LICHTGEDANKEN

The Research Magazine

12

WATER CLUSTER FINDING A CLEAN SOLUTION

PORTRAIT THE VOICE OF THE VICTIMS OF STALINISM

SURVEY WHAT CAN—OR CAN'T—WE DO WITHOUT?

FRIEDRICH-SCHILLER-
UNIVERSITÄT
JENA

THE ELIXIR OF LIFE

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Photo: Anne Günther

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We're running out of water

Do you know your water footprint? By that I mean the amount of water you consume on a daily basis. Each and every person in Germany uses over 5,000 litres of water every day. In addition to the 126 litres of water we use for drinking, cooking, washing and showering, most of our consumption can be traced back to the »virtual water« involved in the production and transportation of food and consumer goods. On average, 140 litres of water are needed for a cup of coffee, and around 4,000 litres of water go into producing a cotton T-shirt.

Just like the air we breathe, we need water to live. That's why the feature of this issue of LICHTGEDANKEN has been given the title »The Elixir of Life«. But the precious resource is limited. When it comes to the way we deal with water, environmental chemist Prof. Michael Stelter sees an urgent need for »transformation on a social and economic level« to counteract the looming shortages brought about by climate change and increasing pollution. Prof. Stelter is a spokesperson for the new »Thuringian Water Innovation Cluster« (»ThWIC«). This interdisciplinary network of science and business started its work in Jena earlier this month with the aim of developing innovative water technologies and establishing new ways for society to deal with water. In our LICHTGEDANKEN interview (p. 16), Prof. Stelter assesses the current situation and explains why Jena is already a water hub.

In our feature, we present some of the topics emerging from the new cluster and also shed light on other water-related projects involving researchers from our university. For example, the Chairman of the Thuringian Climate Council, hydrogeologist Prof. Kai Uwe Totsche, discusses the effects of climate change on groundwater (p. 28), and we present a research project that is using water as a raw material to produce »green« hydrogen (p. 32).

In view of the energy crisis accelerated by the war in Ukraine, awareness of the finite nature of resources is also shaping the research and teaching at our university. We have conducted a survey (p. 40) to find out what our researchers are currently doing without—and also what they consider essential.

The aftermath of the war in Ukraine is the focus of our interview with the Russian historian Irina Shcherbakova (p. 38). The co-founder of »Memorial«, the human rights organization that won the Nobel Peace Prize in 2022, is currently working as a visiting professor at our university. The portrait introduces her (p. 36).

I hope you enjoy reading our magazine and always welcome any feedback, comments or criticism you may have. You can contact the editorial team and me at presse@uni-jena.de.

Jena, March 2023

PHOTO: JAN-PETER KASPER

FEATURE

The Elixir of Life

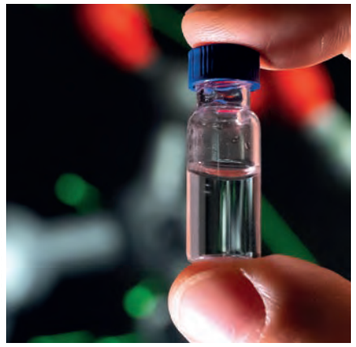

PHOTO: JENS MEYER

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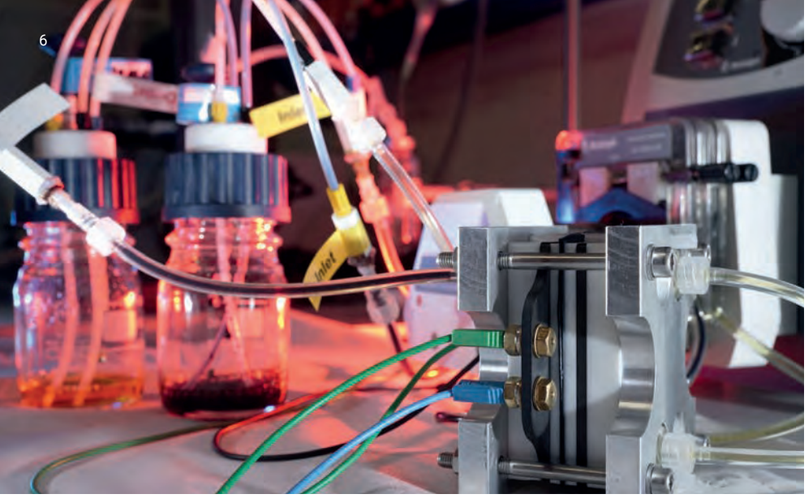


A redox flow battery prototype developed by Prof. Schubert and his team. · Photo: Jan-Peter Kasper

ERC Advanced Grant

Project for the development of sustainable energy storage solutions has been granted funding

The energy transition can only be successful if the electricity produced in an ecological way is available at all times—day and night. For this purpose, appropriate solutions must be developed that can store the energy generated in different quantities and release it again when required. This »battery of the future« is exactly what Prof. Ulrich S. Schubert and his team are working on. His new research project, »FutureBAT«, was recently awarded an Advanced Grant by the European Research Council (ERC). The chemist and materials scientist will receive around 2.5 million euros in funding over the next five years, which will be invested in eight new research positions and two jobs for technical staff.

Motivation for future-oriented research

»The ERC Advanced Grant is yet another sign that our research is on the right track—we want to create sustainable energy storage solutions that will save resources in the world of tomorrow,« says Prof. Schubert. Prof. Schubert's research is based on redox flow batteries. »These are the only type of batteries where performance and capacity can intrinsically be varied independently, making them perfect for scalable stationary applications,« he explains. The innovation made by the researchers from the University of Jena revolves around the fact that the new batteries are based on watery electrolytes and work with organic macromolecules (polymers). These battery systems enable the use of inexpensive dialysis membranes together with pH-neutral saline solutions as electrolytes. The systems work—the laboratory tests have proven that. However, they still have significant limitations in terms of their capacity, service life and temperature stability. The aim of the new »FutureBAT« project is to reduce these limitations. Specifically, the team is looking to improve the energy density, temperature range, efficiency and service life of the batteries while making them more sustainable and affordable. AB

Center for the Transformation of Chemistry

Prof. Ulrich S. Schubert supports new large-scale research centre

In the autumn of 2022, the new »Center for the Transformation of Chemistry« (CTC) emerged as one of the winners of the »Science Creating Prospects for the Region!« competition run by the Federal Ministry of Education and Research (BMBF), the Free State of Saxony and the State of Saxony-Anhalt. On the back of this award, the centre began its work in Delitzsch at the start of 2023. Prof. Ulrich S. Schubert (pictured) is a core member of the CTC team. »We see it as a task and challenge for the future to make chemistry more sustainable,« he emphasizes. At a time marked by the energy crisis and climate change, he sees an urgent need for change in terms of raw materials and production processes. Instead of gas and oil, waste products from nature should be used as basic chemicals. Carbon dioxide should no longer be emitted, but instead used as a raw material. sh

Ulrich S. Schubert is a chemist and materials scientist at the University of Jena. · Photo: Jens Meyer

Leibniz Prizes for two researchers from Jena

The most valuable research grant in Germany has been awarded to Prof. Hartmut Rosa and Prof. Sarah Ellen O'Connor

The world is locked in the jaws of an economic and environmental crisis. Economic growth as we know it is no longer possible without further aggravating its catastrophic effects on the environment. Conversely, climate protection and the conservation of natural resources require a departure from established business practices and transportation methods. Prof. Hartmut Rosa is investigating what the society of the future could look like under these conditions, in harmony with people, and how best to get there. The sociologist from the University of Jena has been granted 2.5 million euros from the German Research Foundation (DFG) to fund his project over the next seven years. Prof. Rosa is one of ten researchers to receive the Gottfried Wilhelm Leibniz Prize in 2023.
»I'm delighted and honoured to receive the award,« says Hartmut Rosa. »I see it as recognition of the good work that has been done in recent years by all my staff and colleagues in the Theory department and the entire Institute of Sociology at the University of Jena, but also at the Max Weber Centre at the University of Erfurt. With the help of the funding, I want to do everything I can to ensure a brighter future for humanity«.

On social acceleration, resonance and property

Hartmut Rosa has been working as a Professor of General and Theoretical Sociology at the Friedrich Schiller University Jena since 2005 and has also been the Director of the Max Weber Centre at the University of Erfurt since 2013. He also acts as a spokesperson for the DFG Collaborative Research Centre TRR 294 »Structural Change of Property«, which brings together the social science research conducted at both institutions and expands it to other disciplines. Hartmut Rosa highlights some of the current research topics: »It's not just about the distribution of income and wealth, but a variety of issues such as ownership of data, gene sequences, global resources—even the wind and raw materials on the moon—and the question of who a city belongs to or whether bodily organs can be owned«.
The research and publications of the 57-year-old scientist, in particular on the social acceleration and dynamic stabilization of modern societies and on a sociology of our relationship to the world—i.e. the concept of resonance—have been translated into numerous languages. His views have garnered international attention both in scientific circles and in much wider interdisciplinary and public spheres. His concepts and theories have themselves become the subject of academic discourse.

Hartmut Rosa is a sociologist who conducts research at the University of Jena and the University of Erfurt. · Photo: Anne Günther

Decoding the synthesis of complex natural products

The second Leibniz Prize 2023 winner from the University of Jena is the chemist and biologist Prof. Sarah Ellen O'Connor, who is the Director of the Max Planck Institute for Chemical Ecology in Jena and is also an Honorary Professor of Biosynthesis at the University of Jena. Prof. O'Connor is researching biosynthesis pathways in plants. She is using gene functions and enzyme mechanisms, as well as molecular genetics and genomics, to decode the synthesis of complex natural products such as anti-cancer and neuroactive substances. Her research group recently succeeded in completely unlocking the biosynthesis pathway of strychnine, which other teams had been trying to do for years. AB

Prof. Sarah Ellen O'Connor is a chemist and biologist. · Photo: Sebastian Reuter

Research Spokesperson of the Year 2022

PHOTO: JENS MEYER

Katja Bär (pictured), Head of Communications and Marketing at the University of Jena, has been voted »Research Spokesperson of the Year 2022« in the category of »Research Institutes and Universities«. The award was presented by three communications associations: BdKom (German Association of Communicators), DPRG (German Public Relations Association) and GPRA (Association of Leading PR and Communications Agencies). Their aim is to recognize exemplary science communication in all scientific disciplines. AB

University Manager 2022

University President Walter Rosenthal honoured by weekly newspaper »Die Zeit« and Centre for Higher Education (CHE)

Prof. Walter Rosenthal has been crowned »University Manager of the Year 2022«. In the eyes of the jury, he has played a significant role in putting the Friedrich Schiller University Jena in a very strong position: »Walter Rosenthal has put the University of Jena on the map«.

Sustainability from top to bottom

The jury placed special emphasis on Rosenthal's achievements in the strategic strengthening of the university's profile lines (»Light, Life, Liberty«), the introduction of faculty advisory boards, and the university's strategic realignment. »Rosenthal has involved all members of the university in this transformation process. He has also been highly assertive and willing to make decisions,« said the jury. The President has also pushed ahead with the structural development of the university and made sustainability a top priority. He has set up a »Green Office«, which acts as the coordination centre for the university's sustainability strategy. Above all, he is a source of ideas and has developed networks to advance projects and ensure their long-term success. KB

PHOTO: JENS MEYER

PHOTO: JENS MEYER

Victory in the Science Battle

In the picture on the left (from left to right), Anne Dünger (presenter), Felix Wechsler (Physics and Computer Science), Paulina Fuentes Zacarias (Medicine), Dr Jürgen Kaufman (Psychology), Dr Katrin Fröhlich (Microbiology), Rachael Akinyede (Geomicrobiology), Prof. Matthias Perkams (Philosophy) and Jack Pop (presenter) celebrate winning the second round of the European Campus of City Universities (EC2U) Science Battle on 30 September 2022. Jena's team came out on top against researchers from Coimbra (Portugal), Iaşi (Romania) and Salamanca (Spain) and will now be competing in this year's final against the team from Pavia (Italy), which won the first round in 2021. US

A historical sheet in the Herbarium Haussknecht library. · Photo: Jan-Peter Kasper

Jena welcomes new Senckenberg Institute

Herbarium Haussknecht will be part of the Collectomics module in the new Senckenberg research project

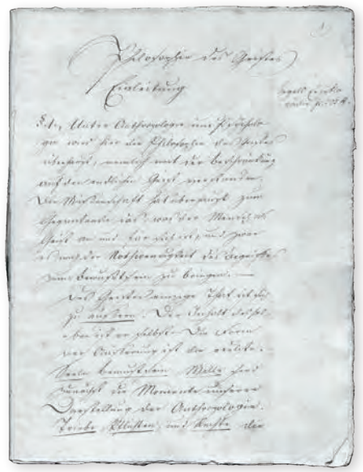
The Joint Science Conference (GWK) has approved the »Anthropocene Biodiversity Loss« expansion project envisaged by the Senckenberg Society for Nature Research. As part of this cooperative project with the University of Jena, a new Senckenberg Institute will be established in Jena. This will involve the long-term preservation and use of the Herbarium Haussknecht—one of the most important herbaria in Europe with around 3.5 million plant specimens. Two new professorships will be established, which will further enhance the German Centre for Integrative Biodiversity Research (iDiv) and Jena's appeal as a research location. Jördens

Philosophy of the mind

Jena philosopher Klaus Vieweg has discovered lecture notes written by one of Hegel's students

A set of lecture notes found in the library of the Archdiocese of Munich and Freising opens up new approaches to the thinking of the philosopher Georg Wilhelm Friedrich Hegel (1770—1831). Hegel's biographer and researcher, Prof. Klaus Vieweg from the University of Jena, was browsing the library collections when he stumbled upon five archive boxes with notebooks and papers containing lots of intricate scribbles, which had escaped the inquisitive eyes of research for almost 200 years. The lecture notes, comprising around 4,000 pages, were written by Friedrich Wilhelm Carové (1789—1852), one of Hegel's first students at Heidelberg University. The Catholic writer, journalist and politician was one of the leading intellectuals of his time.

The manuscripts cover almost all aspects of Hegel's encyclopaedic architectonics, including a long-sought set of notes from an Aesthetics lecture in Heidelberg—there are no other records of that lecture to date. They are now being prepared for print as part of a scientific project that will take place over the next few years. Hinterberger



The first page of Friedrich Wilhelm Carové's lecture notes on the teachings of Georg Wilhelm Friedrich Hegel. · Photo: Archive and library of the Archdiocese of Munich and Freising

Water droplets on a smooth surface. · Photo: Jens Meyer

FEATURE

The Elixir of Life

Why we need water and how we can protect it

No living thing can exist without water. This applies to humans as much as it does to the simplest of single-celled organisms. There is plenty of it on Earth—more than two-thirds of its surface is covered by water—but it has become a scarce and threatened resource around the world. As it stands, 2.2 billion people have no access to clean drinking water. And even in Germany, climate change and increasing pollution levels are endangering the availability and quality of our livelihood. Researchers from the University of Jena and their partners in the new interdisciplinary »Thuringian Water Innovation Cluster« (»ThWIC«) want to counteract this problem by developing new technologies and concepts to promote a more sustainable use of the precious resource and by presenting the issues to policy-makers, businesses and civil society.

The blue planet

If we gaze at our planet from the depths of space, it shines like a deep blue globe. This is due to the sheer mass of water that covers most of its surface. Water is also found on other celestial bodies, in other planetary systems and galaxies, but here, on our »blue planet«, it occurs in large quantities in a liquid state. We owe our very existence to this cosmic circumstance. Life as we know it could not have evolved without liquid water. But where does the water on Earth actually come from and what makes this extraordinary chemical compound the »elixir of life«?

BY UTE SCHÖNFELDER

If we want to trace the origins of water in the universe, we have to go right back to the beginning. In the first few seconds after the universe was born, hydrogen nuclei—the positively charged protons—condensed out of the matter that was being formed. This was immediately followed by the combination of protons, negatively charged electrons and neutral neutrons to form the elements helium, lithium and beryllium. All other, heavier elements needed the help of gravity; they could only be formed when gas clouds had formed and matter had been compressed and heated to create stars.

To this day, however, almost the entire mass of the universe consists of the gases hydrogen (around three quarters) and helium (around one quarter). The third most common element is oxygen. As helium is extremely inert, water is the chemical compound formed from the most common elements that can actually react with each other. So, it is not all that surprising that water is formed in the universe.

How did water end up on the Earth?

However, how it got to Earth has not been clarified to this day. The most credible hypothesis is that water was brought to us by impacts from asteroids, meteorites and comets from cold regions far from the sun, and initially accumulated as vapour in the atmosphere during the early stages of the Earth's formation around four and a half billion years ago. Once the Earth had cooled sufficiently, the vapour clouds rained themselves out and the resulting oceans made the Earth what it is today: the blue planet. More than two-thirds of the planet's surface is covered by water. And most of the land masses are also formed by water; rivers shift sediments, erode mountains and carve valleys into the land.

What forms of water are found on Earth?

The water that shapes our planet is constantly in motion. It is distributed between the Earth's surface and the atmosphere, evaporating and condensing in a continuous cycle. It occurs on Earth in all three states of matter: ice, liquid and vapour. The smallest part—only about one thousandth of a percent—is found as vapour in the atmosphere, but it has an enormous influence there; water vapour causes precipitation and acts as a natural greenhouse gas, keeping temperature fluctuations on Earth low and forming cloudy shields that protect us from intense solar radiation.

Another small proportion of the Earth's water—albeit slightly larger at 2%—is frozen. This »cryosphere« in the polar regions and glaciers was much larger during the past ice ages than it is today: As a result, the sea level was up to 200 metres deeper during the last ice age than it is today. The frozen water contains around three-quarters of the Earth's entire freshwater resources. Most of this can be found in Antarctica, where it forms a sheet of ice that is several thousand metres thick and several hundred thousand years old.

A boat passes through Paradise Bay in West Antarctica. The sheet of ice at the Earth's poles contains a large amount of the world's freshwater supply. However, only about 2% of the water on Earth is frozen. · Photo: Christina Braun

The chemical peculiarities of water

Despite the prevalence of water on Earth, it is an absolute exception from a chemical point of view. It behaves differently than expected with regard to many of its properties, especially in comparison to similar compounds. For example, this »anomaly« means that frozen water has a lower density than liquid water. This is reflected in the fact that ice floats on water and doesn't sink. As a result of this characteristic, bodies of water freeze over at sub-zero temperatures first on the surface and not at the bottom. If water wasn't such an anomaly, there would be no ice floes and we wouldn't be able to skate on a frozen lake. Above all, however, marine life would be much different if fish, amphibians or plants were not able to thrive at the bottom of the water during the winter.

The water molecule H_2O has a basic tetrahedral structure; it resembles a pyramid with four triangular bases and four corners. The oxygen atom is in the middle of the molecule, and the four corners are formed by two hydrogen atoms and two lone electron pairs from the oxygen atom. This charge distribution—positive at the hydrogen corners and negative at the electron corners—causes individual water molecules to be attracted to one another and align themselves accordingly. The resulting hydrogen bonds hold the molecules loosely together and prevent them from moving freely in a completely disordered manner. This can be observed, for example, as surface tension; up to a certain volume, water forms round droplets instead of simply flowing apart, and small insects can walk on water without sinking. The high melting and boiling point of water is also a result of this chemical peculiarity. By way of comparison, methane has a similar molecular size to water and also has a basic tetrahedral structure, but it boils at -162°C. This is because it does not form any hydrogen bonds.

In its solid state, water is perfectly arranged as an ice crystal. Each molecule is firmly connected to four neighbouring molecules, creating a regular network with a basic hexagonal pattern. This is the reason why ice crystals (e.g. snowflakes), as unique as they may be in their individual shape, always have exactly six points.

And last but not least, hydrogen bonds are also effective in other molecules, such as in the large biomolecules that make up life on Earth. This is why proteins remain folded in defined structures and DNA strands form the famous double helix—hydrogen bonds are fundamental components for the basic molecular processes in living cells.

Thanks to its hydrogen bonds—the way in which its molecules interact with one another—water has a high surface tension. This is reflected in the fact that water forms droplets. · Photo: Jan-Peter Kasper

The source of life and human civilization

There is no living thing on Earth that can do without water. Not only is liquid water the foundation of all life processes in cells; it is also a reaction chamber, transport medium and means of transport for nutrients and metabolites. It was also the cradle of life itself; for the vast majority of time since its emergence on Earth more than three billion years ago, life has been found exclusively in water. To this day, water is by far the largest habitat on Earth, home to millions of species.

We humans cannot do without water either. It is our most important food—we can only survive for a few days without drinking water. We need it for washing, agriculture, industry, energy production, transport routes and much more. Early human civilizations settled along the great rivers: the Euphrates and Tigris, the Nile, the Indus and the Yangtze. And to this day, most of our cities have access to a river or sea.

Water is the largest habitat on Earth. It includes not only the oceans, which cover more than two-thirds of the Earth's surface, but also rivers, lakes and swamps. Even the smallest puddles are swarming with life. These jellyfish were not pictured in their natural habitat, but in the Phyletic Museum at the University of Jena. · Photo: Anne Günther

This photograph of the Earth was taken in 1972 by the crew of NASA's »Apollo 17« mission on their way to the moon. It is known around the world as the »Blue Marble«. · Photo: NASA

The »Blue Marble«

Although water seems to shine in majestic blue from space, it is actually transparent and colourless. The fact that it appears blue is due to various effects. On the one hand, its molecules primarily absorb the long-wave (red) part of sunlight. When white light, which combines all colours of the light spectrum, hits water, more and more of the red part is filtered out as the light travels through the water. On the other hand, the remaining part of the light is scattered by particles suspended in the water and cast back to the surface. This makes water appear blue.

We have to do more than just save water

The »Thuringian Water Innovation Cluster« (ThWIC), an interdisciplinary network combining science and business, was launched on 1 February. The aim is to develop new water technologies and find ways for society to deal with the increasingly scarce resource. In our interview with ThWIC spokesperson, Prof. Michael Stelter, he assesses the current situation and explains why Jena is already a water hub.

INTERVIEW: UTE SCHÖNFELDER

Michael Stelter is Professor of Technical Environmental Chemistry at the University of Jena and Deputy Director of the Fraunhofer Institute for Ceramic Technologies and Systems as well as one of two spokespersons for the new water innovation cluster »ThWIC«. · Photo: Jürgen Scheere

You initiated the »ThWIC« innovation cluster and played a key role in shaping it. Why did you find it important to focus on the topic of water?
At the Chair for Technical and Environmental Chemistry, we've been specializing in water research for a number of years and have built up quite a bit of expertise in that time. When the Federal Ministry of Education and Research (BMBF) submitted an open-topic invitation to tender, we saw the opportunity to take our work to a completely new level and to establish it as an interdisciplinary research focus. The fact that we are among the few funded among 120 consortia to submit an application for such a future cluster shows that we were not entirely wrong in choosing this topic.

Where does your scientific interest in water come from?
One aspect is the increasingly visible impact of climate change. I come from the Ore Mountains, where there has been, as in other places, heavy rain and flooding in recent years, which has shown very impressively just how destructive water can be. And on the other hand, you can see what happens to our forests when there's no water. I'm certainly not the only one who has realized how important water is to our existence and environment.
I have been doing research on energy and environmental technology for years—and I've always had an eye on sociotechnology. In this time, I've constantly found that it's not necessarily the fascinating technical solutions that are the focus of public debate. Instead, there seems to be a focus on the potential risks of new technologies and concerns about making sacrifices and changing our ways. This is very clear in the case of renewable energies. And I feared early on that the same could happen when it comes to water in view of increasing water scarcity and climate change. I think there's a lot to be learned from the failings of the energy transition when it comes to water management so we can avoid making the same mistakes. In addition to all the technology, we also have to include society in the transition, and that's what makes the topic of water so interesting from a scientific point of view.

What are your goals within the cluster?
We want to make Jena a centre for water research, from which relevant economic products and services will emerge. In the future, Jena should not only be seen as an optics location, but also as a water hub. We're relying on Jena's unique strength: its culture of cooperation. In addition to the University of Jena and the University of Applied Sciences Jena, a number of strong non-university research institutions are also involved in »ThWIC«, including the Fraunhofer Institute for Ceramic Technologies and Systems (IKTS), the Fraunhofer Institute for Applied Optics and Precision Engineering (IOF) and the Leibniz Institute of Photonic Technology (IPHT), as well as numerous companies that are global leaders in water technology solutions. In the past, however, there has been a lack of contextual cohesion and no link to the social sciences in particular. That framework is now provided by »ThWIC«. After all, we need to do more than just water research. We need a transformation on a social and economic level.

How will this be implemented?
The cluster is running 22 individual projects with three distinct objectives. First of all, we want to develop methods that can be used to remove micropollutants from water that have not been captured in sewage treatment plants up to now. And we want to develop digital, real-time techniques for measuring the quality of water in its systems, such as rivers, lakes and sewage pipes (see p.18).
Our second goal is to establish a water assessment, which means that we want to find new and improved ways of evaluating water to provide a rational basis for political decisions on water use. And thirdly, we want to develop modern, digital and classic tools to make the general public and businesses aware of the current and fundamental challenges relating to water (see p. 34)

Are we discussing the topic of water enough outside of science?
I think we've reached a point where many people are realizing we have to do something about it and where there's a growing understanding that the issue affects us all. We can see the droughts and the effects of climate change right on our doorstep, including the aftermath of the 2021 flooding disaster in the Ahr Valley. Using the Tesla Gigafactory in Brandenburg as an example, we can see what distortions can arise if we prioritize jobs over water. There's clearly a need for action here. We still have time to act—and so we should. But for this to work, it's important to explain the situation and enable people to make informed decisions. By the way, when it comes to saving water, industry is often way ahead of the general public.

How so?
These days, industrial companies are no longer competitive if they don't produce sustainably. Sustainability is becoming increasingly important for investors. And most companies have learned their lesson in terms of their carbon footprint. It is now crucial for stakeholders to save not only CO_2, but also water, because it's a finite resource. A lot of water is still being used, especially in the food and paper industries and in the production of detergents and cleaning agents. Those companies are now looking for ways to improve their water consumption—for economic reasons, but also because it's otherwise difficult for them to sell their products.

But just saving water is probably not the solution.
That's right. Of course, we can and should use water as sparingly as possible, just as we're currently trying to use energy as sparingly as possible. But, as with energy, we won't be able to solve all our problems just by cutting down; we need to develop new, sustainable technologies to conserve our resources. As a matter of fact, there's no shortage of water in Central Europe and Thuringia—it's just that we sometimes have it at the wrong time. In other regions of the world, however, there actually is a lack of water, so we need technological solutions and other costly investments, for example to desalinate seawater. This calls for holistic strategies.

What ideas and innovations can »ThWIC« offer for global water management?
First of all, we can gain knowledge. For example, there are very different water ownership regulations around the world. There are countries where water is private property and treated as a commercial resource. In other countries, however, water is in the public domain, which often means that nobody takes care of it and the water quality is poor. In Germany, we're somewhere in between. And those are the kind of differences and perspectives we want to study and analyse with an interdisciplinary focus in ThWIC. And we want to make the technologies we develop here, such as our water purification solutions, available for use not only in Central Europe, but also in other parts of the world. A basic prerequisite for this will be that our technologies work exclusively with renewable energies.

How do you personally ensure the sustainable use of water? And what can each of us do to live more sustainably every day?
I can give you a very mundane example: We try to only drink tap water. We have realized how lucky we are in Germany to have water that we can drink straight from the tap without any concerns. The same applies to skincare products—my family and I make sure that we buy products that don't contain any microplastics. These are personal consumption decisions that everyone can make for themselves. ■

Picture left: Drinking water in Germany—environmentally friendly, inexpensive and safe—but new micropollutants are placing an increasing strain on the water cycle. · Photo: Jan-Peter Kasper

Finding a clean solution

Clear, clean water, straight from the tap, available in every household. What is now taken for granted by many people really shouldn't be. After all, climate change, industry and agriculture—and not least our way of life—are putting our precious resource in danger. A team of chemists in the »ThWIC« water cluster are looking for new ways to detect pollutants in wastewater and reliably remove them to ensure the quality of our drinking water in the long term.

BY UTE SCHÖNFELDER

In Germany alone, 27 million cubic metres of wastewater flow into the sewage system every day—from showers, washing machines and toilets. Around 96% of this is purified in sewage treatment plants. Various mechanical and biological cleaning processes are used to remove rubbish, gravel, sand, grease and oil, as well as dissolved organic substances, heavy metals, nitrates and phosphates. Around ten billion cubic metres are purified every year in approximately 10,000 sewage treatment plants across Germany before being returned to the natural water cycle.

However, the existing sewage treatment plants do not have a clean solution for all the substances and residues found in wastewater. In fact, the number and quantity of previously unconsidered pollutants in wastewater is constantly on the rise, as emphasized by Dr Patrick Bräutigam.

Drugs, pesticides, antibiotics: more and more pollutants in wastewater

»We've got a growing problem on our hands,« says the chemist from the Institute of Technical and Environmental Chemistry at the University of Jena and the Fraunhofer Institute for Ceramic Technologies and Systems. »In particular, the existing plants are often unable—or only marginally able—to remove drug residues, antibiotics, agricultural pesticides and industrial chemicals«.

The wastewater that passes through our sewage systems is often a real chemical cocktail. More and more (new) substances are being placed on the market around the world, and these can all end up in our wastewater. Around 100,000 different chemicals are currently approved in the EU. They are found in plastics, pharmaceuticals, skincare products, textiles and paper coatings. »Many of them occur in very low concentrations and cannot yet be effectively removed from wastewater,« says Dr Bräutigam. As the German population continues to age, for example, the amount of drug residues is steadily on the rise; according to the draft National Water Strategy presented by the German government, there will be a 70% rise in the consumption of medicines in Germany alone by the year 2045, placing an additional burden on the water cycle.

Some pollutants can be avoided or replaced with safe, biodegradable alternatives. Another forward-thinking approach to reducing water pollution is to recycle water in closed systems (e.g. in industry) to completely avoid wastewater. »But that's not possible for many chemicals, especially medication,« explains Dr Bräutigam. There is therefore an urgent need for new, effective methods of wastewater analysis.

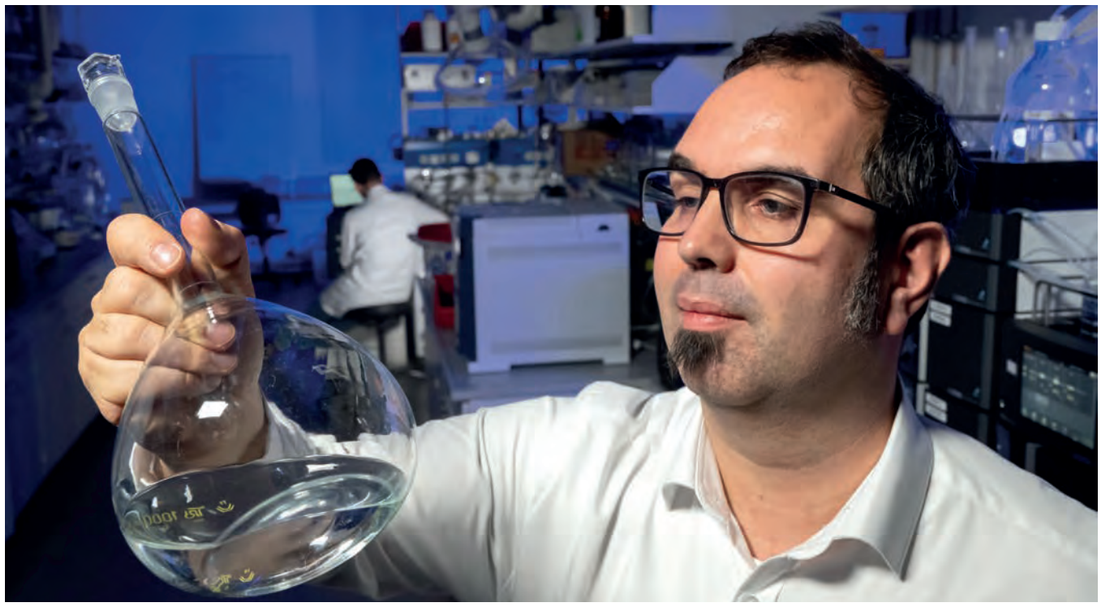
And that is exactly where Dr Bräutigam and his teams at the University of Jena and the Fraunhofer Institute come into play. In future, they will also take this task on as part of the »ThWIC« water cluster, for which Bräutigam is a spokesperson. The environmental chemists at the University of Jena are researching a number of methods for treating water in such a way that all pollutants can be removed. »We're also developing ways of recording even the slightest pollution as continuously as possible,« continues Dr Bräutigam, »because only then can our sewage treatment plants react appropriately«. This also presumes that specifically adapted water treatment methods are required for different pollutants and the most suitable methods for degrading the detected chemicals can be predicted based on their chemical structure. The researchers are already working on this topic.

Pollutants removed by recyclable ceramic filters

There are various ways of removing micropollutants from wastewater. Some of the methods that are already in use attempt to remove micropollutants from the water by binding them to surfaces such as activated carbon. However, this does not work efficiently for all chemicals. »In addition, the activated carbon then has to be removed, transported and incinerated, or the substances themselves have to be removed from the activated carbon, which is complex and requires a lot of energy,« says Dr Bräutigam. That's why the chemist and his team are working on new materials that are highly effective in binding pollutants and clean themselves »at the push of a button«. »We're developing switchable ceramics for this purpose,« explains the chemist from the University of Jena.

The term »switchable« means that the ceramic surface properties can be changed by adjusting certain external parameters such as pH, light or temperature. In their original state, for example, the ceramics are water-repellent; if wastewater is passed through such an adsorber, the dissolved pollutants accumulate on its surface. The water leaves the adsorber in a purified state. The environmental parameters are

Dr Patrick Bräutigam is an environmental chemist and one of two spokespersons for the new »ThWIC« water cluster (see box on p. 25). · Photo: Jens Meyer



Picture right: A reactor in which methods for oxidizing pollutants (e.g. ultrasound and ozonation) are tested on a laboratory scale. · Photo: Jens Meyer

Picture below: Ceramic adsorbers adsorb and desorb water pollutants »at the push of a button«. · Photo: Jens Meyer

then changed to convert the material into a water-absorbent state; the captured substances can be washed off again and disposed of as a concentrate. In the future, various textiles could also be coated with switchable materials and used as microorganism-resistant work clothing (e.g. in the medical field).

Nano sieve filters

Ceramic materials are also used to create microscopically fine filters that can remove substances from water according to their molecular size and structure. This method can be used, for example, to separate oil-water emulsions. »We're currently working on a project with an industrial partner to recover metal processing lubricants used in the automotive industry,« says Patrick Bräutigam. The lubricants that stick to the metal surfaces are washed off with soap—and it is very difficult and expensive to dispose of the wastewater that accumulates during the car wash. »Our aim is to completely remove the lubricants from the water using filtration, so that the water can be reused on site and the factory is practically free of wastewater«.

Ultrasound and ozone for harmful chemicals

In addition to removing pollutants from water, they can also be rendered harmless by oxidation. »This is a bit like cold combustion,« explains Patrick Bräutigam. »During oxidation, the pollutants react with oxidizing agents and are converted into CO_2 and water«. In order to set this process in motion, the chemists generate »hydroxyl radicals« in the wastewater. These are formed from the water itself without the need for any additional chemicals.
The researchers are testing various methods for creating hydroxyl radicals. One of the main areas of research covered by Dr Bräutigam's team revolves around »cavitation«. This is where bubbles are created in the water and then made to collapse. The bubbles are very small—only a few micrometres in diameter. When they collapse, however, extremely high temperatures develop locally—up to 5,000°C, like the sun—which produces the hydroxyl radicals needed for oxidation. The researchers initiate the cavitation process using high-power ultrasound or strong hydrodynamic flows—the efficiency of the procedure can be significantly enhanced by combining several methods at once.
The hydroxyl radicals required for the cold combustion process can also be generated by channelling ozone into the wastewater. This gas, which consists of atmospheric oxygen, is finely distributed throughout the wastewater in a pressurized environment. In addition to the hydroxyl radicals, the ozone itself also helps to oxidize pollutants and kill microorganisms.

Real-time monitoring with new sensors

In addition to various ways of purifying wastewater, Patrick Bräutigam and his colleagues are also developing new sensors that can be used to continuously determine wastewater quality in real time. This is particularly important in view of the new micropollutants, explains Dr Bräutigam. For example, drug residues can be detected in wastewater according to a distinct daily rhythm, because people tend to take their medication at the same time every day (e.g. in the morning or at night). »In an ideal world, sewage treatment plants would be able to actively respond to these fluctuations by adapting their purification processes according to the pollutant input«. However, this requires continuous monitoring—at present, that is only a vision for the future.
The ability to measure the specific concentrations of substances in water at specific times of the day would not only be an advantage for monitoring wastewater. Such methods could also be used to monitor the water quality of rivers and lakes with much more precision. This would significantly reduce the time needed to detect events such as the massive fish deaths that occurred in the River Oder last year, so that countermeasures can be taken in good time. ■

Water in figures

55,000

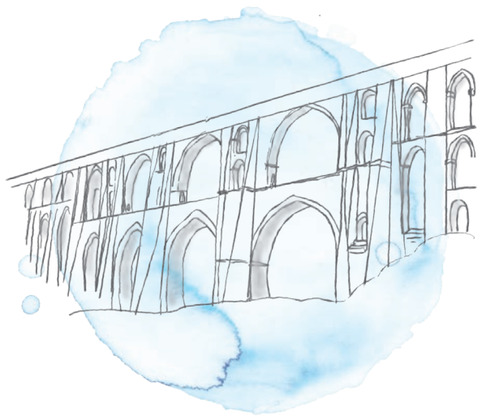
litres of water have been drunk by the average person at the end of their life if they reach the age of around 80 with a daily consumption of 2 litres. The recommended daily intake of water is between 1.5 and 3 litres, depending on factors such as age and height.

148

litres of bottled water are bought by the average person in Germany every year. This makes mineral water the most popular drink in Germany, ahead of fruit juice and coffee.

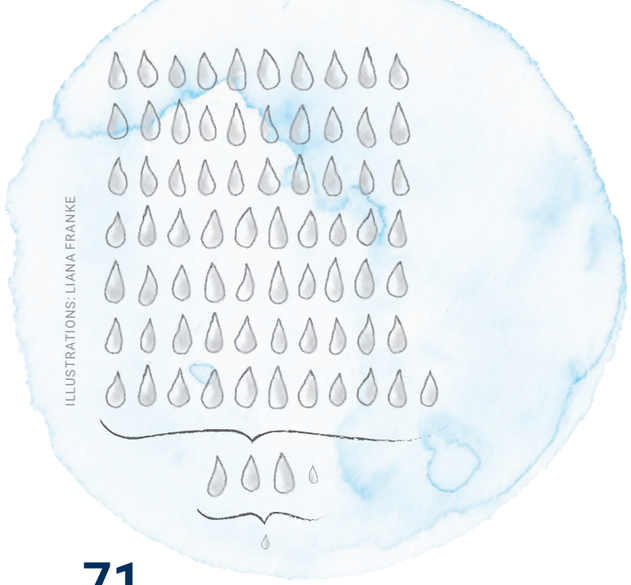
6,000

water utility companies around Germany ensure the quality of our drinking water. Hardly any other country has controls as stringent as Germany. 65% of our drinking water is obtained from groundwater and prepared for consumers with the help of complex processes.



426

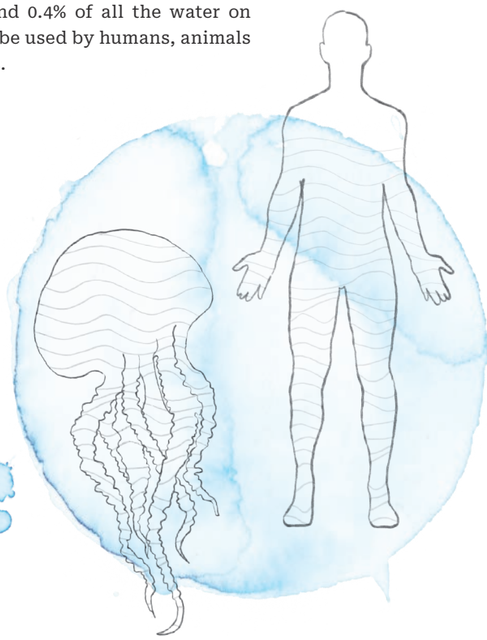
kilometres—the longest ancient structure for transporting water. The Aqueduct of Valens was built by the Romans to supply water to Constantinople (modern-day Istanbul). Even though Romans were well ahead of their time in many ways, they are not credited with inventing the aqueduct. The first systems for transporting water were used in ancient Egypt and Greece.



ILLUSTRATIONS: LIANA FRANKE

71

percent of the Earth's surface is covered by water. However, only 3.5% of that is freshwater. And a large percentage of our freshwater is stored as ice at the poles, in glaciers or in permafrost—only around 0.4% of all the water on Earth can be used by humans, animals and plants.



70

percent of the human body is made of water. That sounds like a lot, but other organisms contain a lot more water. The front-runners are jellyfish—they consist of 99% water. Many of the vegetarian things we eat—including lettuce, tomatoes and mushrooms—contain more than 90% water and help us regulate our water levels.

1886

was the year in which August Gärtner, also known as »Kanal-August«, began his work at the University of Jena. The student of Robert Koch founded the Chair of Hygiene and Bacteriology, organized an epidemic and hygiene policy for the whole of Thuringia and introduced the first ever hygiene standards for a public water supply system.

5,300

litres of water are used every day by the average person in Germany—the equivalent of 25 full bathtubs. This is calculated based on the »virtual water« that is needed to produce a wide variety of everyday products. On average, 140 litres of water are needed for a cup of coffee, and around 4,000 litres of water go into producing a cotton T-shirt.

Prof. Dr Birgitta König-Ries (l.) and Felicitas Löffler. · Photo: Jens Meyer

Searching for gold in a data lake

Whether in the newly launched »ThWIC« water innovation cluster or in successfully established research networks, scientific work always produces a wealth of data. Measurements, texts, images, digitalized historical artefacts or computer simulations are collected, documented and stored. But what happens to the information once the research project has ended and the results have been published? Researchers are setting up a »data lake« so that the data they have collected can also be used for future research questions.

BY UTE SCHÖNFELDER

This data lake is a piece of cloud infrastructure that is currently being set up in the University Computer Centre as part of a water cluster sub-project (»ThWICData«). In addition to the University Computer Centre, the »Competence Center Digital Research« at the University of Jena and an external business partner are also involved in the project. The aim is to centralize, store, edit and archive data and information from all of the 22 »ThWIC« projects for long-term use.

The University of Jena has taken on the role of cloud provider. The data from each individual cluster project—from streamed sensor data from sewage pipes and information from sociological interviews to image, sound and text data—will »flow« into the data lake via automated »pipelines«. »We're creating a centralized access structure for this purpose, through which the partners involved in each project will initially have access. In the long term, however, we also want to make data accessible to the general public,« says Felicitas Löffler from the Institute of Computer Science, who coordinated the cluster's data science division.

But what are the advantages of setting up a huge cloud and centralizing data instead of storing it locally at the locations where it is collected? »This mainly helps us secure our research data in the long term,« explains Prof. Birgitta König-Ries. The holder of the Heinz-Nixdorf Professorship of Distributed Information Systems points out that long-term data availability has become increasingly important in recent years—and not only in research. The German government set up the Council for Scientific Information Infrastructures in 2014, and the National Research Data Infrastructure was subsequently launched in 2020. As part of this initiative, Prof. König-Ries is involved in a project relating to the management of biodiversity research data. »In order to make the research data available for long-term use across borders and disciplines, it's stored according to the FAIR principles,« says König-Ries. FAIR stands for Findable, Accessible, Interoperable and Reusable.

Open formats and precise metadata

Sustainable research data management involves much more than long-term storage. Storing data for many years has long been part of good scientific practice. »However, this often meant that data was simply stored somewhere and couldn't be used by others, because it wasn't locatable or understandable,« says König-Ries. That's why it is important to describe the data as precisely as possible. This metadata contains additional information that allows people who didn't collect the data themselves to relate to it and understand it (e.g. details about the methods used and the underlying scientific issues). »It's also important that the metadata is stored in open formats that are universally understandable«.

In the water cluster, Birgitta König-Ries and Felicitas Löffler are working together with a business partner as part of the »ThWICSonar« project with the aim of automatically capturing and tagging text documents. »We want to set up an information system that can be used to automatically monitor documents, classify them by subject and describe them«. They are doing this with the help of artificial intelligence. »First of all, we have to tag documents manually so that we can then train the algorithms. This will create a language model to enable automatic tagging in the future«. The prepared documents will then be proactively recommended to various user groups within the cluster.

In their work for »ThWIC«, the researchers build on existing expertise. For example, an »Electronic Lab Notebook« (ELN) for the management of chemical research data has been under development at the University of Jena and the Leibniz Information Centre for Science and Technology in Hanover since 2020 as part of the National Research Data Infrastructure initiative. The project is being coordinated by Prof. Christoph Steinbeck, who is also involved in the »ThWIC« cluster. »The ELN is an electronic version of the classic laboratory notebook, but it also offers lots of advantages in terms of long-term data use,« emphasizes Felicitas Löffler. If data can be shared with other researchers and stored in a cloud, for example, it is available all around the world and can be linked to other sources. »This makes it possible to use data at different locations and to identify and understand overarching relationships«. ■

The Thuringian Water Innovation Cluster

»ThWIC« is an interdisciplinary hub that is developing new solutions for the sustainable use of water and wants to raise awareness of the importance of this issue in society. The network of 28 university and non-university research institutions, companies and associations is funded by the Federal Ministry of Education and Research (BMBF).

The innovation cluster, which was launched by the University of Jena in cooperation with the Fraunhofer Institute for Ceramic Technologies and Systems (IKTS) and the University of Applied Sciences Jena, was one of the few proposals to be granted funding as part of the »Clusters4Future« competition, which attracted a total of 120 submissions and is being funded by the German government since 1 February 2023. Over the next nine years, up to 45 million euros in funding will be invested in the development of new water technologies and research into how society is dealing with the increasingly scarce resource. The innovation cluster has more than 20 sub-projects with a focus on the following four fields:

Analysing water

The aim is to develop solutions that will enable water to be analysed comprehensively, quickly, digitally and affordably in the future. This requires sensors that can record water data directly without the need for lengthy laboratory analyses. For example, the »KontiMonit« sub-project team is developing an electrochemical sensor that can be used in municipal sewage treatment plants and for environmental monitoring. The sensors developed in the »MIKA« project are aimed at specific micropollutants using photonic spectroscopy methods.

Purifying water

The researchers are seeking ways to remove anthropogenic wastewater pollutants from wastewater that cannot be captured using the traditional methods of today's sewage treatment plants. In the »Kerasorb« and »Technical Kidney« sub-projects, which are linked together, the aim is to remove micropollutants by adsorption, while the »UltraStaRK« project aims to render them harmless by complete oxidation.

Evaluating water

The researchers are systematically compiling a comprehensive pool of key figures that expresses a new attribution of value to water; for this purpose, the effort involved in removing pollutants has to be recorded, which can be quantified as a »water footprint«. In addition, sociological criteria will be used to highlight a possible change in awareness in dealing with water.

Understanding and explaining water

One of the key goals pursued by »ThWIC« is to improve »water literacy« by giving citizens extensive knowledge that will empower them to make informed decisions when using the resource. The projects focus on everyday practices of water use in private households, as well as complex water cycles and water-related infrastructure. A greater awareness of water-related issues will also create opportunities for businesses to quickly and appropriately react to anticipated water problems.

Narratives often speak louder than statistics

As the altered relationship between humankind and nature continues to be portrayed in art and culture, it is emerging as a research topic in the humanities. So, it comes as no surprise that the humanities are also being incorporated into the work of the Thuringian Water Innovation Cluster »ThWIC«. Professor of North American Studies, Caroline Rosenthal, explores how the topic of water is reflected in North American literature and how it can shape, define, and change entire regions.

BY SEBASTIAN HOLLSTEIN

Prof. Caroline Rosenthal is examining how the Anthropocene and its impact are expressed in North American literature. Within the framework of »ThWIC«, she wants to develop a hydro-regionalism model. · Photo: Jens Meyer

»Water is the principle of all things, for all things are from water and all things are resolved into water«. This wisdom, articulated by ancient philosopher Thales of Miletus, has formed the foundation of science and art for millennia. The fundamental concepts of life and death have found symbolic expression in liquid form for thousands of years, whether as an indomitable, divine act of nature as in the floods portrayed in the Epic of Gilgamesh or the Genesis flood narrative, mythological beings such as mermaids and mermen, or as the living cosmos depicted in the film »Avatar: The Way of Water«. In works of literature, rivers are the perfect metaphor for the meandering course of life, while the seemingly endless nature of the oceans opens up a reflective landscape and a world of possibilities for literary heroes and heroines as well as readers themselves.

However, in recent decades various literary movements have emerged that no longer use water—and nature in general—as a mere backdrop or stylistic device, but rather specifically address its importance along with a growing number of ecological issues. »Art and literature are important and powerful in identifying problems and mediating them to society,« Prof. Caroline Rosenthal states. »Narratives often speak louder than mere statistics«.

Viewing nature with a political eye

For several years now, Caroline Rosenthal has been studying how the Anthropocene—the geological epoch shaped by humans—is reflected in North American literature. »In the 19th century, nature writing emerged as a Romantic literary genre, especially in Great Britain and the USA, in which authors focused on the experience of landscape, flora and fauna. This encounter often also has had a political dimension, for example with regard to the national identity of the United States where vast landscapes and seemingly untouched nature conveyed a sense of grandeur and freedom.«

In this way, literature acts as a seismograph of society, foreseeing and preserving the ecological discussions of our time. As pollution, extinction, and climate change continue to threaten our existence, various movements such as ecocriticism, which emerged in the USA in the 1970s, provide a critical platform for people to question the relationship between humankind and nature. Among other things, the proponents of this approach demand that humanity sees itself as part of the ecosystem as well as its steward. Literature plays a crucial part in raising awareness and in highlighting dangers but also in presenting possible future scenarios which instigate change and directly impact society.

Regional identities are defined by water

This school of thought has long been the subject of literary studies—and Jena is no exception. Caroline Rosenthal's professorship of American Studies accommodates a group of doctoral candidates who are dealing with various ecocritical topics and have formed an »Ecocriticism Research Collective«. In addition, a team of American Studies experts from the University of Jena is working on a ThWIC sub-project to investigate how water and bodies of water help to shape regional identity. The aim of the project is to develop a hydro-regionalism model based on the concept of bioregionalism that emerged in California in the 1970s, according to which regions are defined by geological and geographical factors as well as cultural practices as opposed to political borders. Some of the most important components of bioregionalism are watersheds, mountain ranges, and collective storytelling traditions. »We believe that water—in all its forms—can also assume such a function in creating a sense of unity within a specific region,« says Caroline Rosenthal. »This applies both to the knowledge of water passed down through generations within a region and to symbolic attributions such as myths and legends that have survived in various forms to this day«.

In order to design the model using an exemplary region on the North West Coast of Canada, the literary scholars are first investigating fictional and non-fictional sources which constitute a local archive about water. Where does the region's water originate? Where does it flow? What are the region's precipitation cycles? How is the water quality? What relationship do the locals have to individual bodies of water? What stories and symbols have been inspired by water? The answers to these questions can be found by analysing texts and ascertaining the importance and function of water for the region. In this way, the researchers can learn more about the region's cultural traditions—and can even potentially discover how water defines regional identity in a way that raises environmental awareness and promotes behavioural change.

Literature as a realm of possibility for dealing with water

»We want to examine literature as a hypothetical space of possibility which allows us to imagine a variety of future scenarios for the usage of water as a material and cultural resource,« Caroline Rosenthal explains. »People who identify with the water around them are more protective of it,« she adds. ■

Drought summer of 2022: the dried-up river bed of the Leutra near Jena. · Photo: Jens Meyer

Underground climate change

In commercials, seemingly inexhaustible supplies of crystal-clear groundwater gush from springs in idyllic mountain landscapes. But in reality, it is often only a few metres beneath our feet and anything but inexhaustible. What exactly is groundwater? Where does it come from? And how can we stop it running out anytime soon? The hydrogeologist and spokesperson for the Thuringian Climate Council, Prof. Kai Uwe Totsche, provides some answers in our interview.

INTERVIEW: SEBASTIAN HOLLSTEIN

We are coming off the back of a drought summer, and many more are likely to come—how is climate change affecting our groundwater?

On the one hand, we can see that groundwater levels are falling—very clearly in some cases. This isn't just something that happened last year—the losses occurring in many parts of the world have increased over the past fifteen years. On the other hand, we are observing changes in the properties of our groundwater, which affects the quality. For example, there has been a rise in water temperature, which is both worrying and astonishing. It is worrying because this speeds up various processes, and astonishing because the surrounding rock must have also been heated up, which usually takes a long time due to the aquifers thermal capacity. This is an unmistakeable sign that climate change has arrived underground. At our measuring stations, we have observed that this warming process is also accompanied by a change in the biogeochemistry of our groundwater. The higher the temperature of our groundwater, the more soluble substances it can contain. This ultimately makes it more difficult—and therefore more expensive—to treat our drinking water.

What actually is groundwater?

Groundwater is the water found in the interconnected void space in the bedrock. On the one hand, it includes deep waters that are primarily the product of geochemical processes. These can be millions of years old and have hardly been used by humans, but this will presumably change in the future.

On the other hand, it is water that comes from precipitation that infiltrates the soil and percolates further down. Depending on the depth and the properties of soil and bedrock, it can take anywhere between a few days and several decades for the percolating water to reach a rock formation that prevents further seepage. This water gathers in the overlying rock—this is known as an »aquifer«. It's worth emphasizing that groundwater isn't just »water in rock«; groundwater systems provide habitats that harbour a tremendous biological diversity that is organized into complex food webs. Groundwater systems are ecosystems!

Ideally, the impurities contained in the percolating water are filtered out, transformed, or even broken down on the way through soil and the deeper layers of the Earth's crust. However, a large amount of the infiltrating precipitation never reaches the groundwater, but is stored near the surface in the soils, where it is available to plant roots or is released back into the atmosphere through evapotranspiration.

In which areas do we rely on groundwater?

Noteworthy, around two-thirds of our drinking water comes from groundwater—and this figure is on the rise. In our latitudes, it is usually pumped out of sedimentary or fractured rock, treated, and supplied to households or the beverage industry. It is also essential for irrigation in agriculture, fruit production, and horticulture with increasing demands due to climate change. Moreover, groundwater has industrial applications as process water—both in residential areas, and, notably, is used to extinguish forest fires. As it feeds our rivers, it also plays an important role for fisheries and inland waterways.

Apart from lower amounts of precipitation, what else is having an adverse impact on groundwater formation?

Land use is a key factor in groundwater formation and quality. Of course, soil sealing plays an important role here, as it makes it difficult or even impossible for precipitation to infiltrate into the soil. But even in places that aren't completely paved over with concrete, water can't always seep away as it should. If, for example, the soil becomes too compacted due to high pressure—»surcharge«—the water doesn't seep away slowly, but preferentially and more quickly in large pores and cracks. As a result, the filter function fails and alien substances enter the subsurface were these don't belong to, such as pesticides.

To break down such pollutant inputs, the numerous life forms and functions of the groundwater ecosystem are essential. I've been researching this at the »AquaDiva« collaborative research centre for the past more than ten years alongside my colleagues Prof. Kirsten Küsel and Prof. Susan Trumbore. We're trying to find out how surface ecosystems and groundwater ecosystems are connected and how land use on the surface influences the biodiversity and functions of the subsurface. The »clean-up« capacity of the groundwater ecosystems and overlying layers is heavily dependent on the vast variety of organisms inhabiting the subsurface. That's why we are investing a lot of time and effort into shedding more light on this *terra incognita*.

How can we change our land use to aid the formation of groundwater and improve its quality?

In general, we should see both, groundwater recharge and groundwater quality, as important goals of land use. There are many ways to encourage this. First of all, we should stop sealing ground and unseal more areas. We then have to create land management practices that keep water in the area by restoring and increasing the seepage and cleaning capacity again and significantly slowing down the run-off via watercourses.

There are many ways of doing this—in residential areas, in agriculture, and in forests. For example, a deciduous forest ecosystem provides much more

Prof. Kai Uwe Totsche (pictured left) and environmental protection engineer Heiko Minkmar take groundwater samples from a research measuring point in the forested groundwater recharge area near Hummelshain. · Photo: Anne Günther

recharge than a coniferous forest. At the same time, we can influence condensation processes such as dew formation, but also evaporation or transpiration—and not only through vegetation. By managing our use of land, we can ensure that more water infiltrates into the soil instead of being released back into the atmosphere.

What other points of attack are there, for example in agriculture?

We need more areas where water isn't seen as a nuisance, but is given time to seep away. For example, large districts of agricultural land were drained during land consolidation projects in the 20th century, so that the land could be cultivated without the risk of flooding. In addition, the course of running waters has been straightened, leading to a gradual increase in their flow velocity and causing the proximate soils in the vicinity to dry out. However, we should aim for keeping the »water in the catchment«—especially in the subsurface environment. So, we have to undo our interventions. Many of the measures involved would also benefit agriculture and help us adapt to the effects of climate change.

How so?

Soil moisture is an important prerequisite for the formation of humus and is therefore essential for fertile soils. When humus is formed, CO_2 is sequestered in the soil in the form of humified organic substances. Increasing the humus pool of the subsurface is thus an efficient way to reduce CO_2 in the atmosphere. We're investigating some of the fundamental aspects of this process in my »MAD Soil« research group. We're focusing on the smallest structural elements in soils—»microaggregates«—which range in size from a few nanometres to 250 micrometres and are incredibly effective in binding organic carbon in the form of mineral-organic associations. Among other things, we've shown that biogenic polymers play a very important role as adhesives and stabilizers for the formation and stability of these »soil building blocks«.

The conventional agricultural use of land around the world has led to a significant loss of humus from soil, which has greatly accelerated the greenhouse process. Agriculture must therefore set itself the goal of significantly increasing the soil humus content again.

How can you, as a scientist and spokesperson for the Thuringian Climate Council, encourage and support measures to increase groundwater formation?

Among other things, we're helping to develop new management systems. One of the key areas is urban water management, where it's important to collect precipitation on sealed surfaces.

We're working closely with partners from forestry and water management, providing information as to how landscapes can be redesigned. For example, we're using digital methods to observe and model the »hydromorphy« and its changes due to human activity—not only as the basis for developing management strategies for groundwater catchment areas, but also to devise specific measures in the fields of forestry, agriculture, and urban water management. As a spokesperson for the Thuringian Climate Council, I'm also taking the topic from the scientific field into politics and the public sphere, so that more people are aware of the issues and willing to tackle them. ■

A sociology of water

As water becomes ever scarcer, conflicts are arising. This not only affects parts of the world that are already struggling with drought and water shortages—it is also happening right on our doorstep in Thuringia. A team of sociology researchers in the »ThWIC« water cluster are investigating how society is dealing with the vital resource.

BY STEPHAN LAUDIEN

In Apfelstädt in the district of Gotha, a dispute is raging over the small river also called Apfelstädt that runs through the village. It starts at the Tambach-Dietharz dam and meanders for around 34 kilometres before flowing into the River Gera. Those living near the river are accusing the dam authority of diverting too much water to generate electricity and thus being responsible for the river drying up for a period in the summer months. A citizens' initiative has been set up, a solution is yet to be found.

Multiple lines of conflict

As unpleasant as this dispute may be for the region, it is certainly an invaluable source of information for Dr Diana Lindner. After all, the confrontation reveals lines of conflict that are likely to emerge in a similar fashion in many other places. »This dispute over a diminishing resource has many facets that we want to examine more closely,« says Diana Lindner. At Hartmut Rosa's chairn, the sociologist from the University of Jena is coordinating the sub-projects for the »ThWIC« water innovation cluster that deal with sociological issues. She points out that the fundamental objective is to create a sociology of water. According to the sociologist, various aspects can be observed in the Apfelstädt dispute. For example, there are arguments about numbers, which begs the question of correct monitoring. In addition, there are very different perceptions of the body of water. An angler will see the river in a completely different way than farmers, for example, who use the river to irrigate their fields. Another aspect of the debate about the precious resource is the fact that the rural population feels left behind. »This feeling is getting stronger and stronger,« says Diana Lindner.

Despite the explosive nature of this issue, a look beyond national borders shows that far greater problems have to be overcome elsewhere. In one of the »ThWIC« sub-projects, Alexis Gros is investigating the situation on the Riachuelo and Reconquista rivers in Buenos Aires. The two tributaries of the River Plate are so polluted that all life has died out in them. They are some of the most polluted rivers in the world. »Alexis Gros will be exploring how the local population is dealing with the fact that a vital resource is no longer available,« says Diana Lindner. The projects based in Thuringia will be focused more on finding new ways of dealing with water as a resource. However, the sociologists in Thuringia and Argentina are united in their pursuit of local knowledge, which they want to gather and put to good use. »We want to write and tell stories about water,« says Diana Lindner. The research projects have only just started—but exciting results are on the horizon, both in terms of local conflicts and global issues. After all, the vital resource of water is under threat worldwide—across all borders. ■

Dr Diana Lindner and her colleagues want to develop a sociology of water. · Photo: Jürgen Scheere

A source of energy and hope

Hydrogen has long been considered a beacon of hope for the energy transition—especially during the ongoing energy crisis. However, hydrogen can only really be seen as a sustainable source of energy if it is obtained from water with the help of renewable energy. How such »green« hydrogen can be produced—preferably from the available solar energy—is being researched at the University of Jena in the »CataLight« Collaborative Research Centre.

BY MARCO KÖRNER

Prof. Wolfgang Weigand (pictured left) and his team are investigating the reaction pathway for electrocatalytic hydrogen production. · Photo: Jens Meyer

Even though hydrogen owes its name to water, in practice it is usually obtained from natural gas. This process however produces carbon dioxide. Depending on whether the carbon is released into the atmosphere as a greenhouse gas or is captured and stored, the hydrogen obtained in this process is referred to as »grey« or »blue«. There is also »turquoise« hydrogen; this is where heat is used to split natural gas (methane) directly into hydrogen and solid carbon.

Prof. Kalina Peneva and her research group are researching rylene dyes that absorb sunlight and help to obtain hydrogen from water. · Photo: Anne Günther

Whether green, grey, blue or turquoise, producing hydrogen requires energy, which ultimately determines how sustainable the energy source actually is. However, green hydrogen will ideally solve a problem that is often attributed to renewable energy sources: fluctuations in availability. Depending on the time of day and the weather conditions, solar power plants and wind turbines can deliver more or less energy than is actually needed. The possibility of storing excess energy in the form of hydrogen and using it elsewhere when required is one of the things that makes hydrogen such a promising source of energy.

Following in nature's footsteps

Obtaining hydrogen straight from water and sunlight is the main goal pursued by the scientists in the Transregional Collaborative Research Centre 234 »CataLight« at the University of Jena and Ulm University. They are following in the footsteps of Nature, so to speak, inspired by the way in which plants use photosynthesis to convert sunlight into chemical energy. The photochemical systems that are being developed and researched in the Collaborative Research Centre require a high degree of expertise and cooperation between a wide variety of departments.

From water to hydrogen

As photons (i.e. light particles) are governed by the laws of quantum mechanics, the quantum mechanical properties of the chemical systems that are hit by the light have to be understood in great detail. The desired chemical photosystems, on the other hand, are often difficult to recreate in the laboratory. And finally, the photosystem is used to supply energy to a specially designed catalyst with as little loss as possible, so that water can ultimately be converted into hydrogen. This cooperation between various sub-disciplines of chemistry will ideally result in a system that not only generates the coveted source of energy from sunlight and water, but is also inexpensive, durable and robust.

The question of how dyes are quantum-chemically excited by light is being researched by Prof. Kalina Peneva as part of the »CataLight« project. The chemist and her team are focusing on »rylene dyes«, which offer advantages over common dyes based on metal complexes containing iridium or ruthenium—purely organic rylene dyes can withstand light more effectively and are also less expensive.

Prof. Wolfgang Weigand is investigating the chemical step in hydrogen production using the example of »hydrogenases«. These enzymes are used by certain microorganisms that »feed« on the energy source. In order to find out how these enzymes work, Prof. Weigand and his team of chemists are creating model compounds of them, which are then examined in detail down to their quantum mechanical properties. Prof. Stefanie Gräfe and her team are responsible for examining the compounds at the level of theoretical chemistry.

But even though there are already some systems that can generate hydrogen from water by irradiation with light, there are still many obstacles affecting their practical implementation. After all, sunlight contains light of different wavelengths, including harsh UV radiation, which has to be endured by such a chemical system. And in everyday life, water is actually more than just H_2O—it contains salts, suspended particles and other compounds in different compositions that can influence the photochemical system. Last but not least, such a system also has to be cost-effective and producible in large quantities.

Catalyst for interdisciplinary research

In this way, hydrogen is not just a beacon of hope for industry and business, but also a catalyst for interdisciplinary research. The »CataLight« project brings together researchers not only from the University of Jena and Ulm University, which are providing the spokespersons in Prof. Benjamin Dietzek-Ivanšić and Prof. Sven Rau, but also the Max Planck Institute for Polymer Research in Mainz, the University of Vienna, the University of Mainz, the Technical University of Kaiserslautern and the Leibniz Institute of Photonic Technology in Jena.

It remains to be seen how long it will take for hydrogen to become established as a real source of energy. But if it comes to that, hydrogen might be given a whole new colour again. ■

Picture left: Schleichersee in Jena. Many people underestimate the importance of conserving water and promoting its sustainable use as an essential commodity. · Photo: Anne Günther

Dr Karsten Gäbler is coordinating projects within the »ThWIC« water cluster and, as a member of the Senate Working Group on Sustainability, he is also involved in the development of a sustainability strategy for the University of Jena. · Photo: Jürgen Scheere

»We want to create spaces for discourse«

Water is an essential commodity—we can't live without clean water. Despite posing an existential threat to society as a whole, the issue of water scarcity is not yet anchored in public discourse—even though many people in Germany should remember the extremely dry summer of 2022. That's why the Thuringian Water Innovation Cluster (»ThWIC«), in addition to developing new water technologies, wants to raise public awareness on the topic of water and promote a more sustainable use of our precious resource. In our interview with Dr Karsten Gäbler, he tells us how the innovation cluster is going to tackle this challenge and what role the future sustainability strategy of the University of Jena will play in the cluster.

INTERVIEW: LAURA WEIßERT

What does the Thuringian Water InnovationCluster(»ThWIC«)havetodo withthesustainabilitystrategyenvisaged by the University of Jena?

One of the key goals of the sustainability strategy will be to create a more tight-knit network for the research work carried out in Jena on major societal challenges. Take, for example, the Sustainable Development Goals that the United Nations set out in the 2030 Agenda: The research conducted by many scientists at our university is contributing to the 17 goals in one way or another. In launching the »ThWIC« water cluster, we have created a new platform that can be used to highlight the links between the individual goals based on water-related issues. Because clean water is not just a Sustainable Development Goal in its own right—it is also related to issues such as food security, health, energy and consumption.

What exactly does that mean for the cluster's research activities?

The concepts of »interdisciplinarity« and »transdisciplinarity« are very important to us and are also emphasized in the sustainability strategy. It is a truism that the great problems of our time cannot be pigeonholed into rigid scientific disciplines. In the »ThWIC« cluster, we are therefore trying to combine water research in the field of environmental chemistry, which is very well established in Jena, with sociological and literary research on water-related issues. And computer science is also involved with completely new approaches to managing water-related data. We want to create a more favourable environment for interdisciplinary research in the cluster. Interdisciplinary cooperation takes more time and requires completely different forms of communication, because those involved have very different approaches to the topic. The concept of »transdisciplinarity« is about what the university can contribute to ensure that we as a society achieve the transition to a more sustainable world. In our cluster, for example, collaboration with companies plays a huge role, and we also involve actors from politics and civil society. This cooperation also brings its own challenges, so we want to raise awareness for this and provide people with the qualifications they need. We can only answer complex questions together—we want to ensure that everyone is prepared for that and create spaces for discourse.

How are you fostering interdisciplinarity in teaching?

Starting in the 2023/24 winter semester, we will be introducing a »ThWIC Certificate«, whereby students will be able to practise interdisciplinary and transdisciplinary work on sustainability issues. Water will play a role, but other topics will also be covered. Our primary concern is to introduce students to interdisciplinary thinking and working as early as possible. If, for example, a sociology student and an environmental chemist meet in a seminar, this can present quite a challenging clash of scientific cultures. We want students to be able to learn to appreciate different approaches, listen carefully and respond constructively to the views of others, outside of their usual courses. Among other things, we will be offering compulsory integration events for all certificate participants, where we will answer questions such as »What is disciplinary identity?«, »How can I translate between different disciplines?«, and »What is sustainability?«.

In the future, we want to develop this into a continuing education programme aimed at people from small and medium-sized enterprises, in order to provide them with the qualifications they need to deal with the topic of water and transdisciplinary cooperation. The aim is to create a comprehensive teaching and learning platform on the subject of interdisciplinary/transdisciplinary water research for sustainability.

Theuniversity'ssustainabilitystrategy also envisages ways of making research more accessible to the general public or even involving citizens in research. How is the »ThWIC« water cluster planning to do that?

To name a few examples, we have launched an augmented reality project with the aim of making water infrastructure visible—that could serve as an introduction to the topic. Another project is concerned with individual water consumption. The aim of the »Public Water Science« project is to broaden society's knowledge of water—we call it »water literacy«—through outreach activities. We want to organize »Water Days« in schools, where young people will be able to do experiments and play around with the topic of water. There will also be a mobile water pavilion that can be driven to corporate events—and it will also make an appearance in public spaces, such as during campaign days in the city. There you will find information material on the topic of water, useful contacts and perhaps even interactive formats in the future. In the long term, we would like to succeed in not only raising public awareness of water issues, but also in conducting water research together with members of the public. ■

The voice of the victims of Stalinism

Irina Shcherbakova is the co-founder of the Russian human rights organization known as »Memorial«. The NGO, which was awarded the Nobel Peace Prize in 2022, has by now been liquidated and expropriated by the Russian state. The historian and human rights activist has joined hundreds of thousands of others in turning their backs on Russia and is currently living in exile in Thuringia. This is the portrait of a woman fighting tirelessly for the rights of the disenfranchised.

BY UTE SCHÖNFELDER

It's a Thursday morning in November 2022. Irina Shcherbakova is sitting in her apartment in Weimar, which has been her home for almost six months now and recalls what happened on 7 October 2022. »I was sitting here giving a video interview, just like I am now, when a Russian news tab popped up. The online portal called ›Meduza‹ reported that the Nobel Peace Prize had been awarded to Memorial, among others«. She admits that it hadn't even dawned on her that it was the first Friday in October—the day on which the laureates are announced by the Norwegian Nobel Committee.

Memorial, the human rights organization co-founded by Irina Shcherbakova in the Soviet Union over 30 years ago, had been nominated for the award on several occasions. The NGO had already received numerous other honours, including the Right Livelihood Award in 2004. »The fact that we've been awarded the Nobel Peace Prize at this difficult time is a great endorsement and recognition of our work. It's reassuring to know the past 30 years haven't been in vain in the eyes of the global community. And it motivates us to continue our efforts—even under the current circumstances«.

When she thinks back to that day, she was mainly concerned about the circumstances in Moscow. »At the time of the announcement, my colleagues were sitting in a courtroom. That was the day our premises were illegally seized by the state. It made the whole situation pretty absurd«. Memorial International had been dissolved by the Russian government at the end of 2021, and this was finally confirmed by the Supreme Court of the Russian Federation in February 2022. In spite of this tremendous challenge, Irina Shcherbakova and her fellow campaigners have not remained idle for a day and continue their work in dozens of international and regional Memorial organizations in Russia and the rest of the world.

Shcherbakova recalls that the Nobel Prize announcement was immediately followed by a string of »turbulent« weeks full of interviews, lectures, television appearances, the Marion Dönhoff Prize for International Communication and Reconciliation, a speech delivered to the EU Parliament, and tireless work to fight injustice in her homeland. At the University of Jena, she gave a moving speech during the welcoming ceremony for new students at the start of the winter semester.

As if on cue, Shcherbakova's phone rings. She takes the call with a curt response: »I can't talk right now«. Then she switches off her phone and says apologetically: »It's like that all the time«.

Family history shaped by Stalinist terror

Irina Shcherbakova was born in Moscow in 1949—»still during the Stalinist era«, as she points out. She comes from a family of Jewish communists. In the 1920s and 30s, her grandfather worked as a functionary in Lenin's »Communist International« (»Comintern«). Her mother grew up in Moscow's famous »Hotel Lux«, which served as a guest house for the Comintern, accommodating numerous political émigrés in the 1930s—many of whom were from Germany.

»The atmosphere was highly political. Most of my grandfather's friends and colleagues fell victim to the great Stalinist terror of the 1930s«. Irina Shcherbakova's childhood and youth were shaped by the experiences of her parents and grandparents. Her father was a literary scholar who published a journal on literature. »Literature was his way of enlightening people about what happened during the Stalinist era,« she says. In the post-Stalinist era of the 1950s, this could usually only be done in secret; many books recounting the horrific details of terror and the Gulag were self-published and banned. Up until the period of de-Stalinization that occurred during the »Khrushchev Thaw« in the 1960s, when the everyday life of a Gulag prisoner was first portrayed in Aleksandr Solzhenitsyn's novella entitled »One Day in the Life of Ivan Denisovich«, very little had been published on the subject at all.

This type of literature would ultimately be Irina Shcherbakova's gateway to history and her professional career. »I actually wanted to study history, but not the ideologized courses offered at the time,« she recalls. So, she opted for German Studies instead. After graduating and obtaining a doctorate from Moscow State University, she first worked as a translator of German fiction and as a journalist and editor for literary magazines.

Irina Shcherbakova is a historian and human rights activist on a tireless campaign to uncover injustice in her native Russia. · Photo: Jens Meyer

In the late 1970s, Irina Shcherbakova started to conduct secret interviews with Gulag survivors and recorded their conversations on tape. »At the time, those people were the only source available on the Gulag system. All official traces had been scrubbed away, and the archives were firmly locked,« she says. It was important to her that the victims of political persecution weren't forgotten; she wanted to aid their rehabilitation by giving them the opportunity to speak openly about what they had been through. Up until the 1990s, Irina Shcherbakova recorded around 100 interviews with contemporary witnesses, gradually revealing the sheer magnitude of Stalinist repression and injustice.

Mikhail Gorbachev's time as the leader of the Soviet party and head of state saw the emergence of the »glasnost« and »perestroika« policies, which sparked a major movement that affected millions of people in the Soviet Union and ultimately led to the establishment of the human rights organization »Memorial« in 1988. Irina Shcherbakova was one of its founding members; the dissident and Nobel Peace Prize laureate Andrei Sakharov served as the first chairman.

While researching the Soviet camp system in the late 1980s, she stumbled upon the history of Buchenwald Special Camp Number 2. The Soviet occupation forces kept German prisoners on the site of the former Nazi concentration camp between 1945 and 1950. In addition to Buchenwald, there were nine other camps in the Soviet Occupation Zone, in which a total of around 150,000 people were interned. Irina Shcherbakova then coordinated a research project to delve into the history of the special camps together with historians from the FernUniversität Hagen, who were joined by members of the University of Jena such as Lutz Niethammer and Volkhard Knigge. This is when she started to develop close ties to Thuringia.

Long-standing academic contacts in Thuringia

This was followed by numerous other joint projects, including the »Traces of the Gulag« exhibition by Memorial and the Buchenwald and Mittelbau-Dora Memorials Foundation, which was shown in Buchenwald and other parts of Germany under the direction of Shcherbakova and Knigge. Since the early 2000s, she has been collaborating with Norbert Frei and the Jena Centre for 20th Century History at the University of Jena, where she was a visiting professor in the 2008/09 winter semester. Since 1999, Shcherbakova has also been a member of the Academic Advisory Board for the Buchenwald and Mittelbau-Dora Memorials Foundation.

This close relationship to Weimar and Jena is one of the main reasons why Irina Shcherbakova now lives in Thuringia. »Even immediately before the Russian attack on Ukraine in February, I never expected to leave my homeland,« she says today. But as the reprisals against Memorial and its members grew, she started to fear that it might not be possible for her to leave the country at some point in the future. And so, like hundreds of thousands of her compatriots, she and her husband turned their backs on Russia in March. After spending a few months in Tel Aviv, she moved to Weimar in the summer of 2022. Since the start of the winter semester, she has also found her academic home in Thuringia as a visiting professor at the Imre Kertész Kolleg at the University of Jena. ■

»Stop looking away!«

In an interview, Memorial co-founder Irina Shcherbakova (p. 36), explains what has gone wrong in German politics in its dealings with Russia and how Putin has so far been able to keep the population quiet in his own country.

INTERVIEW: UTE SCHÖNFELDER

Mrs Shcherbakova, you have long been among the public voices warning against anti-democratic developments in Russia and the war in Ukraine. Nevertheless, this came as a surprise to many people in Germany. Why was the danger not seen?
I think that a lot of people just didn't want to see it. However, it must be acknowledged that we, as an independent NGO, have certainly been heard: there have been visits to Russia by German members of parliament who became familiar with the situation there. Memorial worked closely with partners in Germany, such as the Heinrich Böll and Friedrich Naumann foundations, for many years. So, there were certainly people who were aware of the danger. But there was also another tendency that was significantly more politically dominant: no one wanted a conflict with Russia because of the experience of history. This is especially true for Eastern Germany, where traumatic experiences of occupation, which have long been concealed and repressed, still run deep. Many people are simply afraid of war and, at the same time, there were and still are feelings of guilt towards the Russians. You can't blame the population for that.

Nevertheless, political mistakes have been made.
Yes, definitely. There was a great attempt at self-reassurance. On the one hand, there was the traditional Ostpolitik, which people did not simply want to abandon and endanger good relations with Russia. On the other hand—and this was particularly painful for us—it was always implied that Russia might not be capable of democracy and a lot of excuses were made for that reason. The worst mistake in relations with Russia, however, was the focus on economic interests. That was just very short-sighted. The growing dependence of the West, and Germany in particular, on gas and oil imports from Russia has enabled Putin to undermine relations. The German side has always tried to avoid addressing Russian domestic policy and to separate it from foreign policy. We have always warned against this, but our warnings have not been heeded.
When Russia annexed Crimea in 2014 and waged war in eastern Ukraine, it was clear where things were heading. What the West and Germany have done since then has been absolutely inadequate, in my view. Since then, a lot of time has been lost.

What is to be done now?
We must face the situation and no longer look away. And we must not repeat the mistakes of the past. Now it's simply a matter of supporting Ukraine. Ultimately, this will benefit the Russia of the future, which I may not live to see. I believe that Russia will change. But it will take a long time. But if Putin now succeeds in escalating the war into a permanent conflict, he will always have leverage with which to blackmail the West. In that case, there will be no chance for a better future for Russia for a long time.

What is the attitude in Russia now? Why don't people rebel against Putin?
Unfortunately, most people have learned to adapt during the long years of Putin's dictatorship. There were and are a few people who are critical of this war. But there are simply not enough of them to stop the war. In addition, Putin has been allowed to build a massive apparatus of violence, the extent of which cannot be compared even with the darkest days of Brezhnev's rule. Today, people are being tortured again in Russia! We haven't had anything like this since Stalin's time. This frightens the majority of people and they resign themselves to the situation because they believe that they have no means of opposing this state.
Added to this is the massive amount of propaganda against the West, against Ukraine, against democracy. This propaganda gives people the opportunity to justify the actions of the state and to be »reassured« and look the other way. And that's twice as bad.

Will it be possible to negotiate with Putin at some point about an end to the war?
Not with Putin. And it isn't possible to negotiate, either. Of course, it's clear that every war ends with some kind of treaty. That will also be the case with this war. But I don't think that Putin could play any role in that, because it takes a minimum of trust on the other side that the treaty will be respected. And Putin has squandered that trust. Hopefully, the West has now understood that as well. And in my view, it's quite clear that Ukraine has to set the conditions for any treaty. Not Russia and not the West. ■

The end of multilateralism?

Ever since Russia launched its war of aggression against Ukraine, the United Nations Security Council (UNSC)—and with it the entire system of collective security—has attracted popular criticism. After all, the mechanisms for preventing and managing armed conflict, as enshrined in the Charter of the United Nations, have been unable to prevent or contain the war to any significant extent. Does this mean that the Security Council has failed?

COMMENTARY: CHRISTIAN KREUDER-SONNEN

Christian Kreuder-Sonnen is Junior Professor of Political Science and International Organizations. · Photo: Anne Günther

In theory, the UN system of collective security provides that if one state attacks another, the international community (represented by the UN Security Council) will respond with diplomatic, economic or military sanctions of such significance that a potential aggressor is effectively deterred or an actual aggressor is thrown off course. In practice, however, the Security Council's voting rules make it difficult to implement this principle. It is a well-known fact that a resolution can only be adopted with the approval of the five permanent members, including Russia.
This right of veto afforded to the victors of World War II has always prevented the effective multilateral management of crises involving one or more of these states. It was not least at the instigation of the United States that the authority of the Security Council was limited to impeding wars between smaller or emerging states on the one hand and preventing wars between the great powers on the other. The veto powers never intended to rule out the possibility of their own colonial, imperial, or (later) liberal wars. Hence, we cannot really say that the Security Council has failed in the Ukraine war; the conflict has merely exposed the deliberate flaws of the system.
In view of the current geostrategic situation, however, even a Security Council with a more representative membership and without the right of veto could hardly have made a significant difference. While majority decisions may well have resulted in the Council condemning Russia and imposing more extensive sanctions, any form of military intervention would probably still have been ruled out. After all, NATO is the only military force capable of carrying out a Security Council-authorized mission in response to the Russian invasion of Ukraine. However, this would result in a direct confrontation of nuclear powers, the prevention of which is in the overriding interest of humanity as a whole.

UN still plays an important role in the Ukraine war

One of the bitter lessons of the war in Ukraine is that the institutional achievements after World War II and their consolidation following the Cold War still do not offer effective protection against power politics and the pursuit of national interests by military means. Multilateralism and international law are only effective if their norms are internalized by the members of the international community. As long as countries like China and India, which together make up a third of the global population, as well as a large number of authoritarian developing countries, refuse to even condemn Russia's hostilities, little can be gained from the existing instruments.
Nevertheless, the United Nations still plays an incredibly important role in the Ukraine war. In addition to a number of declaratory resolutions adopted by the UN General Assembly and Russia's exclusion from the UN Human Rights Council, which have accelerated the country's diplomatic isolation, it is mainly the humanitarian aspects of the UN's work that make an impact. Specialised organizations like the UN Refugee Agency, the World Food Programme or the UN Office for the Coordination of Humanitarian Affairs (UNOCHA) are playing a key role in providing first aid and helping to alleviate human suffering. The UN institutions responsible for obtaining and evaluating information are also playing an important role in the current situation; the High Commissioner for Human Rights is documenting evidence of Russian war crimes, the High Representative for Disarmament Affairs has refuted Russia's allegation that Ukraine is conducting a biological weapons programme, and the International Court of Justice has rejected Russia's claims of Ukrainian genocide.
The United Nations cannot prevent wars. However, the organization makes an essential contribution to cushioning their humanitarian impact and enables conflicts to be dealt with through its institutional network. It remains to be seen whether the organization will play an even greater role in peace negotiations or subsequent peacekeeping. In this regard, much depends on the authority of the UN Secretary-General. ■

What can—or can't—we do without?

Lighting, offices, bonus miles… We asked researchers from the University of Jena what they are doing without in the face of the energy and climate crisis, the ongoing coronavirus pandemic and the war in Ukraine. They also told us what is essential for them and what has turned out to be redundant and outdated during the crisis.

SURVEY: IRENA WALINDA

PHOTO: JENS MEYER

Birgitta König-Ries

PROFESSOR OF DISTRIBUTED INFORMATION SYSTEMS

One thing we can't do without is our research, which aims to preserve, develop and integrate FAIR research data in the interest of making science more sustainable and developing solutions to overcome the climate and biodiversity crisis.

What do we not want to do without? A nice mixture of digital and face-to-face formats in research and teaching: fast digital communication in working groups, but also personal meetings; streaming of presentations at conferences, but also networking opportunities that only real meetings can offer; hybrid teaching with plenty of room for interactive elements.

What should we not do without? Breaks. We're often tempted to arrange tight schedules packed with digital formats. You can switch seamlessly from one video conference to the next. We end up sacrificing the time needed to catch our breath, prepare for a meeting or think about something in peace.

PHOTO: JENS MEYER

Malte C. Kaluza

PROFESSOR OF RELATIVISTIC LASER PHYSIC

It's not that easy to save energy in our high-power laser labs. As temperatures have to be kept exactly the same throughout our experiments, our air conditioning system consumes much more electricity than the lasers themselves. The computers and other electronic devices required for controlled laser operations also account for a large amount of our energy consumption. We have already improved our efficiency by minimizing the number of computers as much as possible. We also switch off our devices whenever they're not in use, which also reduces the amount of heat energy that has to be dissipated by the air conditioning system.

Every reduction in energy consumers and heat sources in the laboratory is therefore reflected twice over in the overall energy balance. Far too little attention was paid to these aspects of research work in the past, but the current crisis shows just how important they are and will continue to be in the future.

What can we do without—and what can we not do without? Both of these questions are difficult to answer. On the one hand, we don't want to compromise on our quality of life or prosperity. But if you think about it more closely, that's exactly what is asked of us at the moment. I think that everyone has to do their part but should also be allowed to do so on a somewhat individual basis.

In terms of our day-to-day work, I think that our main focus should be on making our processes more efficient and, above all, more resource-friendly. The ERP project is a good start—it puts us on the right track in the long term.

PHOTO: ANNE GÜNTHER

Kristina von Rhein

MANAGING DIRECTOR, FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION

The overlapping crises of our time are also leaving their mark on legal research and teaching. There's been a shift in topics and priorities; our individual, long-term scientific interests are sometimes overshadowed by objective research needs. To a certain extent, however, this is a natural characteristic of jurisprudence as a discipline which is inextricably linked to the development of the legal system to which it is essentially related.

It is to be hoped that we don't stay in crisis mode for too long, since highly relevant topics such as climate change, digitalization and demographic change are also awaiting legal research. I really do welcome the digital boost that teaching, self-administration and conferences have experienced as a result of the Corona crisis. The progress achieved in this respect should be secured and expanded in the interest of ensuring the quality of our education, sustainability, and time management. Last but not least, the fact that you no longer have to submit paper forms is a real step forward in everyday university life. At the same time, however, I've come to appreciate the special quality of personal exchange. That's why the future is hybrid!

PHOTO: JAN-PETER KASPER

Matthias Knauff

PROFESSOR OF PUBLIC LAW, ESPECIALLY PUBLIC COMMERCIAL LAW

PHOTO: ANNE GÜNTHER

Johannes Grave

PROFESSOR OF MODERN ART HISTORY

While museums are working hard to save energy and air conditioning and drawing up contingency plans, university art history can only adopt the measures we all see in our everyday lives: turning down the radiators, improving ventilation, avoiding unnecessary trips or even working from home more often, so that only one workspace has to be heated instead of two.

The early days of the pandemic showed us some of the things we can't do without unless we're prepared to make huge sacrifices: personal interactions and direct encounters with works of art, which can never be fully replaced by digital copies. As we look beyond the current energy crisis, we should consider rethinking things in other areas. When it comes to publications, we should favour quality over quantity. We should also restructure academic career paths—we're potentially wasting young people's precious time and opportunities by providing them with further qualifications after their doctorate in temporary positions without offering them suitable long-term employment prospects.

PHOTO: ANNE GÜNTHER

Christopher Spehr

PROFESSOR OF
CHURCH HISTORY

The crises of the past few years have brought about positive change in many respects, as we've introduced more flexible ways of working, reconsidered our previous working conditions and structures, and added a touch of inventiveness to our lesson plans. Thanks to digital teaching and forms of communication in research and administration, we've managed to boost our attendance rates and saved on travel time and expenses. We've also noted an increased awareness of sustainability, for example in the use of energy and paper.

At the same time, I've noticed that online formats also have a few weak points. For example, there are significant restrictions when there's a power cut or when the university network is down. More importantly, personal interactions in everyday university life can be supplemented by digital formats, but they can never be replaced. The creative exchange of ideas is fuelled by face-to-face meetings, whether in seminar rooms, at workplaces or in committee meetings.

PHOTO: ANNE GÜNTHER

Georg Pohnert

PROFESSOR OF
ANALYTICAL CHEMISTRY

My team works in the field of microbial communication. We are one of the many groups at our university researching sustainability issues. But are our research activities themselves sustainable? In short, the answer is »no«. After all, we use a lot of energy to run our analytical devices, we use plastic vessels and pipette tips to cultivate our model organisms, and we travel to field stations and conferences.

However, these activities are essential for productive research. We scrutinize the operating times of our devices, we think about where we can avoid waste without jeopardizing our experiments, and we thoroughly evaluate which trips are necessary and whether there are sensible alternatives. We've changed our everyday laboratory practices and critically question our resource efficiency as part of our planning. However, we can't stop using resources if we want to continue to efficiently obtain new knowledge.

If you look at some of the things we were initially forced to give up, and then sometimes ended up being grateful for having to give up, short trips are at the top of my team's list. It's really easy to hold meetings and small conferences online, which also makes it easier to fit them into your everyday life. That's turned out to be a win, because the technical possibilities have provided us with a multi-location seminar that gives us completely new insights.

This has also facilitated our cooperative research activities, because you can talk to one another more often online and not just at conferences. However, many aspects of the teaching covered by my research group still have to be carried out on site, especially practical lessons in the laboratory. But relying solely on classroom-based teaching has become outdated. It's much easier to include those who can't be there for good reason—and you can still save energy at work by heating and ventilating wisely.

PHOTO: ANNE GÜNTHER

Holger Cartarius

PROFESSOR OF
TEACHING METHODOLOGY IN
PHYSICS AND ASTRONOMY

PHOTO: ANNA SCHROLL

Jutta Hübner

PROFESSOR OF
INTEGRATIVE ONCOLOGY

ENERGY: We can do without unnecessary energy that doesn't let us achieve anything worthwhile. We shouldn't do without the energy we sense when we're passionate about something and can inspire others. Enthusiasm is the best form of renewable energy, because it's the foundation of our human existence. HEATING: We can afford to turn down the heating a few degrees here and there, such as in our homes and maybe even in offices, but not in our hospitals, surgeries and old people's homes. RESOURCES: We can and must do without resources that are consumed instead of created, but we can never do away with the most important human resources: values, freedom, dignity and the opportunity to give our own life meaning. POWER: We have to do without power that only serves to destroy, but not where it gives us strength, protection and support, and doesn't make us appear powerless.

Above all, we should avoid focusing on the negatives in our everyday language and science communication. Instead, we should think about what we can do and what we have to do: the unwavering belief that research makes an important contribution to solving current and future problems; the commitment to teaching that inspires young people to get involved and not to despair of their own future; the courage to look beyond the bad sides of life and see the good, beautiful and righteous and to stand up for it.

PHOTO: ANNE GÜNTHER

Frank Hellwig

PROFESSOR OF
SYSTEMATIC BOTANY

The coronavirus pandemic has given us a real boost on the road to digitalization in teaching. On the other hand, we've struggled with a few aspects of our practical teaching, such as in plant identification courses and field work. With a view to climate action and the energy crisis, we've taken the necessary steps to ensure that our greenhouses in the Botanical Garden can be largely heated with renewable energies in the future. We're looking to use geothermal and solar energy, which means that most of our CO_2 emissions will be cut.

The use of digital means of communication has also made many of our business trips unnecessary, which also helps to fight climate change and saves us a lot of time. However, we've also noticed that face-to-face interactions are needed from time to time to cultivate relationships and mutual understanding. Finally, we too have been affected by the war in Ukraine. We've discontinued or postponed our cooperation with Russian scientists.

Katharina Heiling working on the restoration of the historical detention cell at the University of Jena. In the summer of 2022, she stabilized and cleaned the paintings on the walls of the former student prison and touched up a few imperfections. The paintings are a homage to Roman history: the »Rape of the Sabine Women« in the form of professors abducting ladies (on the wall on the left) and »Gaius Marius Amid the Ruins Of Carthage« (the figure on which the restorer is working). Katharina Heiling talks about her work in the detention cell in this video (QR code). · Photo: Jens Meyer

Facts, not legends

200 years after being painted, the former detention cell at the University of Jena—the Karzer—has been restored to its former »glory«. Over the course of the restoration work, it turned out that its history has to be rewritten.

BY AXEL BURCHARDT

200 years ago, in July 1822, one of the nine detention cells for students at the University of Jena is said to have been »decorated« in just one day. The story goes that the Swiss student Martin Disteli was serving time in detention when he decided to use blood, excrement and other organic materials to paint numerous scenes and caricatures on the walls of the approximately 15-square-metre cell. As intriguing as this story may sound, it is merely a legend, as clearly demonstrated by the restoration of the historical detention cell 200 years on.

The only historical student detention cell in Thuringia

The former student prison, built in 1738 and used until the mid-19th century, is located in the building that adjoins the university's old Senate building and that now houses parts of the Institute of Anatomy. The cell window looks out onto the former monastery grounds (»Kollegienhof«). For many years, the detention cell was only opened to visitors on special occasions for fear that the rare paintings might be damaged by wandering hands or perspiration. »It's the only historical student detention cell in Germany that was completely painted by a single artist,« says Dr Babett Forster, Head of the University's Custody. As she and her colleague Gina Grond were keen to make this historical gem more accessible to the public, they set about restoring the cell using methods that would ensure suitable protection for the paintings. Once the Custody had obtained the necessary funding from the Thuringian State Office for the Preservation of Monuments and Archaeology, as well as the Association for City and University History in Jena and the Friends and Patrons of the Friedrich Schiller University Jena, the restoration project could begin.

The work was assigned to Katharina Heiling, a restorer specializing in student detention cells. Before the practical phase of the project could begin in Jena, she sent some material samples from the detention cell to a special laboratory in Prague. The analysis proved that neither blood nor excrement had been used for the artwork, but rather paints that were common 200 years ago. Disteli is thought to have made the colours himself from yellow and brown ochre (naturally occurring earth pigments), using linseed oil and lime casein as binding agents. The first part of the legend had been debunked.

The tale that Disteli had decorated the detention cell as a prisoner in a matter of hours was also consigned to the realms of mythology by Katharina Heiling. The restorer cleaned the surface to gain an unimpeded view of the paintings, allowing her to prove that Disteli had not used a rapid fresco technique on wet lime plaster, but instead employed a secco technique on plaster that had already dried.

Artwork not created »in detention«

It is striking to note that different binding agents have been used on the various walls, which makes the paintings on the north wall differ greatly from the others. Forster says that her team now assumes that Martin Disteli was not serving time in detention when he decorated the room, but was merely visiting the cell and took the opportunity to paint its previously blank walls. The date, 30 July 1822, probably refers to when the work was completed.

The work of the Swiss painter and political cartoonist Martin Disteli is a work of art that should be preserved. Restorer Heiling stabilized the walls and paint, cleaned the paintings and touched up missing areas. »Any marks evidencing the use of the detention cell will not be restored,« she says. A particular challenge was a find Heiling made when examining the fourth, apparently single-coloured wall with UV radiation. The short-wave radiation can cause a work of art to fluoresce, thus enabling a more differentiated perception of the painting materials used. As a result of her investigation, she has proven that other paintings are hiding behind the layers of paint that were added at a later date. »The wall was painted over later,« asserts Heiling. ■

PHOTO: BEATRIX HEINZE

Life in the bowels of the Earth

The microorganisms found in aquifers deep below the Earth's surface produce similar amounts of biomass as those in some marine waters. This is the conclusion reached by a team of researchers led by the University of Jena and the German Centre for Integrative Biodiversity Research (iDiv).
They have used a unique, highly sensitive measuring technique with radioactive carbon to prove for the first time that these communities do not depend on solar energy in total darkness. Instead, they obtain their own energy from the rock oxidation or from compounds transported downwards. Their study has been published in »Nature Geoscience« (DOI: 10.1038/s41561-022-00968-5). Tilch

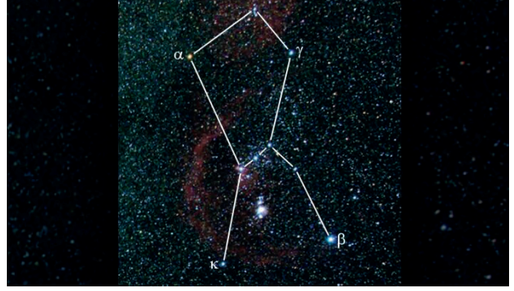


PHOTO: MARKUS MUGRAUER

Red giant was once yellow

As nuclear fusion progresses within a star, there are changes in its brightness, size and colour. These properties provide astrophysicists with information about the age and mass of a star. Stars with significantly more mass than the sun are blue-white or red—the transition to red via yellow and orange occurs relatively quickly by astronomical standards. A team from the University of Jena has succeeded in reconstructing a highly precise time frame for this colour change. With the help of historical sources, they have found that Betelgeuse—the bright red supergiant in the top left of the Orion constellation (see photo)—was actually yellow-orange around 2,000 years ago. They have reported on their research results in »Monthly Notices of the Royal Astronomical Society« (DOI: 10.1093/mnras/stac1969). sh

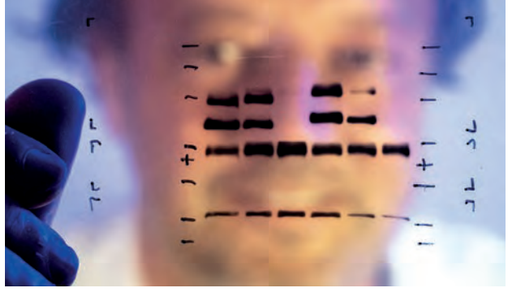


PHOTO: JENS MEYER

New approach to tumour therapy

A novel method for treating malignant tumours of the lymphatic system has been discovered by a team of researchers from the University of Jena together with fellow researchers from Mainz, Regensburg and Montreal (Canada). The team has demonstrated that treating certain B-cell lymphomas with the enzyme inhibitor »Marbostat-100« significantly slows down the growth of the tumour cells. The researchers have shared their results in »Oncogene« (DOI: 10.1038/s41388-022-02450-3).
They have shown that the inhibition of a specific enzyme (histone deacetylase 6) leads to a significant reduction in the concentration of the »myc« transcription factor in the tumour cells. The long-term goal is to develop a new combination therapy to treat aggressive types of cancer. US

PHOTO: JENS MEYER

Watching the lights go out

A team from the University of Jena has installed a new camera on the »ID16B« X-ray nanoprobe at the European Synchrotron Radiation Facility (ESRF) in Grenoble (France) that can measure ultra-fast processes with temporal resolution. The camera has now been used to measure for the first time how the light from a photon source in a nanowire decays after being excited by an X-ray pulse. This basic research opens up the possibility of using nanowires in quantum communication (e.g. as waveguides for light).
The nanowires made of semiconductor material contain so-called »foreign atoms«, which act as photon sources. The researchers have published their first results in »Advanced Science« (DOI: 10.1002/advs.202205304). AB

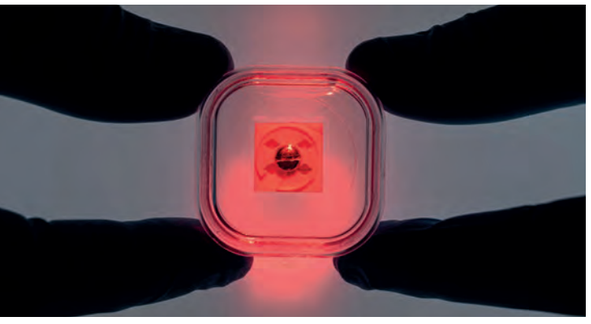


PHOTO: JENS MEYER

The peregrine falcon's prey

An international team of researchers, including scientists from the University of Jena, have been examining soil samples that a Japanese space probe (»Hayabusa-2«) collected from the Ryugu asteroid. By analysing the extra-terrestrial material, the researchers have gained insights into the formation of the asteroid and the processes that took place in the first five million years after our solar system was born. The team has described its findings in »Science« (DOI: 10.1126/science.abn8671).
For example, the researchers have found evidence to suggest that Ryugu's »nursery« was not located near the centre of our solar system, where the asteroid can be found today, but in the outer regions. It is conceivable that Ryugu used to be a comet. As it got closer to the sun, the water evaporated to a certain extent, leaving solid dust behind. Schimmel

PHOTO: UTA VON DER GÖNNA

Test for recognizing voices

A team of researchers from the University of Jena developed a standardized test for voice memory. The aim of the »Jena Voice Learning and Memory Test«, which is freely available on the Internet, is to make research data on person perception more comparable, and it could also be used in clinical diagnostics or forensics in the future. The test first introduces different male and female voices. In the next part of the test, participants have to pick out the voices they have learned several times from various audio samples. The test has been evaluated and proven to be a reliable tool for measuring a person's ability to learn and recognize voices.
Thanks to the test, which has been published in »Behavior Research Methods«, the study team has even identified »super-recognizers« and »voice-blind« people (DOI: 10.3758/s13428-022-01818-3). vdG

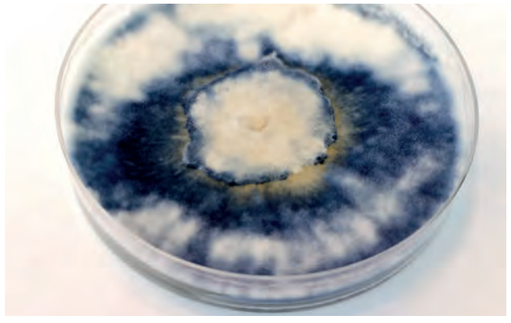


PHOTO: STEFANIE LAWRINOWITZ

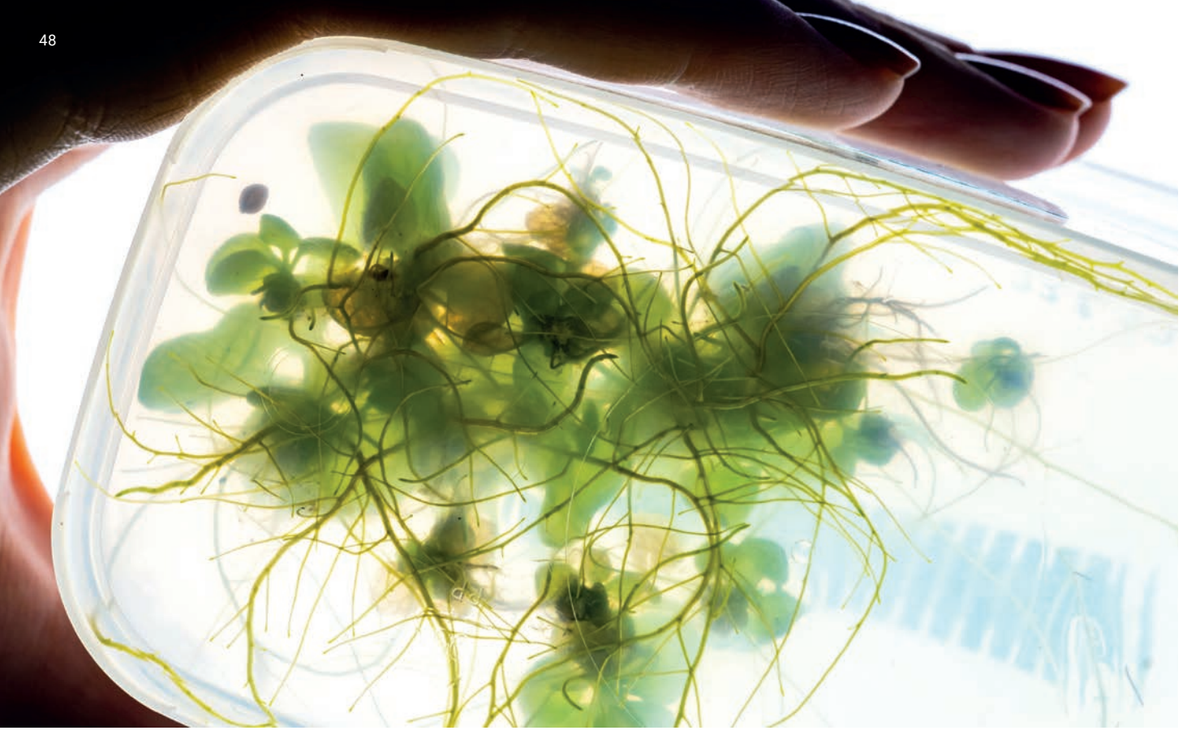
Blue fungus in a new light

Terana caerulea (see photo) is a type of fungus that grows on the trunks and branches of deciduous trees. It is characterized by its intense cobalt blue colour. The class of substances from which this blue colour is derived is common in many species of fungi. It enables fungi to produce bioactive substances that degrade deadwood—and through which they can interact with their microbial environment. Researchers from the »Balance of the Microverse« Cluster of Excellence at the University of Jena have been examining how the fungus produces this blue substance. They have found one crucial factor: light. They have shown that the gene responsible for this colouration can only be correctly read under the influence of light. The researchers have presented the results of their study in »Microbiology Spectrum« (DOI: 10.1128/spectrum.01065-22). Gold

PHOTO: JENS MEYER

Fragrances encapsulated by polymers

As pleasant as some fragrances may be, excessive amounts of perfume from various cosmetics, cleaning agents and detergents can pollute the environment if they get into the sewage system. Chemists from the University of Jena have developed novel polymers with which fragrances can be encapsulated and thus released in controlled doses over a longer period of time. This could help to significantly reduce the environmental impact of fragrances. The team has published its results in »ACS Applied Materials & Interfaces« (DOI: 10.1021/acsami.2c16205).
The researchers have been using »graft copolymers«, consisting of a long molecular main chain and shorter side chains. They are developing polymers that resemble fragrances in their chemical structure, which allows them to bind to the fragrances. JK



Left: The water fern species Ceratopteris richardii is a model organism in plant genetics. · Photo: Jens Meyer

Right: Prof. Günter Theißen is one of the authors of the publication in »Nature Plants«. The paper describes how an international research team has decoded and analysed the complete sequence of the genome of *Ceratopteris richardii* (seedling in the box) · Photo: Jens Meyer

Fern genomes contain accumulated »junk«

They are among the organisms with the most extensive genomes—the genetic material of a fern plant may have up to 720 chromosome pairs. The extravagant size and complexity have so far made it hard for researchers to clarify fundamental aspects of fern biology and the evolution of land plants through genome-based research. However, an international team has now succeeded in fully decoding one of the first fern genomes, with some surprising results.

BY UTE SCHÖNFELDER

Sequencing the genome of *Ceratopteris richardii* was a truly mammoth task. It took researchers from a total of 28 institutions around the world more than eight years to decode the fern's huge genome, which has 7.46 gigabase pairs (billion base pairs)—more than twice as many as humans.

The fern *Ceratopteris richardii* belongs to the monilophytes, the closest living relatives of all seed-bearing plants, which include not only ferns but also horsetails in particular.

»The small plant is easy to cultivate and grows very quickly, so it can be used to study the entire life cycle of a fern plant,« says Prof. Günter Theißen of the University of Jena. That makes this fern the ideal model organism for research, says Theißen, explaining the importance of the plant, which is fairly inconspicuous to laypeople but known as »water fern« by nearly every aquarium enthusiast. Genetics professor Theißen is part of the team that has now published the *Ceratopteris* genome.

Repetitive sequences make up 85 per cent of fern DNA

The analysis of the genome now provides the researchers with the first clues as to why ferns contain so much DNA. Since the 1960s, it had been assumed that this was due to multiple duplication of the genome, in which an extra set of chromosomes is accidentally passed on to the offspring. Such duplications of the entire genome are known from many plants, and even animals, but it has now become apparent that they are not solely responsible for the size of the *Ceratopteris* genome. If *Ceratopteris* had accumulated its DNA through repeated genome duplications, large parts of its genetic material should have shown characteristic similarities, but this is not the case.

Instead, the researchers found a hotchpotch of repeated sequences and millions of short gene snippets that together made up 85 per cent of the fern's DNA. Therefore, instead of multiple genome copies, Ceratopteris mainly contains genetic »junk« that has accumulated over millions of years.

This »junk« is above all the result of the activity of transposons and retrotransposons, known as »jumping genes,« which occur in all higher organisms, but apparently feel particularly at home in fern genomes.

Insights into the evolutionary history of flowers, fruits and seeds

Günter Theißen's team in Jena is not so interested in the many leftovers of transposons and retrotransposon activity in the genome, but instead it has identified and analysed the fern's MADS-box genes as part of the study. Members of this gene family control important developmental processes in flowering plants, especially flower and fruit development.

»To find out how flowers and fruits developed in the course of evolution, we have been studying the evolutionary history of these genes in my research group for a long time,« says Theißen. He and his colleagues were also one of the first groups ever to isolate some MADS-box genes from the fern *Ceratopteris richardii*, some 25 years ago. However, it is only with the analysis of the complete sequence of the fern genome that it has been possible for the first time to obtain a complete overview of all MADS-box genes present in the fern.

»The results show us that 25 years ago, we had already gained quite a representative overview, but not a complete collection of the genes we were interested in,« adds Theißen. It has now been confirmed that the specific subfamilies of MADS-box genes that control flower development in flowering plants arose as early as 300-400 million years ago in the evolutionary lineage that led to today's seed-bearing plants, after the lineage that led to the ferns that exist today had already split off.

The fern genome sequence that is now available also provides the basis for completely new research questions for the working group led by Theißen. »We want to test the hypothesis that changes in specific MADS-box genes played a role in the formation of the seed—one of the most important innovations of land plants and an essential basis of human nutrition.« The functional studies using *Ceratopteris richardii* that are required for this are technically challenging, but they have become much easier with the genome sequence now published. ■

Original publication:
Dynamic genome evolution in a model fern. Nat. Plants (2022). https://doi.org/10.1038/s41477-022-01226-7

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Twisted-wing parasites feel no pain

When insects of the order of twisted-wing parasites mate, their fate is sealed: While the males spend their extremely short lifespan with a single mating flight, the females pay for reproduction with their own lives. A research team has now figured out how they at least endure the traumatic mating.

BY UTE SCHÖNFELDER

Left: Hidden in the abdomen of a mining bee lives a female of the species *Stylops ovinae*. Only the anterior abdomen pinhead-sized foregut (light yellow) protrudes from the host animal. Right: Frontal view of a male twisted-wing parasite. · Photos: Hans Pohl

Reproduction in the insect order *Strepsiptera*—also known as twisted-wing parasites—is not for the fainthearted. To inseminate the eggs of its partner, the male partner injures the »neck« of the female with its hook-shaped penis and injects the seminal fluid directly into the body cavity. This traumatic insemination is risky for the female. For example, the injury may result in a loss of body fluid and invading germs may cause infections. However, in the course of evolution, the females of the strepsipteran species *Stylops ovinae* and *Xenos vesparum* have become morphologically well adapted to the brutal advances of their partners. This is the conclusion of a research team working at the universities of Jena, Kiel and Freiburg, and the Karlsruhe Institute of Technology, which reports on its findings in the scientific journal »PeerJ«.

A whole lifetime hidden in the abdomen of other insects

Twisted-wing parasites can be found all over the world. The fact that almost no one knows them is probably because, like many other insects, they are rather small and inconspicuous, measuring only a few millimetres. Apart from the extremely short life span of the males—only a few hours—the decisive factor is probably that »the females of the vast majority of the species spend their entire lives as parasites well hidden in the abdomens of other insects,« explains Dr Hans Pohl from the University of Jena.

Stylops ovinae, for example, lives in the mining bee (*Andrena vaga*) and *Xenos vesparum* in paper wasps (species of the genus *Polistes*). Only the cephalothorax, which is about as large as a pinhead, protrudes from the host. »So, in order to reproduce at all, the parasites have to come up with something,« says Pohl, an insect expert and head of the team of authors of the present publication. Because the male cannot reach the usual mating area on the female abdomen, only the anterior part of the female's body is available to inject the sperm.

However, as the team has now discovered, the females of the two species studied are not defenceless against the males during the traumatic penetration. »We were able to show that the cuticle of the females of *Stylops ovinae* and *Xenos vesparum* is clearly thickened in a certain part of the body between the head and the trunk. This is the region where the male stabs the female with his penis,« explains PhD student Kenny Jandausch, first author of the study. The entire cuticle contains a lot of resilin, a protein molecule that makes the outer skin particularly elastic. However, as the skin at the puncture site is thicker than at other areas, the injury there is less dangerous for the female parasite because it allows the wound to close very efficiently. »In contrast to *Xenos vesparum*, this site forms a kind of pocket in *Stylops ovinae* into which the penis is inserted,« says Jandausch.

Kenny Jandausch observes twisted-wing parasites mating. · Photo: Jürgen Scheere

Broad range of methods reveals mating mechanism

But how exactly do the females attract the males? First of all, in a very classical way: »Virgin females emit an odour that attracts males from the surrounding area,« says Hans Pohl. The entomologists were able to observe this directly in the countryside around Jena. With a small cage of female twisted-wing parasites ready for mating, the researchers attracted males and took them back to their laboratory. There, they joined males and females in Petri dishes, observing them through a microscope. They discovered that the females not only attracted males of their own species, but also other *Stylops* species tracked the odour, whereas only males of the same species were able to mate with the females. »Our hypothesis is that the mating pocket represents a prezygotic barrier that prevents mating between different species before fertilisation,« explains Hans Pohl.

In the end, however, there is bad news for female twisted-wing parasites: after the sperm has fertilised the thousands of eggs in her body, just as many tiny larvae develop, which are born alive a few weeks later—an event that the mother herself does not survive. ■

Original publication:
Have female twisted-wing parasites [...] evolved tolerance traits as response to traumatic penetration? PeerJ 10:e13655, DOI: 10.7717/peerj.13655

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Happy wife—happy life?

If the woman is satisfied, the relationship will be smooth sailing. This has become a sort of modern wisdom in society. But the cliché that the woman acts as a »barometer« in a heterosexual relationship is not true. As an international team of researchers has now shown, the man's perceptions are also a reliable indication of satisfaction in a relationship. This is just one of many ground-breaking revelations to emerge from a long-term project on couple and family relationships known as »pairfam«.

BY SEBASTIAN HOLLSTEIN

In the 1980s, sporadic scientific findings seemed to suggest that women were more sensitive to relationship issues, allowing conclusions to be drawn about the future of relationships. But this misconception has now been corrected by an international team of psychologists, including Prof. Franz J. Neyer from the University of Jena. Their wide-ranging study proves that satisfaction within a relationship can also be predicted according to the man's perceptions. Their research results have been reported in »Proceedings of the National Academy of Sciences« (PNAS).

Prof. Franz J. Neyer, psychologist and relationship expert · Photo: private

»We're pleased to have helped dispell this cliché,« says Neyer. »It might fit into the gender stereotype that women are relationship experts or more driven by relationships, and that only their perception can be used to predict satisfaction within a relationship, but no evidence of this could be found in our systematic study. In actual fact, men's perception is just as predictive as women's«.

3,400 couples monitored over five years

The researchers surveyed over 4,000 couples for the »pairfam« study. 900 of them provided diary-like entries about their relationship. The information obtained from 3,400 more couples had a more long-term scope over a period of five years. In both cases, the experts analysed the data to make predictions regarding future satisfaction within certain relationships, which then also came true. »Our recent findings not only help to debunk social stereotypes, but also support the development of effective therapeutic methods that could help people with relationship issues,« says Neyer.

The long-term data for the study was obtained from the »pairfam« panel, which had been collecting data on intimate relationships and family dynamics in Germany since 2008 before the platform was closed after 14 years. As part of the study funded by the German Research Foundation (DFG), up to 12,000 people were surveyed each year together with their partners, parents and children. »pairfam was a highly innovative concept that included not only focus persons, but also their family environment, enabling us to study intergenerational relationships as well,« says Neyer, who spent eight years coordinating research on intimate relationships as part of the project.

There's no »undateable generation«

The first ground-breaking research results emerged even before the project had been concluded. The researchers have published over 200 articles in renowned journals. For example, »pairfam« helped to prove that there is no such thing as an »undateable generation«. »We couldn't find anything to substantiate that claim. Most people look for and have intimate relationships,« says Neyer.

While the percentage of stable relationships lasting longer than a year has fallen slightly among young adults, the trend is now shifting towards shorter-term relationships, so the amount of time they are actually in a relationship is not changing. »Perhaps young adults are now more willing to experiment before ultimately committing to a long-term relationship,« suspects the psychologist from the University of Jena.

Most people are still interested in relationships today. · Photo: Anne Günther

The psychologists involved in the »pairfam« project have also observed recent changes in the way people are finding partners. There has been a significant rise in the use of online dating; this mainly benefits highly educated women, who have been able to get married in greater numbers as a result.

Long-term panel to be continued in the new »FReDA« format

The long-term study has provided fresh impetus for research; the wealth of data will enable further results to be obtained for a long time to come, and international cooperation will be intensified through newly created networks. For example, psychologists from the University of Jena are cooperating with a team of Canadian researchers who are looking to develop a project similar to »pairfam« for the North American country.

And the long-term »pairfam« panel will also be continued as part of the new »Family Demography Panel Study« (»FReDA«), which will also be dedicated to the topics of relationships and family life in Germany, based at the Federal Institute for Population Research (BiB). Franz J. Neyer will continue to be involved in the project. ■

Original publication:
Women and Men are the Barometers of Relationships [...], PNAS 2022, DOI: 10.1073/pnas.2209460119

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Picture left: The voters of right-wing populist parties have been examined in a study at the University of Jena. The AfD and similar parties are on the rise in regions with a long-term decline in prosperity. · Photo: Anne Günther

Picture right: Dresden, the Saxon state capital, used to have one of the leading economies in Germany. Today, many of the locals feel as though they have been left behind economically—even though the region in eastern Germany is a leader in terms of innovation and income growth. · Photo: Michael R. Hennig (DML-BY)

Economic decline is a win for populism

Those who live in economically disconnected towns and regions are more likely to vote for right-wing populist parties. This is a common theory that would explain the electoral success of Alternative for Germany (AfD) and similar parties throughout Europe. A team of researchers from the University of Jena have found that the high percentage of votes received by the AfD in the last two federal elections is apparently attributable to a long-term decline in a region's relative prosperity.

BY SEBASTIAN HOLLSTEIN

As the feeling of neglect perceived in places that seem to have been left behind often extends far beyond a voter's own lifetime, the economics researchers assume that voters of right-wing populist parties are driven by a sort of collective memory.
Their work focused on a period spanning almost a hundred years. After obtaining data on regional per-capita income in 1925 and the federal election years of 2017 and 2021, they compared the regional income levels recorded in the national economic rankings with the respective voting results for the AfD.

AfD on the rise in regions in decline

»We found that the AfD received a relatively high share of votes in the areas that had fallen particularly sharply in the rankings,« explains Prof. Michael Fritsch. »While regions such as southern Saxony and cities such as Bautzen and Dresden had some of the strongest economies in Germany—if not Europe—in the 1920s, they have suffered an enormous decline in economic importance over the years. Precisely in these areas, support for the AfD is particularly high, even when other potential factors behind voter behaviour are taken into account«. The same, applies, for example, to the Ruhr area and the city of Duisburg, which shows that such phenomena are not limited to eastern Germany.
The team of researchers from the University of Jena emphasizes that the comparison of a voter's own status with other regions clearly plays a decisive role, because prosperity has essentially increased in all regions. »Income in southern Saxony has increased since German reunification and the region plays a leading role within eastern Germany in terms of innovation, income growth and start-ups,« says Michael Fritsch. »But the location's decline from a leading economic position to the bottom quarter of the rankings is leaving its mark on the region's self-perception and making the locals feel more left behind than they actually are«.

Industrial monuments as a reflection of a prosperous past

The level of resentment felt throughout the region is obviously more pronounced when one knows that there have been much better times in the past. The decision to vote for a right-wing populist party is also an expression of this frustration.

The perception of a region's own decline seems to be anchored in a form of collective memory. The team of experts from the University of Jena chose an unusual method to show the strength and vividness of a region's memory of former times: »We related the presence of industrial monuments to variables that indicate economic decline over the past 90 years. It turned out that the decline effect we had observed was stronger in the regions that had a particularly large number of such memorials,« says Dr Maria Greve, who was also involved in the project. »In places where people are acutely aware of their prosperous past in a way that has a strong influence on regional identity, there is a very clear correlation between perceived decline and the electoral success of right-wing populists«.
By looking into the past, the researchers want to show the importance of studying data from a broader time frame if you want to get to the bottom of phenomena such as the rise of right-wing populist parties in Germany and Europe. »It is important to note that we analyse current situations and developments not only with an eye on the post-war period or the upheaval surrounding German reunification—we also look further back in history,« says Dr Michael Wyrwich from the University of Jena. »This can sometimes reveal decisive events that explain phenomena, as well as role models that can be used politically to create a new regional identity«. ■

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Black holes in eccentric orbit

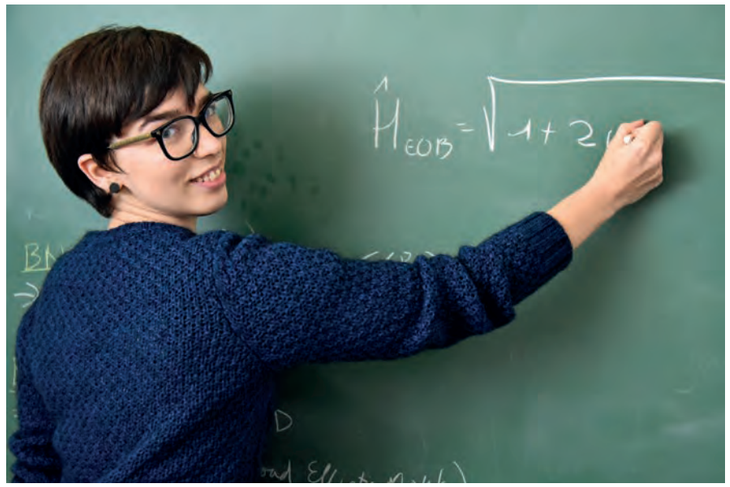
A research team from the University of Jena and the Istituto Nazionale di Fisica Nucleare in Turin has reconstructed the origin of an unusual gravitational wave signal. As the researchers write in the current issue of the scientific journal »Nature Astronomy«, the signal GW190521 may result from the merger of two massive black holes that captured each other in their gravitational field and then collided while spinning around each other in a rapid, eccentric motion.

BY UTE SCHÖNFELDER

When black holes collide in the universe, the clash shakes up space and time: the amount of energy released during the merger is so great that it causes space-time to oscillate, similar to waves on the surface of water. These gravitational waves spread out through the entire universe and can still be measured thousands of light years away, as was the case on 21 May 2019, when the two gravitational wave observatories LIGO (USA) and Virgo (Italy) captured such a signal. Named »GW190521« after the date of its discovery, the gravitational wave event has since provoked discussion among experts because it differs markedly from previously measured signals.

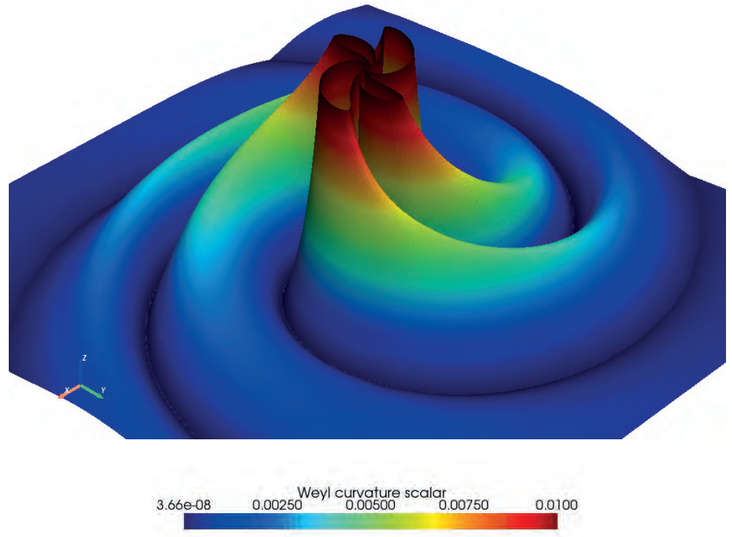
The signal had initially been interpreted to mean that the collision involved two black holes moving in near-circular orbits around each other. »Such binary systems can be created by a number of astrophysical processes,« explains Prof. Sebastiano Bernuzzi, a theoretical physicist from the University of Jena, Germany. Most of the black holes discovered by LIGO and Virgo, for example, are of stellar origin. »That means they are the remnants of massive stars in binary star systems,« adds Bernuzzi, who led the current study. Such black holes orbit each other in quasi-circular orbits, just as the original stars did previously.

Doktorandin Rossella Gamba ist Erstautorin der Publikation. · Foto: Anne Günther



One black hole captures a second

»GW190521 behaves significantly differently, however,« explains Rossella Gamba. The lead author of the publication is doing her doctorate in Jena Research Training Group 2522 and is part of Bernuzzi's team. »Its morphology and explosion-like structure are very different from previous observations.« So, Rossella Gamba and her colleagues set out to find an alternative explanation for the unusual gravitational wave signal. Using a combination of state-of-the-art analytical methods and numerical simulations on supercomputers, they calculated different models for the cosmic collision. They came to the conclusion that it must have occurred on a strongly eccentric path instead of a quasi-circular one. A black hole initially moves freely in an environment that is relatively densely filled with matter and, as soon as it gets close to another black hole, it can be »captured« by the other's gravitational field. This also leads to the formation of a binary system, but here the two black holes do not orbit in a circle, but move eccentrically, in tumbling motions around each other.



Numerical simulation representing the curvature of spacetime during the merger of the two black holes. · Image: AG Bernuzzi

Predictions verified with simulations of Einstein's equations

»Such a scenario explains the observations much better than any other hypothesis presented so far. The probability is 1:4300,« says Matteo Breschi, doctoral student and co-author of the study, who developed the infrastructure for the analysis. And postdoctoral researcher Dr Gregorio Carullo adds: »Even though we don't currently know exactly how common such dynamic movements by black holes are, we don't expect them to be a frequent occurrence.« This makes the current results all the more exciting, he adds. Nevertheless, more research is needed to clarify beyond doubt the processes that created GW190521.

For the project, the teams in Turin and Jena developed a general relativistic framework for the eccentric merger of black holes and verified the analytical predictions using simulations of Einstein's equations. For the first time, models of dynamic encounters were used in the analysis of gravitational wave observation data. ■

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GW190521 as a dynamical capture of two nonspinning black holes. Nature Astronomy (2022), DOI: 10.1038/s41550-022-01813-w

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»It can’t have been a comet«

In early 2022, US researchers published a widely acclaimed paper in »Scientific Reports«. In the article, the alleged sudden decline of the Hopewell culture—a civilization that had spread along the rivers in the mid-western and north-eastern parts of North America—was attributed to a comet that had supposedly hit the continent around 1,600 years ago. While this theory garnered a great deal of media attention, an objection has since been raised in the same journal by astrophysicist Prof. Ralph Neuhäuser from the University of Jena and anthropologist Dagmar L. Neuhäuser. In our interview with Ralph Neuhäuser, he explains what it’s like to have to correct fellow researchers’ scientific errors, which had all the makings of a Hollywood film.

INTERVIEW: SEBASTIAN HOLLSTEIN

What did Kenneth Tankersley and histeamofanthropologistsbasetheir hypothesis on?

Tankersley and his team conducted geophysical examinations in former Hopewell settlements near Cincinnati, Ohio. They found a large number of meteorite fragments and an increased occurrence of platinum and iridium, which were allegedly of extra-terrestrial origin. They considered scorch marks that were around 1,600 years old to be the result of an air burst, when an object explodes after entering the Earth’s atmosphere, and proposed the hypothesis that a comet had exploded over the area at the time.

They attempted to substantiate this theory with historical and cultural evidence, firstly arguing that a large number of comets are said to have come very close to the Earth in the third and fourth centuries AD, as observed by contemporary Chinese astronomers. Secondly, they interpreted artificially created mounds to be a reconstruction of a comet with its characteristic tail. And thirdly, narratives found in the oral tradition of various North American peoples were cited as evidence.

Why do you think that can’t be correct?

In our response, we focused on the non-geophysical aspects we are qualified to assess, which were the decisive factor proposed in the comet hypothesis. But none of the evidence presented points to an air burst caused by a comet.

When claiming that there had been a large number of comets near the Earth during this period, the researchers cited a paper from the 1930s, but this assertion is not reflected in the paper at all. All of the more recent editions and works published in the past decades also show that there were by no means more comets during the period in question—let alone more comets close to the Earth. The sources dating from the period in question, such as the observations documented by the Chinese court astronomers, do not contain any evidence of a large, bright (near-Earth) comet that suddenly disappeared (by entering the Earth’s atmosphere)—and this would have surely been visible to them and worth mentioning. Furthermore, the mounds of earth cited in the paper, stylized into the shape of a comet, are only a small part of a much larger structure, and the researchers do not explain how the remaining segments of the structure fit into their line of reasoning.

The traditional narratives referenced, whose origins cannot be precisely dated, can also be interpreted in a completely different way. For example, the story of »The Day the Sun Fell from the Sky« could also refer to a solar eclipse. The researchers did not take a holistic view of the historical and cultural traditions.

What motivated you to write your own paper refuting the hypothesis proposed by the US researchers?

This is a topic that concerns our field of work and our expertise: the interpretation of historical celestial observations from various cultures for use in modern science. We work in a transdisciplinary team. We thought the hypothesis was questionable and supported by false arguments. In that case, it’s our job to raise an objection.

Specifically, no clear evidence—not even geophysical—was presented to prove the occurrence of a comet. A comet is essentially a huge, dirty snowball, and the metals found on the ground can hardly be traced back to such an incident. It is extremely rare for a comet to enter the Earth’s atmosphere—not a single case has been recorded in human history—so a hypothesis like that would have to be supported by solid evidence. If the decline of the Hopewell culture can really be traced back to an extra-terrestrial event, then it was probably an asteroid.

Did you make the researchers aware of your reservations?

Yes, we put forward our counter-arguments in a letter and received a rather reserved response. We then also submitted our paper to »Scientific Reports« for publication in the »Matter Arising« section, which is intended for corrections of this kind. The journal put six reviewers on the case, which is very unusual—it’s normally only half as many. Five of them agreed with us and even provided further geophysical counter-arguments, and the sixth also voted in favour of publishing our objection. The US researchers released a statement thanking us for our work and have since endorsed our arguments. They now also assume that it can’t have been a comet.

What have you taken away from the process and what can the science community and the general public learn from it?

This shows how important it is to discuss scientific findings and call upon the expertise of different scientists who were not involved in the original research. However, it is regrettable that certain narratives attract different levels of public attention. The news of the supposed comet garnered a great deal of media coverage in the USA with reports from newspapers such as the »Washington Post«. This may have been supported by recent movies such as »Greenland« and »Don’t Look Up«, in which comets enter the Earth’s atmosphere and explode or hit the surface. By contrast, our correction has not enjoyed anywhere near as much publicity, even though we have seen very positive responses, especially in geophysical circles.

However, an air burst from an asteroid or bolide is much more realistic and, depending on its size, can even be more devastating—we only have to look at the extinction of the dinosaurs 66 million years ago or the sheer devastation and injuries caused by the much smaller Tunguska event in 1908 or the Chelyabinsk meteor in 2013. ■

Prof. Ralph Neuhäuser in the dome of the University Observatory in Jena. For his publication, however, the astrophysicist did not focus on the current observations of stars, but evaluated historical celestial observations. · Photo: Jens Meyer

Original publication:
Arguments for a comet as cause of the Hopewell airburst are unsubstantiated, Scientific Reports, 2022, DOI: 10.1038/s41598-022-16211-5

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Fairy tales from different cultures

German Research Foundation (DFG) funds project on »Caucasian narratives in the discourse of comparative fairy tale research«

The project launched in September 2022 by Dr Elguja Dadunashvili (pictured) and Prof. Diana Forker from the Institute of Slavonic and Caucasus Studies is investigating the phenomenon that fairy tale subjects in different cultures are often astonishingly similar. Based on Caucasian narratives, the researchers want to establish, among other things, the authentic unfolding schemes of individual core stories or storylines in fairy tales and the backgrounds of the metaphorical motifs depicted in successive fairy tale episodes. The focus of the project is the construction of computer-aided infrastructure for the development of the fairy tale repertoire and the interdisciplinary use of the compiled text and metadata. US

PHOTO: JENS MEYER

New directions in digital teaching

Stiftung Innovative Hochschullehre funds two projects in the fields of digital humanities and medicine

Two projects launched at the University of Jena and Jena University Hospital are receiving funds from Stiftung Innovative Hochschullehre as part of its »Freiraum 2022« programme. As part of the »Lehr-Lern-Hub: Digital History« project led by Prof. Sander Münster (pictured) in the Digital Humanities department, a teaching and learning lab is being developed and tested with a focus on history in the digital world. The aim is to develop and trial new formats to help students gain digital and practical skills (e.g. through school internships, full-day programmes and extra-curricular places of learning). The medical project, which is being carried out in cooperation with Heilbronn University of Applied Sciences, is about digitally supported learning in interdisciplinary teams. AB

PHOTO: JENS MEYER

Environment and mental illness

Remote sensing team involved in major EU project »environMENTAL«

The European »environMENTAL« consortium wants to identify mechanisms by which mental illnesses are triggered by phenomena such as climate change, urbanization and the COVID-19 pandemic. The consortium also includes a remote sensing team led by Dr Sören Hese. The EU has pledged nine million euros in funding until 2027.

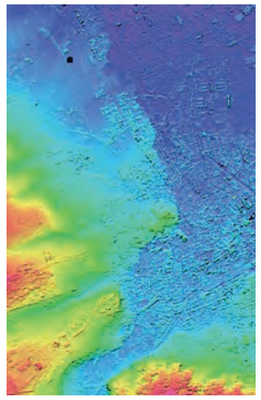

PHOTO: DLR 2022, TANDEM-X

The researchers want to analyse data from healthy and sick people to uncover brain mechanisms related to environmental stress. They will correlate this data with measurements from remote sensing satellites (see photo), climate models and digital health applications, in order to illustrate the impact of environmental challenges on brain structure and function. sh

Drying river systems

Hydrologist conducts research with partner institutions from eleven countries in the »DRYvER« project

In the hot summer of 2022, sinking water levels, cancelled ferries and the disrupted transport of goods via shipping routes made the news with increasing frequency. Dr Annika Künne from the University of Jena states that this situation has become the rule rather than the exception. The hydrologist is involved in »DRYvER«, a cooperative international research project with 25 partners from eleven countries. DRYvER is funded through the European Union's Horizon 2020 programme. The researchers are investigating how the drying up of river systems, accelerated by climate change and human water use, is affecting biodiversity, functional integrity and ecosystem services. Dr Künne's job is to create highly detailed river system models. sl

PHOTO: THIBAULT DATRY

PHOTO: JENS MEYER

Quantum systems

Junior research group receives 3.3 million euros in government funding

The Federal Ministry of Education and Research (BMBF) has pledged around 3.3 million euros in funding to a new junior research group for »Integrated Quantum Systems« over a period of five years. The group of five scientists has set itself the task of testing modern quantum technologies and establishing whether they are suitable for everyday use. The junior research group is headed by Dr Tobias Vogl (pictured) from the Institute of Applied Physics. »We see a great deal of promise in the combination of solid-state photonics and quantum materials,« says Dr Vogl. He and his team are particularly interested in researching the properties and potential applications of boron nitride. This compound of boron and nitrogen is an insulator that can form fluorescent defects that emit single photons when irradiated with a laser. sl

PHOTO: ANNE GÜNTHER

Public Philosophy

DFG provides one million euros in funding for Reinhart Koselleck project

The anti-racism protests of the Black Lives Matter movement and the responses to the racist and anti-Semitic attacks in Halle and Hanau have sparked a discussion amongst philosophers in the German-speaking world regarding the role of their own discipline in the history of European violence.
Prof. Andrea Esser (pictured), Head of Practical Philosophy at the University of Jena, is currently involved in a project within the German Research Foundation's Reinhart Koselleck programme to investigate the problematic legacy of philosophy. The project, entitled »How to Deal with Racism, Sexism and Anti-Semitism in Works of Classical German Philosophy. A Critical and Self-Critical History of Philosophy as a ›Public Philosophy‹ Project«, will receive one million euros in funding from the DFG over a period of five years. sl

PHOTO: JENS MEYER

Sasanian Empire

DFG-funded project investigates power relations

The Neo-Persian Empire of the Sasanians was the arch-rival of the Roman Empire for many centuries. The Sasanian dynasty, which was named after the House of Sasan, controlled an area from around 224 AD that at times stretched from the Caucasus to the Indus. Dr Frank Schleicher (pictured), who specializes in ancient history, is investigating how the Sasanian dynasty was able to exert influence and power over vassals far beyond the borders of the empire itself. For this purpose, the modern concept of a »Commonwealth« is applied to the ancient cultures. Dr Schleicher was recently granted 343,000 euros in funding from the DFG to launch a research project entitled »Vassalage in the Sasanian Commonwealth«. He is examining the interactions between the imperial Kings of Kings and their princes in the periphery. sl/JK

PHOTO: JENS MEYER

New diagnostics

»INTACT« project receives 750,000 euros from the Carl Zeiss Foundation

In Germany, doctors have to feed around 200 out of 800 very premature babies every year—mostly due to an infection—by diverting nutrients out of the body via an artificial intestinal outlet and returning the contents to another stoma to relieve the intestine. Currently, this can only be done manually, which does not guarantee a continuous transfer, requires very intensive care and impairs the babies' development. An interdisciplinary team from University and University Hospital, coordinated by the University of Applied Sciences Jena, is now looking to develop a miniaturized transport system featuring ultrasound and photonics-based sensors to enable the continuous transfer and analysis of the diverted intestinal contents. In doing so, the researchers want to facilitate better treatments for premature babies in the future. The Carl Zeiss Foundation is funding the »INTACT« project for two years. sh

Picture right: These two Se*ymouria sanjuanensis* specimens are known as the »Tambach Lovers«. They lived on Earth even before the dinosaurs. · Photo: Oliver Wings

Travelling back into the Earth's past

Exploratory drilling projects in Thuringia and South Africa are opening a window into the geological history of the planet. The drill cores obtained in this way are like time capsules that store information from the early days of the Earth. Teams from the fields of geology and palaeontology are currently looking back at different eras of Earth's history, when Thuringia was part of the supercontinent Pangea, and even at the time when life was just beginning. The reportage accompanies them for a while in their work.

BY STEPHAN LAUDIEN

The world must have been pretty quiet 3.2 billion years ago: no birds tweeting, no wolves howling, no crickets chirping… The silence would have been broken only by waves, raindrops, wind, storms and thunder. And who should have made a sound at a time when the only living things were the microbial mats that lined the banks of water bodies? They are thought to have produced oxygen, creating the conditions for more highly developed life.
An international team of geologists led by Prof. Christoph Heubeck from the University of Jena has now unearthed excellently preserved remains of the microbial mats. They are contained in drill cores that are around 3.2 billion years old and were obtained from the »Barberton Greenstone Belt« in South Africa, close to the border to Eswatini, formerly Swaziland. »These drill cores are like time capsules that store information from the early days of Earth,« says Christoph Heubeck.

Libraries from the early days of the planet

In addition to traces of simple life forms, the drill cores also contain numerous other pieces of information. This allows the scientists to draw conclusions about the lunar orbit and to analyse the tides, volcanism, UV radiation, the intensity of weathering, meteorite impacts and the temperature of the oceans and the atmosphere. The decoratively patterned stone cylinders are veritable libraries from the early days of our planet.

Carnival atmosphere at the Institute for Geosciences

It's a sunny day in autumn. The grounds of the Institute for Geosciences are bustling with activity. There's a real carnival atmosphere! However, the only thing spinning is the blade of a circular saw as it carefully works its way through drill cores. The machine is operated by Frank Linde, whose focused expression reveals the delicate nature of his work. The technician is wearing safety goggles, gloves and rubber boots. The »Steinadler« saw works with cooling water, leaving a jet of reddish sludge in its wake. The stone rods are precisely cut open lengthwise to reveal a reddish, marbled interior that shimmers in the sun. However, these drill cores have not been brought to Jena all the way from South Africa. They were drilled near the Bromacker fossil site in the Thuringian Forest. They are around 290 million years old—they date from the early Permian Period. This is the second major drilling project in which Christoph Heubeck is involved. It just so happens that both projects were carried out almost at the same time last year. In geological terms, the finds near the town of Tambach-Dietharz mark a huge leap in time compared to the samples unearthed in South Africa. They date from the period before the dinosaurs reigned over the Earth, when their ancestors were already leaving numerous traces. These ancestors can be described as being somewhere between amphibian and reptile, including Orobates pabsti and Seymouria sanjuanensis. The latter species had previously been found for the first time in Utah, USA. It was named after the San Juan River, a tributary of the Colorado River. It is no coincidence that the fossils have been found at two different sites; at the time of the supercontinent Pangea, both sites were located on one continent along the northern margin of the Variscan mountain range.
The species Orobates pabsti was named after Wilhelm Pabst, who was the curator at the Ducal Museum in Gotha. He was one of the first people to discover and describe »track slabs« at the turn of the 20th century. These are slabs of rock on which the footprints of primeval animals are preserved. Later, individual bones and even entire skeletons came to light. The most well-known are arguably the »Tambach Lovers«, a pair of Seymouria sanjuanensis immortalized side-by-side in stone for millions of years. Dr Thomas Martens, a geologist and palaeontologist, was the first to discover fossils at the Bromacker site in 1974. The student of Arno Hermann Müller has made studying the Bromacker fossils his life's work. He has even bought the site to secure it for science.
As soon as the drill cores are extracted from rock, they are measured and precisely labelled. By cataloguing and securely archiving them in this way, they are made available for further investigations, including future generations of researchers. This principle applies to both the drilling project in South Africa and the work in Thuringia. Over the course of the drilling project in the Barberton Greenstone Belt, the diamond core bit drilled down to a depth of 300 metres—often from older to younger layers of rock—at an angle of 45 degrees. »Around 20 to 40 metres of cores were extracted every day,« says Christoph Heubeck. In Thuringia, the drilling depth increased by eight metres every day until around 250 metres depth had been reached.
The drilling itself was essentially routine work. The geologists had originally identified a spa hotel's car park as the most promising drilling site. As the hotel did not close in the winter, however, another site had to be found. »We ended up drilling in the forest, right next to a forest road,« recalls Christoph Heubeck. The only sour note for the contracted company came when the drill bit broke off at a depth of 243 metres and had to be replaced. A large core drilling rig was the main exploratory tool used in both projects. »In terms of approach, this is not much more than a magnifying glass or a hammer,« says Christoph Heubeck. »It's not so much the size and type of equipment that matters, but a smart choice of research question, the best possible location for carrying out the work, efficient data acquisition and optimal evaluation«.

Drilling rig and crew in South Africa. · Photo: Christoph Heubeck

As the sedimentary rocks that provide information about the Earth's geological past are usually covered by younger layers, weathered soils and vegetation, core drilling is often the method of choice for extracting unweathered and continuous material, which can then be »interrogated« in the laboratory.
This opinion is clearly shared by those involved in the International Continental Scientific Drilling Program (ICDP),

Picture top: apl. Prof. Peter Frenzel and Dr Anna Pint at the Bromacker excavation site. · Photo: Claudia Hilbert

Picture left: Frank Linde sawing a drill core. · Photo: Jens Meyer

Picture top right: Student Fabio Berlin records data from the freshly cut and washed drill core. · Photo: Jens Meyer

Picture bottom left: Rig used for deep geological drilling on the Hainfelsen rock face near the Bromacker site. · Photo: Claudia Hilbert

Picture bottom right: The drill cores are stored in air-permeable boxes made of sturdy spruce wood. · Photo: Jens Meyer

the main funder of the South African project. That's why a major conference on the future of scientific drilling will be held in Potsdam in July 2023.
The first insights emerge even as the drill cores are being cut open. On first inspection, Christoph Heubeck points at blue-grey lumps in the drill core: »Those are carbonate nodules. Their isotopes act as a paleothermometer«. This means that the researchers can use these lumps to analyse what the temperature was like when the mineral formed. In this way, statements can be made about the climatic conditions of prehistoric times and comparisons can be made with today's conditions.

Fossils in former quarry

The Bromacker site near Tambach-Dietharz paints a rather unassuming picture these days: a meadow, sparse trees, hiking trails and information boards… But it used to be home to one quarry after another. The mining work revolved around »Rotliegend« strata (»Underlying Red«), a type of red sandstone that was used as a building material for things like gate stones, fence poles and veneers. Some of the former quarries are still fairly recognizable today—dangerous areas are highlighted by warning signs.
Dr Anna Pint knows the area like the back of her hand. The geologist and palaeontologist from Prof. Heubeck's research group has been digging at the Bromacker site since 2020. She specializes in invertebrates and burrows. »We've found fossils of insects, crustaceans and a few centipedes,« says Anna Pint.
The current Bromacker project is a collaboration between scientists from the Natural History Museum in Berlin, the University of Jena and the Friedenstein Castle Foundation in Gotha. The digging campaign takes place every summer. About 20 people are involved, including numerous students and doctoral candidates. Their tools are hammers and chisels—large pieces have to be smashed up. As a member of the excavation management team, Anna Pint decides which finds are promising. The rest remains in the overburden. The finds are analysed by the relevant specialists. If vertebrate bones are found, they are placed in the hands of Tom Hübner—the curator of the Friedenstein Castle Museum—and Jörg Fröbisch from the Natural History Museum in Berlin, who is also in charge of the overall Bromacker project.

Footprints of the dinosaurs' ancestors

Lorenzo Marchetti is another expert from the Natural History Museum in Berlin; he is responsible for examining the footprints of the dinosaurs' ancestors preserved in the rock. As long as the finds are still moist, they can be processed. For this purpose, Frank Linde prepares »thin sections« of the burrows in Jena. These are wafer-thin slices that can be viewed under the microscope. When held up to the light, you can clearly make out the tunnel that was dug out by an insect millions of years ago. Other finds have to be carefully dried. Once they have been dried, they cannot be exposed to any more moisture. »The clay contained in the samples would swell up and fragment the pieces,« explains Anna Pint.
The drilling in South Africa was mainly funded by the International Continental Scientific Drilling Program (ICDP), a consortium comprising 21 member states. A total of 1.8 million euros was raised for the drilling costs—and several times that amount went towards funding the investigations and paying the wages of doctoral candidates and post-docs involved in the project. Even the US space agency NASA is involved because 3.2 billion years ago, the surface of the Earth resembled that of other planets. »How could life survive and spread in this challenging, high-energy environment?,« asks Christoph Heubeck. An average sedimentation rate of around one metre per thousand years can be estimated in the drill cores. This is similar to the sedimentation rate observed on many of today's coastlines, although daily tides are often recorded in thin layers of sediment as well. The scientific evaluation of the drill cores will not take anywhere near as much time. Nevertheless, it will take a few years before these time capsules from the early days of Earth will have been comprehensively examined and analysed, says Christoph Heubeck. Firstly, they are sawn lengthwise, photographed and described. Then one half was trucked to South Africa's national core repository, effectively a »library of the underground«; the other half has

Prof. Christoph Heubeck is managing the geological aspects of the Bromacker project; here he is inspecting rock in the drill core repository. · Photo: Jens Meyer

been shipped to the ICDP's core repository in Berlin-Spandau, where they are currently X-rayed, documented again in detail and distributed to the participating research institutions during a sampling workshop.

The area around the Bromacker site once resembled the landscape of today's Mongolia, as noted on one of the information boards. Anna Pint explains that it was a sedimentary basin; the sandstone was laid down in rivers that crossed the area. The aim now is to create an exact scientific reconstruction of the habitat found in this distant period. »We're looking through a window into the past and exploring a section of the Earth's history,« says Anna Pint. By »we« she means Christoph Heubeck and his team: Thomas Voigt, Frank Linde, Peter Frenzel and Anna Pint, as well as the students Jakob Stubenrauch, Rebecca Lellau and Fabio Berlin. The group from the University of Jena is the smallest in the Bromacker project, which was launched in 2020 and is scheduled to run for five years.

Finds belong to the State of Thuringia

The Bromacker site may apply for UNESCO World Heritage status. This status would represent a promotion to the »big league« including the Messel pit in Hesse or the Solnhofen site in the Altmühltal Nature Park in Bavaria, where famous specimens of the primeval bird Archaeopteryx were found. If the Bromacker site is granted this status, it will be fenced off and secured, if only to deter robbers. The fossils already belong to the State of Thuringia. Anything that is not exhibited in the museum collection at Friedenstein Castle is stored in the depository there. Anna Pint points out that most of the fossils found belong to herbivores. However, it is difficult to say what they ate, because plant fossils are rare among the finds, but this could also be due to the unfavourable conditions for preserving them. Nevertheless, the researchers want to reconstruct these animals' habitat, their food and the climate of the time in as much detail as possible. The window into the past will be thrown wide open. As wide as possible. ■

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