like to use traffic counters. This is exactly what brain researchers like Jülich neuroscientist and physicist Prof. Markus Diesmann need – but there aren't any for the brain. "We are learning more and more about the road network in the brain, but we are not yet sure how the traffic moves at each individual point, i.e. how the information flows," says Diesmann.

COMPUTERS CAPITULATE

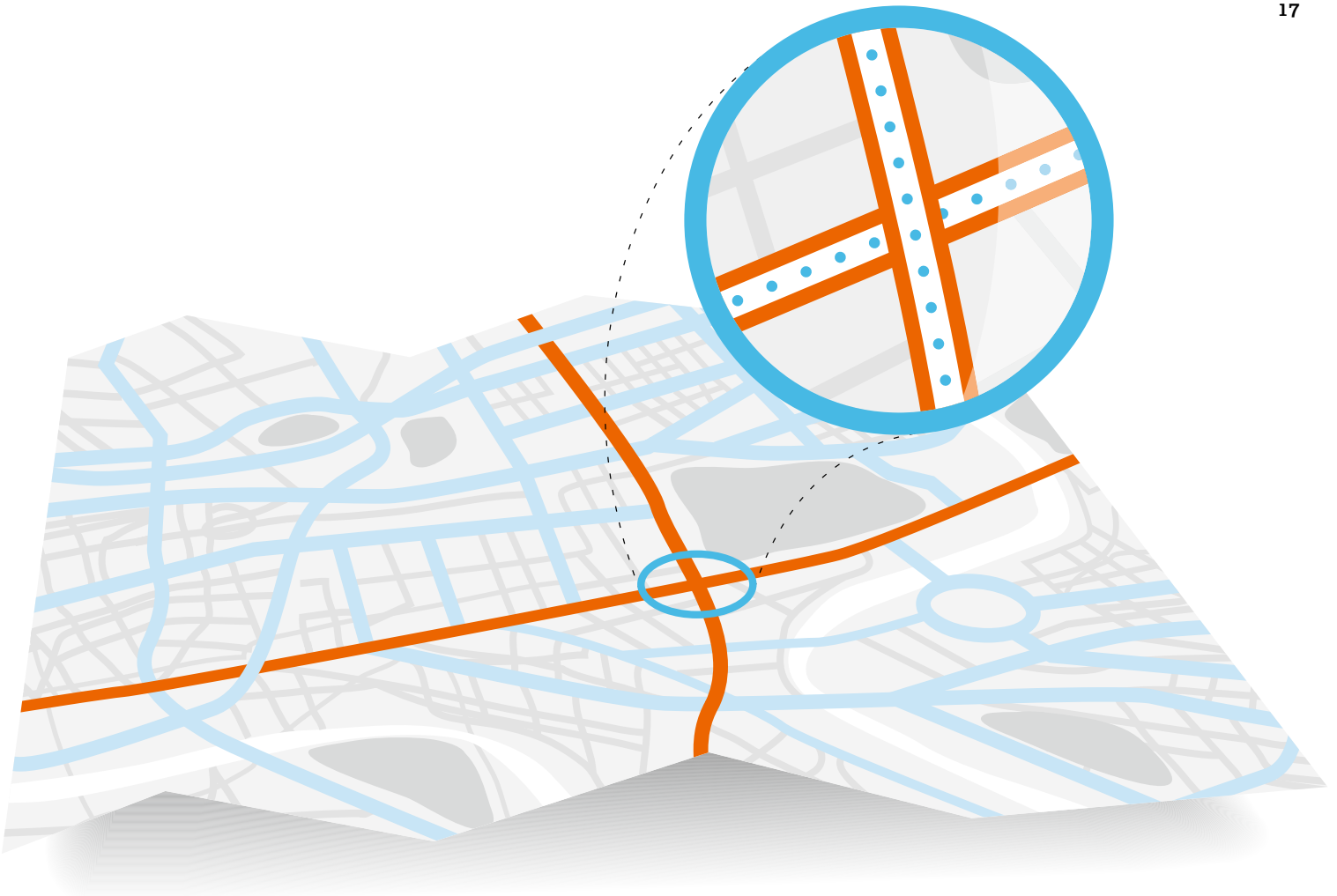
As a consequence, scientists try to help themselves by using computer simulations to better understand what goes on in our brain. But there's a catch: the network in our heads is unbelievably complex. Around 100 billion nerve cells in the brain ensure that we can think, read books, go jogging, laugh about jokes, and lots more. Each of these nerve cells possesses around 10,000 contact points, known as synapses. Through these, information is passed on to other nerve cells in the form of electric impulses. "But when trying to simulate such a gigantic network, even the most powerful computers in the world are brought to their knees," says Diesmann. Only about 1% of the brain's activities can currently actually be simulated.

So what do the researchers do to draw conclusions pertaining to the whole brain? They work with simplified networks, from which conclusions on the bigger picture can be drawn. In highway terms: they reduce the number of roads and junctions that they simulate. For one junction, i.e.

a nerve cell, this works quite well. But nerve cells work together, and the intensity at which they do so varies. "The interactions between as few as two neurons, known as a correlation, pushes our model to the limit," explains Dr. Sacha van Albada, one of the scientists in Markus Diesmann's team. "This means that we can, for example, predict that there will be a lot of traffic in Cologne, and less in Frankfurt – but when it comes down to checking whether there is traffic in Cologne when shortly beforehand there was traffic in Frankfurt, the reduced model is not reliable."

»We are learning more and more about the road network in the brain, but we are not yet sure how the traffic moves at each individual point.«

Nevertheless, reduced models are also useful. "Although mathematical theory demonstrates the limitations of current simulations," says physicist Prof. Moritz Helias, "we have succeeded in mathematically compensating these simulation discrepancies to a certain extent." The researchers recently published their results in the journal *PLOS Computational Biology*. The problem is that the complex formulas which describe the activity of



neurons require calculating with approximations. Approximations, however, permit uncertainties. Whether or not the calculated correction is absolutely precise can only be shown by a computer simulation of the entire brain. That, however, is still a vision of the future.

In order for this vision to become a reality, Prof. Diesmann and his team have adopted a two-pronged strategy: on the one hand, they have been working together with brain researchers from all over the globe on the simulation software NEST (see info box) for many years. On the other hand, they are collaborating with Jülich colleagues to design an exascale computer which is hoped to be 100 times more powerful than today's high-performance computers.

SIMULATING THE BRAIN

That's one of the aims of the Human Brain Project, a neuroresearch project within the scope of which Jülich is collaborating with more than 80 scientific institutions all over Europe. It is hoped that the exascale computer will go online in 2022. This is also an important date for Markus

Diesmann and his team: "By then, we need to have further developed our simulation methods so that they can run on supercomputers of the next generation," says Diesmann. The long-term objective is calculating traffic on the most complicated data highways in the world as precisely as possible.

ILSE TRAUTWEIN

100,000

nerve cells are contained in one cubic millimetre of the human brain – 100 billion in the entire organ.

NEST – the Neural Simulation Technology initiative

NEST is an initiative by software developers who have been developing brain simulation software for more than 20 years. The software is freely available on the Internet at www.nest-initiative.org. Anyone interested is invited to optimize the software. Since 2012, the NEST initiative has been classed as a non-profit organization with its headquarters in Switzerland.

Home improvement for the worse

Viruses are not classed as living beings. But that doesn't mean they're not "smart": if a host bacterium does not provide everything they need for their reproduction, viruses will produce the required components themselves. And they always have the relevant blueprints with them.



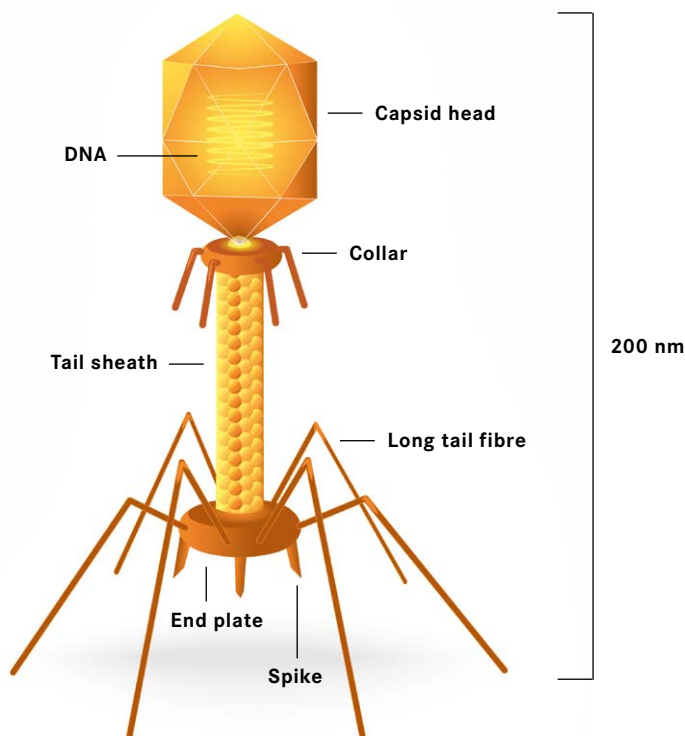
↑ **Prof. Julia Frunzke** is group leader of the Helmholtz Young Investigators Group "Population heterogeneity in industrial microorganisms" at Jülich's Institute of Bio- and Geosciences (IBG-1). She is also junior professor at the University of Düsseldorf.

Imagine that, during the night, someone breaks into your house unnoticed, modifies it as they choose, and once their offspring is old enough, they pull down all the walls. Sounds like a nightmare? For many bacteria, this is the bitter reality – one that costs them their life – because this is exactly what bacteriophages do to them. These viruses spurn both humans and animals, instead misusing bacteria to multiply on a massive scale. Once the new viruses are ready, they dissolve the outer wall of the bacterium. Between 10 and 100 viruses will come pouring out to look for new victims. For the bacterium, this typically means certain death.

In the process, bacteriophages prove themselves very skilful at home improvement, as scientists from Forschungszentrum Jülich and Ludwig-Maximilians-Universität München discovered: They carry with them the information required to make use of their host according to their needs. Often, the virus will exploit its host's cytoskeleton, which consists of filament-like cell structures designed to reinforce the bacterium.

The uninvited guests use the cytoskeleton to transport their DNA to the location at which the new viruses are assembled, for example. Some bacterial strains, however, don't have a cytoskeleton. Among them is *Corynebacterium glutamicum*, used by the Jülich and Munich scientists for their research. The viruses have a nifty solution for this problem: "They simply produce the filament structures themselves," reveals Jülich microbiologist and junior professor Julia Frunzke.

Bacteriophage



BLUEPRINTS AT THE READY

The blueprint for these structures is available at all times: it is stored in their genome. The way in which viruses organize their reproduction with the aid of the cytoskeleton has a long history. "It's even possible that bacteria originally acquired their own cytoskeleton from viruses. We can learn a lot about evolution here," Frunzke is confident. But there are still many unanswered questions. This is why the researchers, together with their Munich colleagues headed by Prof. Marc Bramkamp, now want to examine further phages. They want to understand in greater detail how a virus' DNA is transported within the bacterium, for example.

JANINE VAN ACKEREN

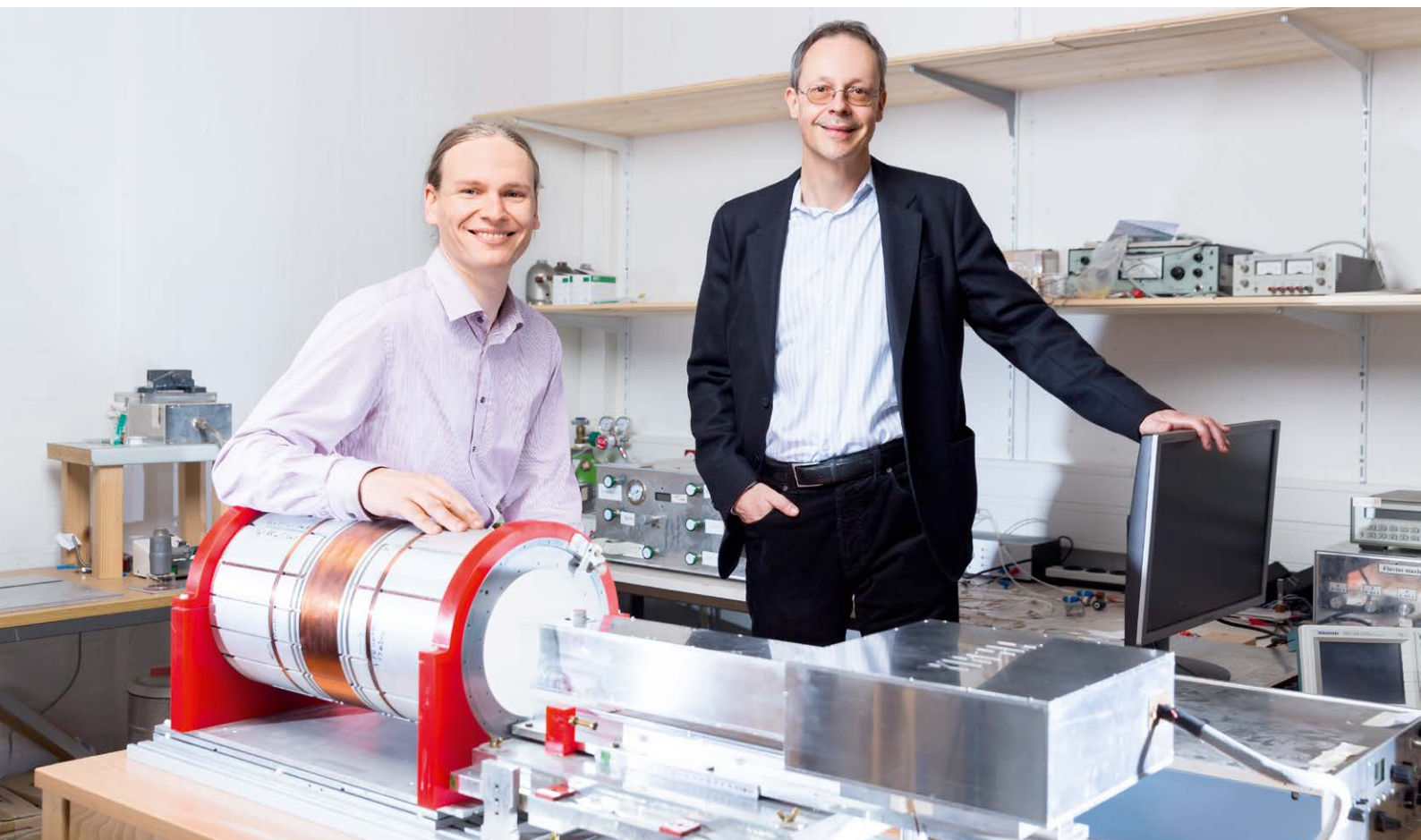


↑

What's your research all about, Dr. Rack?

Dr. Michael Rack is Jülich's 2015 Excellence Prize winner and postdoc at the Institute of Energy and Climate Research – Plasma Physics.

„Inside the Sun, atomic nuclei fuse, and this produces energy. In fusion reactors, we want to re-create this process on Earth. This can only succeed in what we call plasma, at temperatures above 100 million degrees Celsius. Since no material can withstand this heat for any extended period of time, we enclose the plasma in a magnetic field, which keeps it away from the reactor wall. I want to understand what processes take place between plasma, magnetic field, and wall. My objective is to increase the lifetime of reactors of the future.“



↑ Dipl.-Chem. Martin Sufke from the Institute of Energy and Climate Research (IEK-9) and Prof. Stephan Appelt from the Central Institute of Engineering, Electronics and Analytics (ZEA-2) (right) with "Mjölmir".

Measuring with Thor's hammer

It doesn't always have to be bigger and stronger: compact, mobile, and with astoundingly small magnetic fields, the prototype of a new magnetic resonance scanner analyses liquids and gases. It also raises hopes for many other applications.

It is cramped, and it hums and throbs. Many patients feel uncomfortable inside the tube of a magnetic resonance imaging scanner, MRI scanner for short. The humming noise is due to the very strong magnetic fields generated by

the narrow tube, which is basically a huge coil. Interactions between various magnetic fields and radio waves within the tube permit the examination of tissue, inner organs, or the brain. The same principle is also applied in nuclear magnetic resonance spectroscopy (NMR spectroscopy). Researchers make use of it to chemically and physically analyse atoms and molecules, as well as liquids and solids.

SMALL, MOBILE, AND CHEAP

But these devices are extremely large and their technology is expensive and complex. For example, the coil of an MRI scanner has to be cooled down to temperatures just above absolute zero, -273 °C. However, there may be an alternative

quite soon: Jülich researcher Prof. Stephan Appelt and his PhD student Martin Sufke, together with colleagues from Aachen headed by Prof. Bernhard Blümich, have found a way to achieve comparable results using considerably weaker magnetic fields – scientists call this low-field NMR. “For our new low-field NMR, we don’t need large and expensive coils. The device is accordingly smaller – and thus also suitable for mobile applications,” explains Appelt. The prototype is about the size of a guitar and looks like a chunky hammer. “That’s why we christened it Mjölner, after the hammer of the Nordic god of thunder, Thor,” says Sufke.

100

times stronger than
comparable methods:
Mjölner’s measurement signal.

In the past, there was one basic problem with low-field NMR: the signal was lost in the noise – just like a radio whose antenna is too weak. One decisive improvement made by the researchers changed this: “To put it crudely, we made two out of one,” says Appelt. “In conventional NMR devices, the signal from the sample is detected by a coil close to the sample, and simultaneously amplified there. We separated this spatially: a coil in close proximity to the sample detects the signal, and a resonator located far away from the sample amplifies it. This means that the measurement signal is amplified considerably more than the noise, and the entire measurement becomes more sensitive,” says Appelt. During the first experiments, the researchers achieved a hundredfold amplification of the signal compared to previous measurements with low-field NMR methods. “We have calculated that further improvements by another factor of 100 should be possible,” says Appelt. This calculation was performed with a mathematical model that the scientists developed for the new setup.

NEW OPPORTUNITIES

The model helps to calculate how detection coil and resonator must be adjusted to each other in order to generate an optimal signal for various

The principle behind nuclear magnetic resonance (NMR)

Certain atomic nuclei, such as those of hydrogen, have a special property, nuclear spin, which can be imagined as a little bar magnet. In a magnetic field, these nuclear spins align themselves like tiny compass needles. When they are irradiated with the right radio waves, the atomic nuclei send out a signal. This signal depends on the chemical surroundings and therefore permits conclusions to be drawn on the atomic structure of molecules. In MRI scanners in medicine, for example, the effect is used to make inner organs visible.

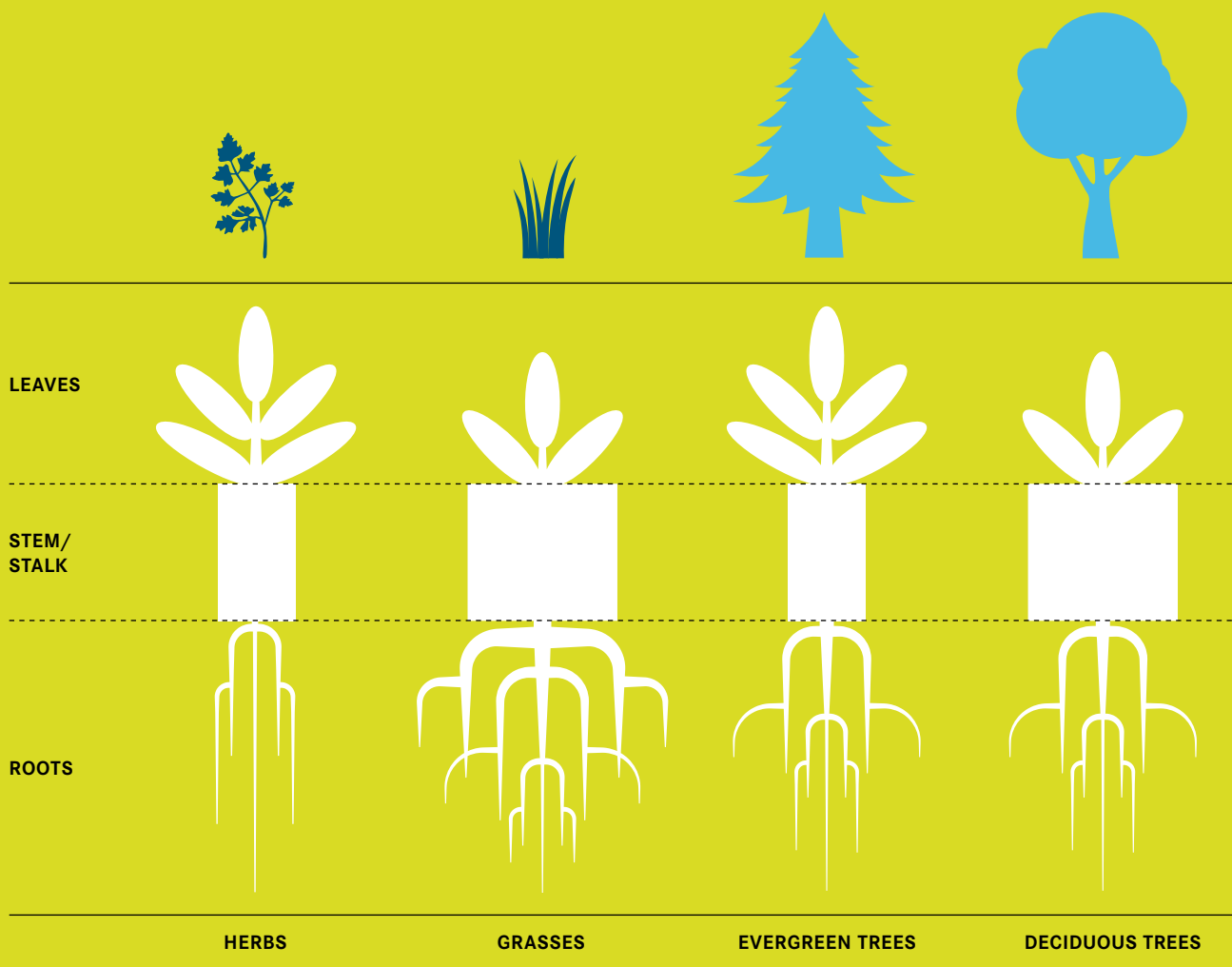


samples. “This means that we can simulate what an appropriate low-field NMR device must look like to handle current NMR applications. And completely new possibilities arise: we can measure large sample volumes for which larger detection coils are needed, but also smaller sample quantities in micro-coils,” explains Appelt. “With our model, we then calculate what the resonator must look like in order to obtain a good signal.”

If it is inserted into a drill bit during drilling operations, for example, the technology could be used to directly check the quality of the oil in the borehole. It could even be integrated into a chip. With mobile NMR spectrometers, health parameters may be monitored in the future, or chemical processes in production controlled. It is also conceivable that the technology will be further developed into an MRI scanner.

“First, we will concentrate on using low-field NMR technology in energy research,” says Martin Sufke. An example of this are investigations on lithium-ion batteries. NMR technology with strong magnetic fields is only suitable for this to a limited extent. This is due to the conductive components of these batteries: they weaken and falsify the high-frequency radio waves necessary for strong magnetic fields. “With low magnetic fields, this is much less problematic. That’s why, in the future, we may be able to gain insights into the electrochemical reactions inside mobile phone or notebook batteries,” hopes Sufke.

JENS KUBE



The basis: 11,000 data sets from 1,200 plant species from 5 continents; weight of the plants examined: 1 mg–14,000 kg. The white graphical elements represent the relative proportion of leaves, stem/stalk, and roots in comparison to the entire biomass.

Massive difference

Although plants look very different from each other, they all consist of leaves, a stem or stalk, and roots. Together, these constitute a plant's biomass. But how is the biomass distributed over the various parts of the plant?

Researchers used to think that there is a generally applicable correlation between two plants of roughly the same weight. This means that two different kinds of delicate plant such as a grass or a herb are supposed to contain similar amounts of biomass in stem or stalk, and also develop similar quantities of roots and leaves. The same should apply to different types of trees, if they have a similar biomass. But is this really the case?

Jülich biologist Dr. Hendrik Poorter wanted to find this out. Together with colleagues from five continents, he compared data from plants from all over the world. It turned out that plants with similar biomass distribute it differently over the three categories. Herbs, for example, have more leaves and stalks than grasses – these invest more in their root mass. “In grasses, this may be down to their growth. Grass is more often eaten by animals. The large amount of roots may enable grasses to store carbohydrates more easily and thus regrow faster,” speculates Poorter. There are also big differences among trees: “They are particularly interesting,” says Poorter. “Their biomass distribution also changes with increasing

growth.” Once they are fully grown, the leaves of evergreen trees represent a much larger proportion of their biomass than those of deciduous trees.

With their insights, the researchers want to make climate models more precise. Plants are increasingly considered in these because they absorb carbon from carbon dioxide and influence the water balance in the atmosphere. “We can now better assess how biomass is distributed over leaves, stems, and roots, and therefore better illustrate the diversity of forested and green areas,” says Poorter.

BARBARA SCHUNK

Learning from mistakes

No one likes making mistakes. But it's not that rare that failed experiments turn out to be a great success for science. A cell sample stained too strongly led to a new technique for measuring the oscillations of biomembranes.

“Science only ever publishes experiments that work. But we learn more from those that don't work,” says Jülich biophysicist Prof. Rudolf Merkel. This was an experience he made as a young scientist: during his doctoral work, it was unclear for a long time whether the device he was constructing would ever work. It was the values of a calibration, which seemed odd to him, that got him on the right track.

“Ever since then, I always analyse inconsistencies intensively,” explains Merkel. He sometimes drives his students to the brink of insanity with this, but his success proves him right: for example in the case of his former PhD student Cornelia Monzel. Initially, she wanted to measure the diffusion of molecules through cell membranes. For this purpose, she introduced dye-labelled molecules. Under a fluorescence microscope, she was thus able to observe the glowing molecules on their journey. What's important here is that the measurement only works with small amounts of dye – which Monzel and Merkel accidentally ignored. Individual molecules could no longer be observed, but instead, the entire membrane glowed – sometimes brighter, sometimes darker.

“We shouldn't have been getting any more fluctuating signals,” explains Merkel. The researchers initially took this for a measuring error. But Merkel did not let up and discussed the observation with his colleague. In the end, they agreed: the fluctuations must stem from the membrane moving up and down. According to Merkel, “If you statistically analyse the differences in brightness, you can calculate how much the membrane moves.”



↑ **When something goes wrong, Prof. Rudolf Merkel from the Institute of Complex Systems (ICS-7) gets really excited.**

Cornelia Monzel verified their theory using model membranes. Everything fitted together: the moving molecules cannot be detected when large amounts of dye are used, but the movement of the biomembrane can be measured at every point – quantitatively very precisely, and even in the smallest of samples. Compared to conventional methods, the technique also has a better temporal resolution: this measuring technique yields an image every ten microseconds instead of the usual ten milliseconds.

Merkel and Monzel have since successfully applied the technique to measure the cell membrane movement of white blood cells, the “health police” in the body – which is a first. “We were able to quantitatively prove that the membrane fluctuates more strongly if it is stimulated with the immune system's “messenger” interferon gamma,” says Merkel. The health police are, so to speak, alerted. It is hoped that, in the long term, every illness or mutation will be attributed a certain fluctuation: “We now have a tool with which we can observe subtle differences. This may help us to better understand the role of membrane movement in illnesses.”

Staying clean

Living cells have an elaborate system which disposes of and recycles waste. Understanding it may hold the key to curing numerous illnesses – and maybe even to slowing down ageing. Jülich structural biologists are tracking down its principles.

Each and every cell in our body resembles a biochemical factory where new biological molecules are constantly produced. However, a lot of waste is also generated in the process: deformed, clumped, or surplus proteins, defective mitochondria, metabolic products, and much more. If this waste is not removed, it can hamper metabolism and thus cause a lot of damage.

The process that keeps cells clean and even recycles the waste is called autophagy. Literally, this means something like “self-digestion”. As early as the 1960s, researchers found the first traces of this sophisticated recycling system: they discovered that inside cells, membrane vesicles are formed time and time again, and that they envelop parts of the cell and then fuse with what are called lysosomes. Lysosomes are membrane-bound pockets containing enzymes which decompose the entire contents into recyclable constituents.

RECYCLING IN A GARBAGE BAG

“Autophagy processes are present in similar forms in almost all living organisms, ranging from simple yeasts to human beings,” says Prof. Dieter Willbold, director at Jülich’s Institute of Complex Systems (ICS-6). In addition to garbage disposal, autophagy also helps cells survive starvation periods. If not enough nutrients are available, the recycling activity is boosted, and everything that is not necessary for survival is used for ongoing operation. “Behind this is a fascinating and very complex system which we are still learning to understand,” stresses the scientist. The tiny proteins on which it relies are currently being investigated by two working groups at his institute, headed by Dr. Melanie Schwarten and Dr. Oliver Weiergräber.

Worldwide, more and more researchers have discovered the topic because it has become apparent that autophagy plays an important role in a multitude of illnesses. Cells which practise autophagy are less susceptible to the most well-known type of cell death, apoptosis. In rare cases, this can cause problems, for example in cancer treatment: in tumour cells, autophagy often runs at full speed. This seems to make some of them resistant against chemotherapy and radiotherapy. Cancer researchers are therefore looking for ways to suppress the recycling system in these cells. In contrast, autophagy has been identified as an important defence mechanism against viruses and



↑ Prof. Dieter Willbold is director at the Institute of Complex Systems – Structural Biochemistry (ICS-6).



↑ Dr. Melanie Schwarten is head of the research unit “Autophagy and Viruses”.



↑ Dr. Oliver Weiergräber is head of the research unit “Structural biology of cellular autophagy”.

bacteria. If these intruders overcome the outer defence lines of the immune system and make it into the cell, the recycling system can elegantly rid itself of them. Many viruses have therefore developed strategies to stop autophagy or even to use it for their own reproduction.

“If it were possible to control autophagy in a targeted manner, for example by boosting it at the right time, or suppressing it, or modifying its target structures in the cells, this could have enormous therapeutic value,” says Willbold.

This is why researchers are compiling information piece by piece in order to understand the exact molecular processes. However, the task resembles a jigsaw puzzle where initially not even the shape of the pieces is known. So far, more than 30 autophagy-associated proteins, ATG proteins for short, have successfully been identified. Some of them belong to the core machinery of autophagy while others have regulatory functions. But often, the exact structures of the complex, mostly only nanometre-sized molecules are not yet known and have to be determined by means of elaborate techniques such as X-ray crystallography or NMR spectroscopy.

THE VIRUSES' TRICKS

Among the latest breakthroughs by Jülich researchers is the three-dimensional structure of the protein ATG101. It belongs to a complex which initiates the formation of membrane vesicles. If this protein is missing from the cells, autophagy is greatly reduced. A further study by the researchers is concerned with the defence function against viruses. “Pathogens such as the HI virus, for example, are able to evade the autophagy system,” says Willbold. The scientists observed how one of the virus proteins interacts with various autophagy proteins to avoid being disposed of in the enzyme bath and instead be transported out of the cell. The role this plays in the infection process is currently being investigated intensively.

Autophagy also seems to play an important role in ageing. When the recycling system weakens during later life, defective components and deformed proteins are no longer removed efficiently. A simple method may hold the key to solving this: “Tests with lab rats have shown that the animals live significantly longer if they have regular phases of fasting,” explains Willbold. Nutrient deficiency caused by hunger boosts the autophagy-based recycling system. Some researchers think that, when cells “fast”, they

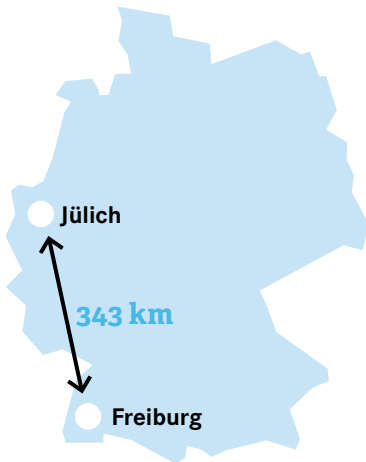
renew their components more frequently – a kind of life-prolonging self-cleaning effect. According to Willbold, the underlying mechanisms must be further investigated to better evaluate this exciting theory.

PETER ZEKERT



Chosen siblings from Freiburg

Scientists working at the Bernstein Network use computer models to investigate how the brain thinks. They are coordinated from Freiburg. Some weeks ago, the institution there became a branch office of Forschungszentrum Jülich.



Jülich's campus measures 2.2 km². But Jülich scientists are active beyond the campus. This section features brief reports on where they work. This time around, Freiburg is in the limelight.

The Bernstein centres

6 LOCATIONS

Berlin, Freiburg, Göttingen, Heidelberg-Mannheim, Munich, Tübingen

23 INDUSTRIAL PARTNERS

A list of all industrial partners is available at www.bit.ly/1K6c8CT

€ 180 MILLION

BMBF funding 2004–2015

At some point, it is time to leave the parental home and find a new place in life. For the partners from the National Bernstein Network Computational Neuroscience, this point in time has arrived: funding from the German Federal Ministry of Education and Research (BMBF) with which the network had been built up since 2004 is now coming to its planned end.

Some members of the Bernstein family, which has grown to six centres and more than 200 research groups in the past ten years, are already well accommodated: the centres were all taken over by the universities with which they were affiliated. The research – among other things, the scientists are developing mathematical models to better understand the functions of the brain – will continue uninterrupted.

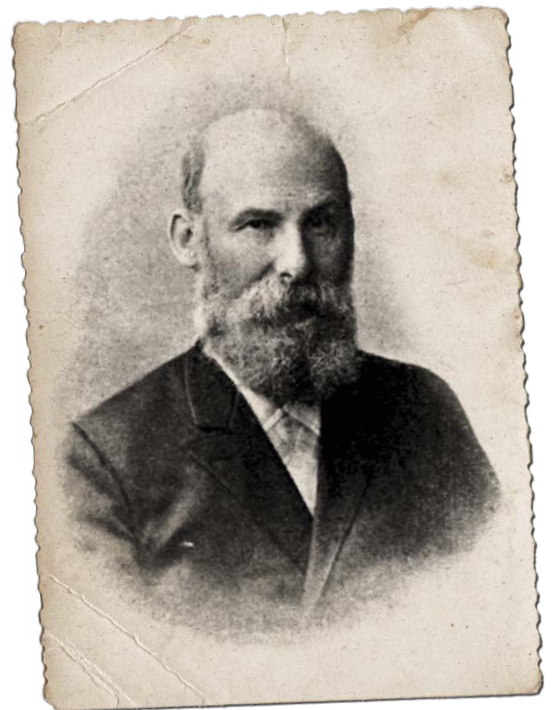
The Bernstein Coordination Site in Freiburg has also found its new home: it now “lives” with a close relative, as it were, Forschungszentrum Jülich. This autumn, it became a Jülich branch office as part of the Institute of Neuroscience and Medicine – Computational and Systems Neuroscience (INM-6). The Bernstein Facility for Simulation and Database Technology is already at home at Jülich. It assists scientists in using supercomputers for their research.

“The affiliation with Jülich corresponds to the Helmholtz Association’s mission of taking care of long-term scientific infrastructures which universities can’t provide,” says Prof. Markus Diesmann, head of INM-6. Nothing will change in the work of the Coordination Site: still located in Freiburg,

2.2
plus

it will continue to ensure smooth communication between the members and other organizations, as well as media and industry, and help to organize conferences and attract young scientists.

FRANK FRICK



↑ The Bernstein Network is named after physiologist Julius Bernstein (1839–1917).



THUMBS UP

IG NOBEL PRIZE

The world's maddest accolade

Does an elephant urinate faster than a cat? Can a boiled egg go back to being runny? On what part of the body is a bee sting most painful? The research that received the Ig Nobel Prize at the end of September is bizarre – and not only at first sight. The satiric magazine *Annals of Improbable Research* honours scientific “achievements that make people laugh, and then think” with its Ig Nobel Prize. The humorous award ceremony takes place at the venerable Harvard University in Cambridge (USA) and has long been an iconic event in science. The winners receive a flower pot and a not really valuable 10-trillion-dollar bill from Zimbabwe – from the hands of real Nobel Laureates. Afterwards, they have 60 seconds to present themselves and their research. The audience thus learnt that elephants and cats both take around 21 seconds to pass water.

– WWW.IMPROB.COM/IG/ –

BIOTECHNOLOGY

Aachen students achieve gold

A team of students from RWTH Aachen University made first place at the iGEM international synthetic biology competition in Boston (USA) and thus repeated the previous year's success. With their innovative and bio-economically relevant approach to converting methanol so that it can be used as a carbon source for biotechnological processes, the team of 15 won in the category Best Manufacturing Project, Overgrad. The budding biotechnologists and engineers were mentored at Aachen and at Jülich's Institute of Bio- and Geosciences (IBG-1). This is the eleventh year of the iGEM competition (short for International Genetically Engineered Machine Competition), which is viewed as the core of the synthetic biology movement.

– WWW.IGEM.RWTH-AACHEN.DE –



LUNAR ECLIPSE

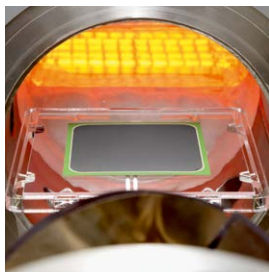
Rare event pictured

René Borowski from Jülich's Peter Grünberg Institute got up very early on the morning of 28 September to observe the total lunar eclipse above Jülich. With a telescope, the amateur astronomer watched how the moon slowly moved into the Earth's shadow and released the shutter at exactly 05:10. The result is this impressive photo. The shade of red that the moon takes on during an eclipse is of particular interest to astronomers and meteorologists: the Earth's atmosphere diffracts the red-wavelength light from the sun into the Earth's umbra. The more dust and aerosols are present in the atmosphere, the darker the red becomes.

This eclipse was surprisingly dark – meteorologists suspect the eruption of the Chilean volcano Calbuco in April as a likely cause.

RESEARCH IN A TWEET

None runs longer! For 70,000 hours, I have been generating electricity from hydrogen. That's a world record!
#fuel cell



The Jülich solid oxide fuel cell (SOFC)

is a joint project between five Jülich research fields. After eight years of continuous operation, the record-breaking stack has demonstrated that the materials remain stable in the long term. SOFCs can be used to supply energy in private households, for example.

www.fz-juelich.de/sofcs