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The Journey Is the Reward

Future route planners will be more comfortable, individual, and realistic

Light and life:
The molecules in the atmospheres of planets outside of our solar system

Monarch and model:
The struggle over the legacy of the French emperor Napoleon

DNA and diversity:
The risks of fragmented habitats for the survival of species

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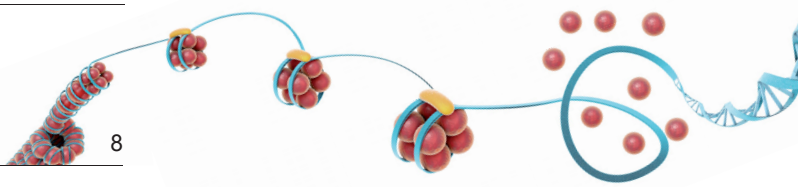
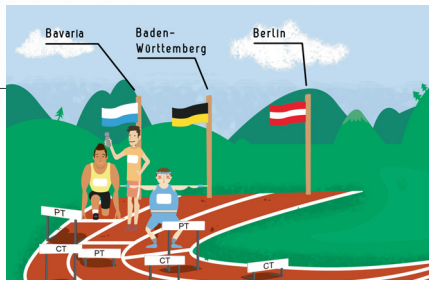
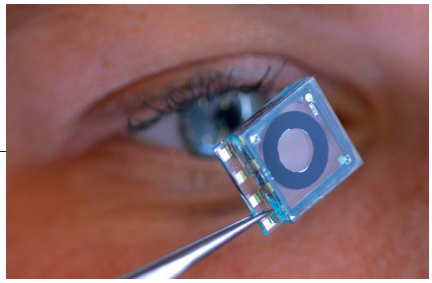
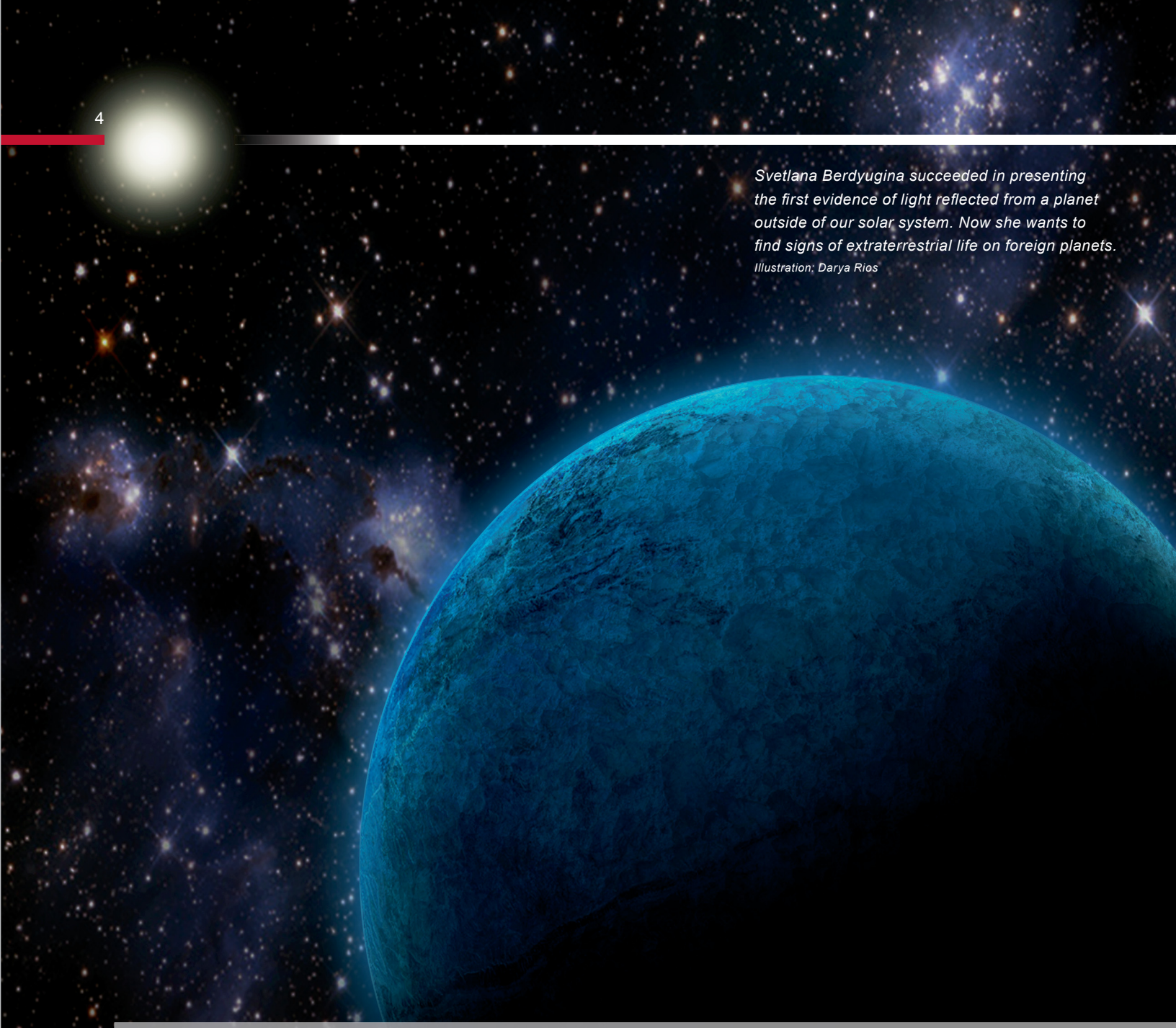






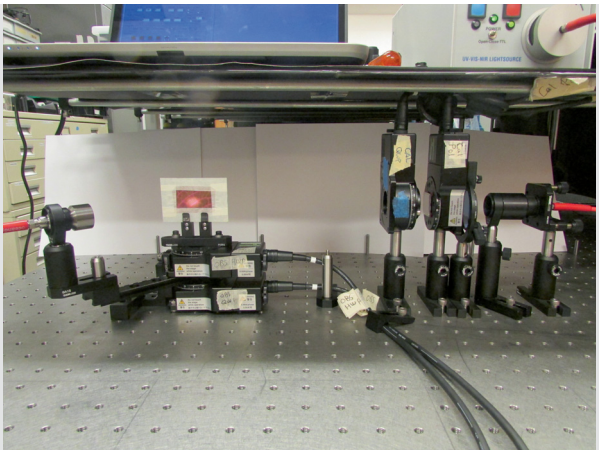


Svetlana Berdyugina succeeded in presenting the first evidence of light reflected from a planet outside of our solar system. Now she wants to find signs of extraterrestrial life on foreign planets.
Illustration: Darya Rios

The Other Blue Planet

The astrophysicist Svetlana Berdyugina is looking for signs of life in the reflected light of distant celestial bodies

by Martin Jost



With the help of a prototype of the "Innovative Polarimeter" (left picture), the researchers studied pigments typically used by bacteria for photosynthesis – such as chlorophyll, carotenoids, and anthocyanin (right picture, from left). Photos: Svetlana Berdyugina

If there is life on other planets, Prof. Dr. Svetlana Berdyugina might just be the first person to discover it. The astrophysicist measures the polarization of light reflected from planets outside of our solar system – so-called exoplanets. In 2008 she and her team, then at ETH Zurich, Switzerland, succeeded in presenting the first evidence of light hitting one of these planets – more than 1.5 billion times farther away than the Moon. Today Berdyugina conducts her research at the Kiepenheuer Institute for Solar Physics in Freiburg and serves as a professor at the Institute of Physics of the University of Freiburg. Her next goal is to use polarization to find out what substances are present in the atmospheres of exoplanets. Perhaps she will also find molecules produced by living organisms there.

Invisible Properties of Light

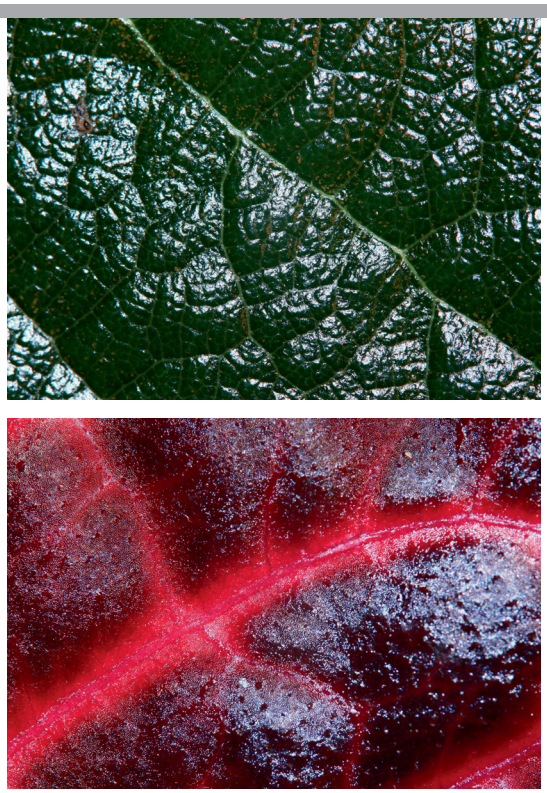
The European Research Council (ERC) has furnished Berdyugina with a five-year Advanced Grant worth 2.5 million euros. "During the funding period we want to build a polarimeter that is even more sensitive. This will allow us to detect molecules in a planet's atmosphere," says the researcher. This instrument can measure the light of planets located – as seen from the Earth – directly next to their home star on the course of their orbit around it. Other methods only work when the planet is passing directly in front of its sun. The polarimeters Berdyugina and her team are developing will need to be very sensitive, because the quantity of light reflected from the planet is infinitesimal compared to that emitted directly by the star. The measuring instruments filter out of the blindingly bright light of the star the tiny bit of light that has traveled through the planet's atmosphere. In doing so, they make use of a property of light that is measurable, although it is not visible – its polarization.

> "Our main goal is to study the composition of the atmospheres of exoplanets."

Polarization describes the direction in which light waves strike out. Light races through the cosmos in the form of waves. These waves oscillate crosswise or edgewise or helically in relation to the direction in which they spread. In the direct

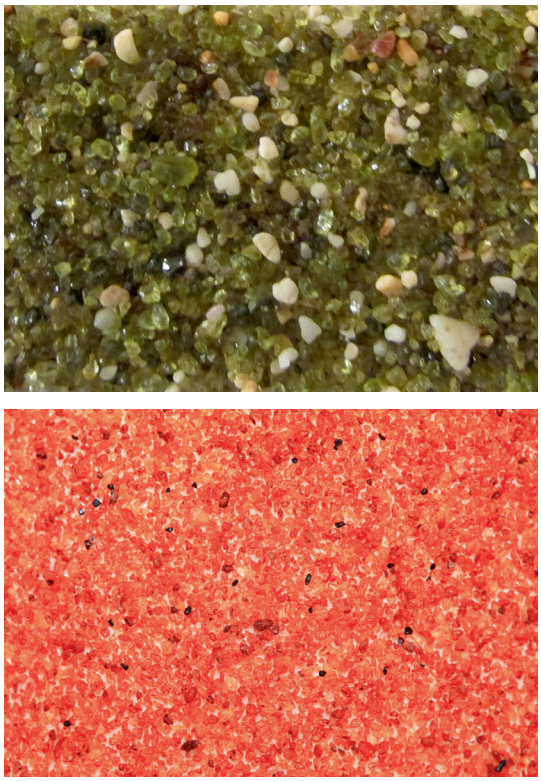
ray of a light source – a sun or a light bulb – all directions are represented equally. Since no direction is predominant, such light is referred to as unpolarized. However, as soon as these waves shine through an obstacle or are reflected from a surface, they are polarized, meaning that they oscillate more strongly in a certain direction. This principle is also useful in everyday contexts, such as for anti-glare sunglasses, whose lenses do not allow light with a particular polarization through. In this way, car drivers can protect themselves from being distracted by reflections from puddles on the street. This is also why photographers attach polarization filters to their lenses, and polarization filters are also used in 3D glasses for movie theaters: The image for the left eye is projected onto the screen with light whose polarization is different from the light with which the image for the right eye is projected. The filters in these special glasses only allow one kind of light through.

The polarimeters Svetlana Berdyugina and her team are developing basically follow the same principle as these polarization filters. The main difference is that the scientists do not hold them in front of their eyes but build them into powerful telescopes. These instruments have become so sensitive that they can detect a polarization of only 0.001 percent in the light they are measuring. In 2008 Berdyugina and her colleagues became the first scientists ever to detect light reflected by the planet HD 189733 b, which is located 63 light years away from Earth; a light year is roughly equal to 9.5 trillion kilometers. "Experts were naturally skeptical of our interpretation of the data initially," says Berdyugina, "but that is healthy scientific skepticism. When the prediction we made in 2011 about the color of the planet was confirmed by an independent source, it of course still gave us great satisfaction." Berdyugina had deduced with the help of more precise polarimetric data that HD 189733 b would appear bright blue to the naked eye. In 2013 Prof. Frédéric Pont and Dr. Tom Evans succeeded in



Polarization describes the direction in which light waves strike out. The corresponding signatures of photosynthetic molecules, such as those of green and reddish leaves (above), are unmistakable. Moreover, the signatures of the leaves are clearly different from those of green and red sand (below).

Photos: Svetlana Berdyugina



confirming the blue color with another method and with help from the Hubble Space Telescope.

To See Where No One Has Seen Before

Besides its color, however, the blue planet does not have much in common with Earth. It is larger than Jupiter, probably consists entirely of gas, and orbits its sun so closely that it doesn't even take three days to complete the journey.

> "We must first learn to identify life that functions differently than on Earth."

The radiation and temperatures on HD 189733 b are therefore extreme – no environment for life as we know it on Earth. "Our main goal is to study the composition of the atmospheres of exoplanets," says Beryugina, "but the next step will be to look for biological signatures – on Earth-like planets in the habitable zones of foreign solar systems." The habitable zone consists of the narrow belt around a star in which planets can support water in liquid form. It cannot be too hot or too cold. An atmosphere containing water polarizes light differently than one that is completely dry. In theory, however, any conceivable molecule could be detected by means of polarimetry. Svetlana Berdyugina will thus not settle for merely finding water. She wants to search for indisputable signs of extraterrestrial life.

"We must first learn to identify life that functions differently than on Earth – life based on substances other than water and carbon," says Berdyugina. "Initially, we are therefore on the lookout for organic molecules of the simplest forms of life we know." With the help of a prototype of the "Innovative Polarimeter" (InnoPol), she and her team measured the polarimetric profiles of pigments typically used by bacteria for photosynthesis. Examples of such pigments are chlorophyll, which makes plants green, or carotenoids, to which carrots owe their orange color, or anthocyanin, which gives blackberries their dark bluish-violet hue. Biologists at the University of Aarhus in Denmark are collecting these bacteria with special airplanes and growing them in the lab. Together with astrobiologists from the University of Hawaii, USA – the location of one of the telescopes Berdyugina is using – the team from Freiburg measured these colorful colonies of bacteria with the InnoPol. The result: "The polarimetric signatures of these photosynthetic molecules are unmistakable." There is no mistaking red bacteria for red dust, for instance, even though they are both the same color when seen in visible light.

InnoPol might just be sensitive enough to measure polarization that is typical of particular molecules in the atmosphere of exoplanets. That would mean evidence of life outside of our solar system – though probably not on HD 189733 b, the other blue planet.

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Prof. Dr. Svetlana Berdyugina

Berdyugina is deputy director of the Kiepenheuer Institute for Solar Physics and professor of physics at the University of Freiburg. Her research focuses mainly on cosmic effects that polarize light – such as magnetic fields on stars or gas clouds in planetary systems. Berdyugina studied physics in St. Petersburg, Russia, and served as professor of astrophysics in Oulu, Finland, and at ETH Zurich, Switzerland, before coming to Freiburg in 2008. She is involved in a project to build the world's largest optical telescope: "Colossus" will have a mirror measuring 74 meters in diameter and be capable of detecting civilizations on faraway planets. In September 2014 she will present her research at the TEDx Conference in Maui, Hawaii, USA.

Photo: private

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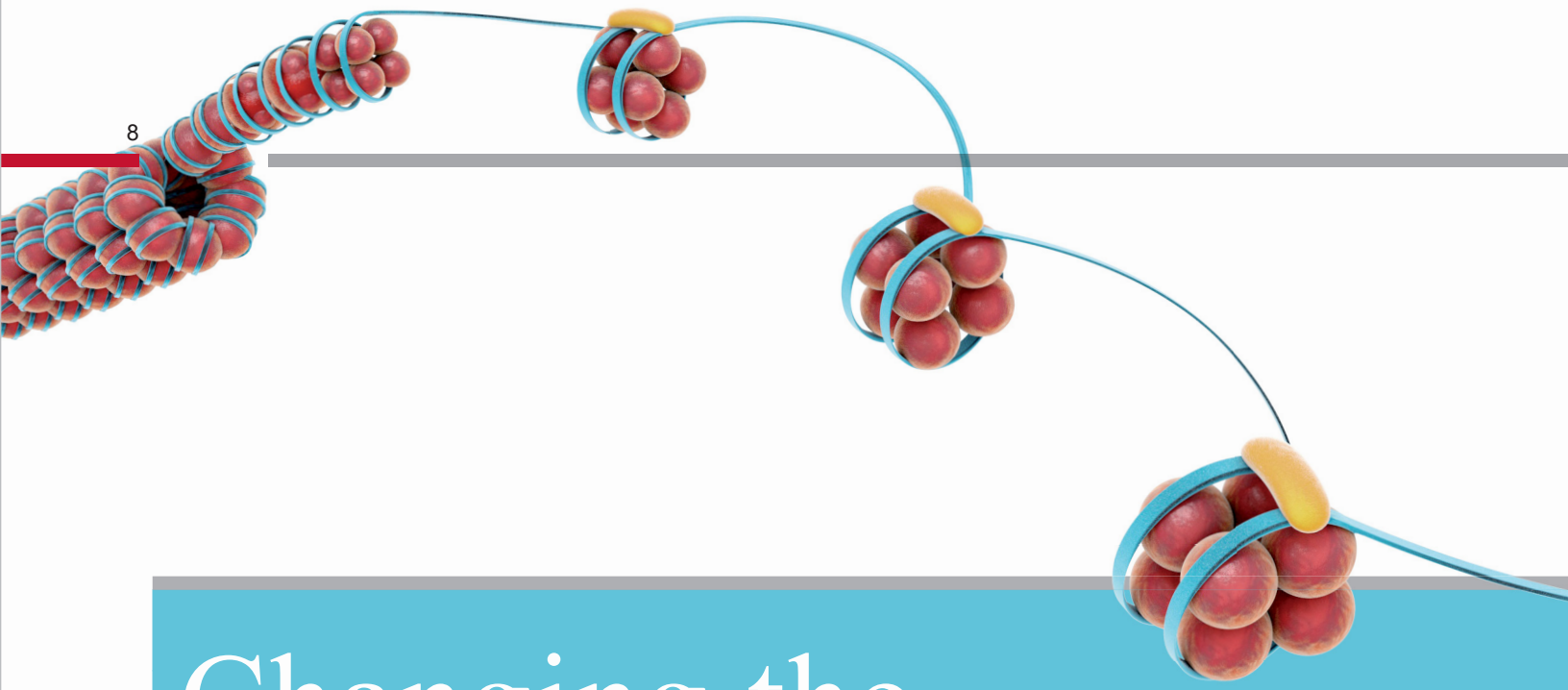


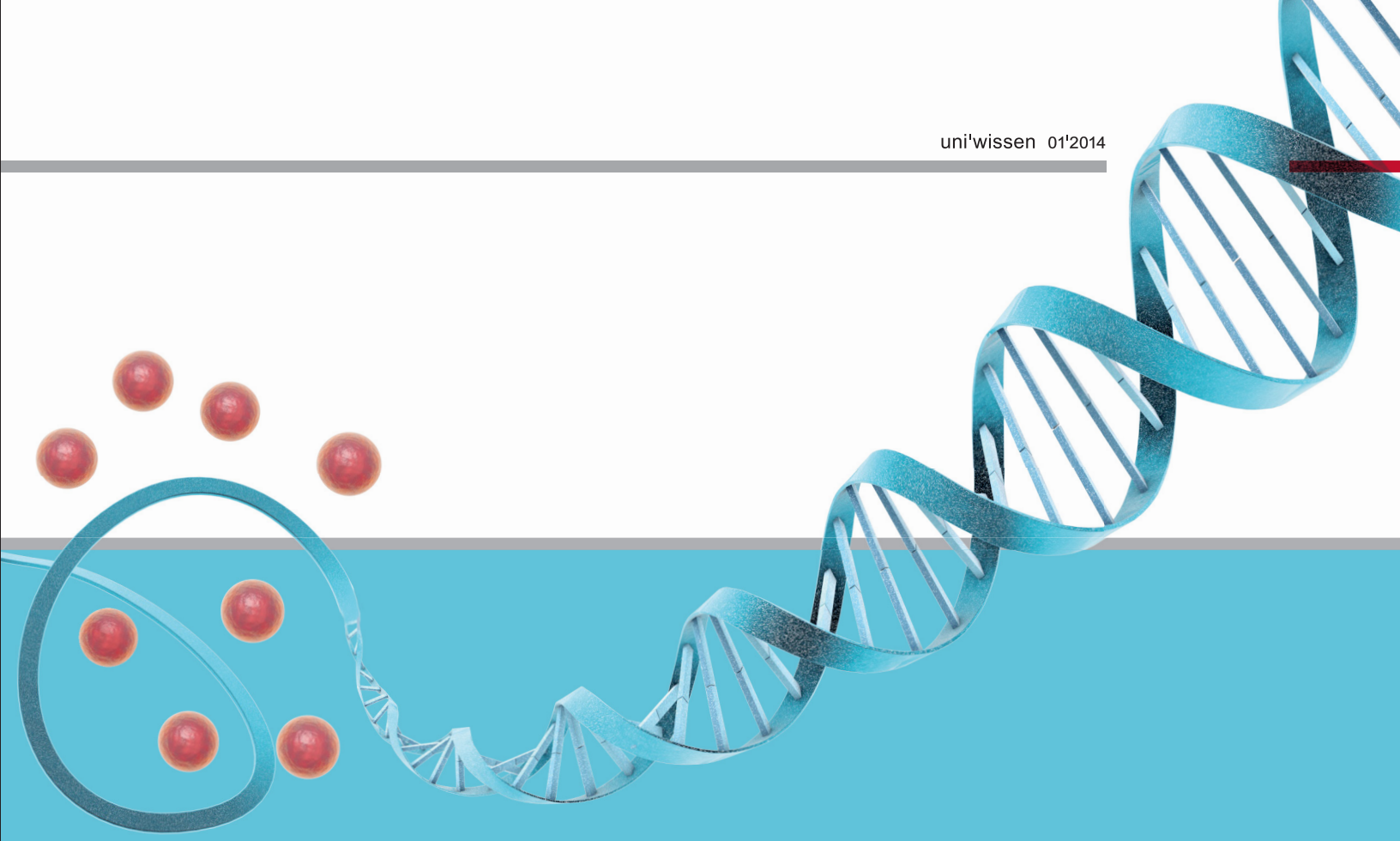
Changing the Packaging of Genes

The biologist Roland Schüle is studying epigenetic processes and searching for new therapies for cancer and other diseases

by Katrin Albaum

When a child takes after her parents, it must be the genes, right? No, because the genetic information stored in deoxyribonucleic acid (DNA) is not the only thing humans pass on to their offspring. They can also pass on epigenetic changes in the structure of chromatin, which serves as the packaging of DNA, over the course of generations. Scientists at the University of Freiburg and the Freiburg Max Planck Institute of Immunobiology and Epigenetics have been studying such changes since 2012 at collaborative research center (SFB) 992, "Medical Epigenetics." Epigenetic modifications play a key role in diseases like prostate cancer, leukemia, and diabetes, as well as in the formation of fat and in other important processes in the body. "We want to understand the foundations as a basis for developing new therapeutic procedures," says Prof. Dr. Roland Schüle, director of the SFB.

Every body cell in humans and other mammals contains a roughly two-meter long strand of DNA in which their genetic information is stored. In order to ensure that it fits inside the nuclei of these cells, nature did a good job of packaging this strand: It is coiled tightly around a kind of column – a nucleosome, which is a compound of so-called histone proteins. All of the DNA, the histones, and further proteins in the nucleus all combine to make up the chromatin. Chromatin can be present in open or condensed form. In its condensed form the chromatin is more tightly wound up into a ball, which makes it fit even better in the cell. However, the genes on this condensed part of the strand are more difficult to transcribe, because in order for this to happen so-called transcription factors have to be able to reach them. These proteins bind to the DNA to show another protein which gene it should transcribe and which product it should produce according to that blueprint.



Wound up into a ball or open: Epigenetic modifications can change the structure of chromatin, the packaging of deoxyribonucleic acid (DNA). Chromatin is made up of so-called histone proteins (red), DNA (blue), and further proteins in the nucleus (yellow).

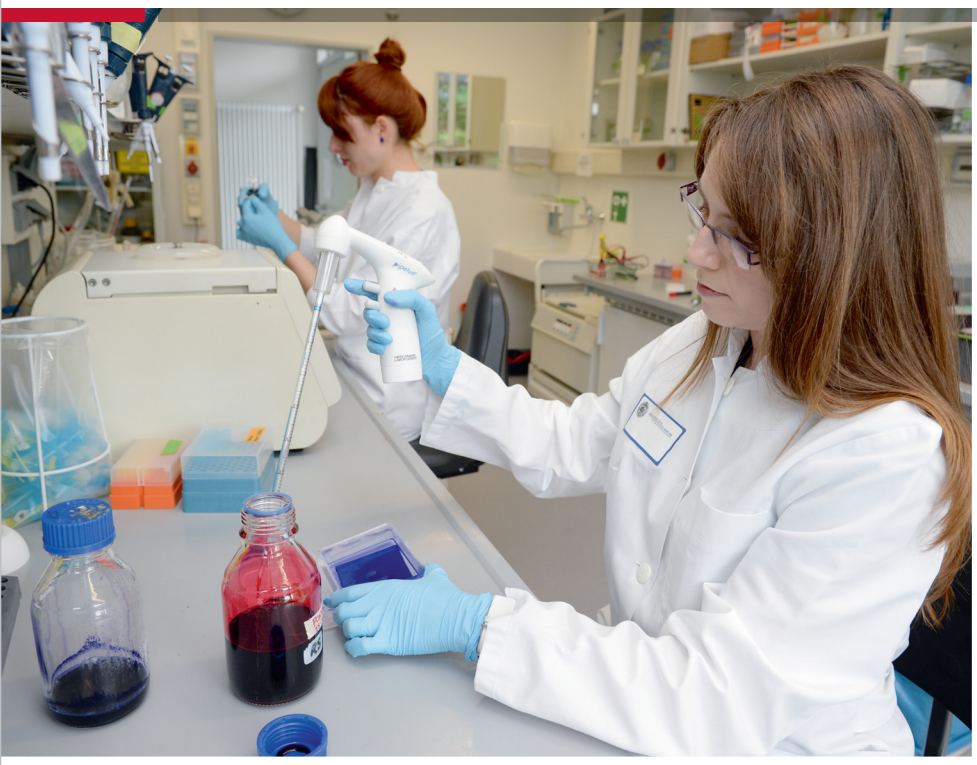
Illustration: Christian Eisenberg

When chromatin takes on its open form, on the other hand, the DNA is freely accessible, and transcription factors can bind more easily to the genetic information. "One of the things epigenetic changes do is to spread this packed chromatin structure out into an open structure or the other way around," explains Schüle. In a manner of speaking, they can thus switch a gene on or off by packing or unpacking it. One way a structural change can be initiated is when an enzyme – a substance that triggers or accelerates a biochemical reaction or steers it in a certain direction – influences the histone proteins in the nucleosome.

"We want to understand the foundations as a basis for developing new therapeutic procedures."

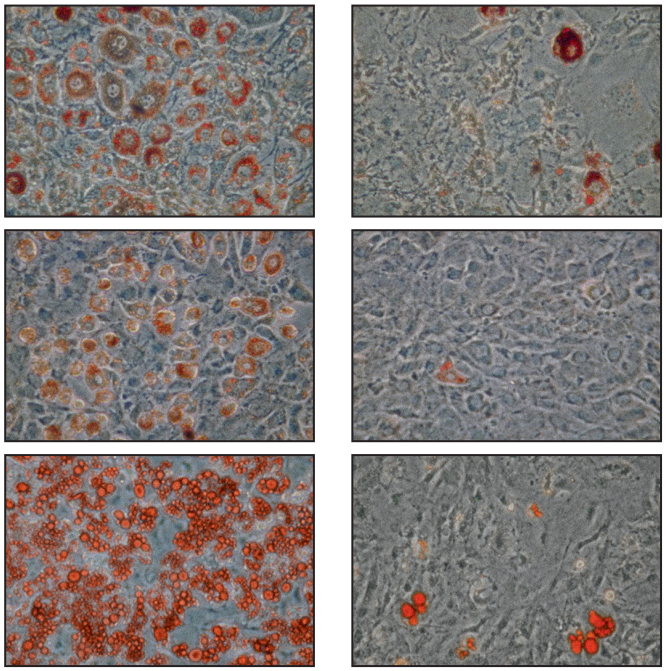
The enzyme Schüle and his team are devoting most of their attention to removes a methyl group from the histone and can thus set off various reactions. Since it docks onto lysin – an amino acid that often sticks out of the histone like an antenna – this enyzme is called lysin-specific demethylase, LSD1 for short. It could be the key to the reliable diagnosis and treatment of prostate cancer.

Up until 2004, the general consensus was that when a methyl group is present at one of the histone proteins, it cannot be removed again. Then scientists at Harvard University, USA, showed that enzymes of the class histone-demethylase do precisely this and thus switch off genes. In 2005, Schüle and his team demonstrated in an article in the journal *Nature* that LSD1 can also do the opposite: "Depending on where LSD1 removes the methyl groups from the chromatin, it can also activate genes."



On the lookout for proteins: Roland Schüle's research group is studying the epigenetic regulation mechanisms of prostate cancer.

Photos: Patrick Seeger



The photographs show various cultures with fat cells (the fat is dyed red). The cultures in the photos on the right contain a substance that inhibits the epigenetic enzyme LSD1, thus blocking fat formation.

Photos: Delphine Duteil

Schüle's research group found out that LSD1 interacts with the so-called androgen receptor. This receptor activates genes responsible for growth and plays a key role in the development of prostate cancer. The aim of many prostate cancer therapies is thus to block the androgen receptor. After spending a certain time under such therapies, however, some patients develop a resistance to the anti-androgen hormone: The blocking fails, and the cancer continues to spread. LSD1 could be the solution for the future, because tests with cell cultures have shown that inhibiting the enzyme blocks the androgen receptor–dependent growth of the tumor.

Interrupting the Chain of Events

Schüle and other researchers at the University of Freiburg and the collaborative research center have discovered a second approach for fighting prostate cancer: "We have identified a new mechanism that shows how LSD1 could lead to prostate tumors in interaction with the androgen receptor." At the root of the disease is a complex process involving several epigenetic enzymes. The enzymes that add a methyl group to the chromatin do the same thing to LSD1. The histone-demethylase becomes methylated itself. This gives it another surface that attracts a further epigenetic enzyme. This new enzyme binds to LSD1 and causes the condensed chromatin structure to open, allowing transcription factors to reach the androgen receptor–dependent genes more easily. These genes are activated, giving rise to uncontrolled cell growth. "If we could interrupt this chain of events, we could impede the growth of the tumor," explains Schüle. "We have created a three-dimensional x-ray crystal structure of the complex of LSD1 with the epigenetic enzyme." The scientists can use this model to draw more precise conclusions concerning the surfaces of the two epigenetic enzymes and the interaction between them. "We know what the key and the lock look like. Now we can design the inhibitors to block this bond."

"LSD1 regulates many genetic programs for metabolic processes, such as those for fat burning and blood sugar balance."

Prof. Dr. Roland Schüle

is scientific director of the Department of Urology at the Freiburg University Medical Center, a member of the Cluster of Excellence BIOSS Centre for Biological Signalling Studies of the University of Freiburg, and director of collaborative research center 992 "Medical Epigenetics." Schüle studied biochemistry at the University of Tübingen, where he earned his doctorate in 1988. Afterwards he worked in La Jolla, USA; Basel, Switzerland; and Freiburg. In 1997 he completed his habilitation in biology at the University of Freiburg. In 2012, the European Research Council (ERC) awarded Schüle a 2.5 million-euro Advanced Grant, one of the European Union's most prestigious research awards.

In addition to its role in the development of tumors, LSD1 also plays an important part in other processes in the bodies of mammals. One example is early embryonic development. Schüle and his team succeeded in switching off LSD1 entirely in so-called knockout mice. However, the genetically modified embryos were not strong enough to survive and died before they could implant themselves in the placenta. The Freiburg scientists studied why this was so. They determined that LSD1 is essential for the stem cells later responsible for the development of a part of the placenta. The enzyme gives them information on where they should be at a certain point in embryonic development and where they should migrate to.

Another important function of LSD1 is its role in the formation and function of white fat, one of the two main types of fat tissue in mammals. "LSD1 regulates many genetic programs for metabolic processes, such as those for fat burning and blood sugar balance. It can control the activity of fat cells, thus reducing the symptoms of diabetes mellitus type 2." Schüle and his colleagues demonstrated that the production of fat is blocked when LSD1 is inhibited.

From the Lab to the Hospital

Fundamental research is an essential component of the SFB, which rests on three pillars: The researchers of the first pillar work on fundamental molecular epigenetic mechanisms. The scientists of the second pillar develop systems for testing hypotheses, working, for instance, with cell cultures or mice that exhibit disease patterns similar to those of humans. The third pillar is concerned with transferring the findings from the first two pillars to the hospital. The researchers develop new active ingredients for drugs, methods for therapy, and markers doctors can use to make a solid diagnosis. "Ultimately, we want to use the knowledge acquired in our fundamental research to help patients better," explains Schüle. An example of this concept is a team led by Prof. Dr. Michael Lübbert from the SFB and the Freiburg University Medical Center, which is coordinating a clinical study funded from 2014 to 2016 by the German Consortium for Translational Cancer Research (DKTK). Doctors in five German research centers are developing LSD1 blocking techniques for the therapy of acute myeloid leukemia (AML).

The German Research Foundation has been providing funding for the SFB for two years. The maximum period of funding is twelve years. "The wide range of expertise the participating research groups bring to the table and their technical know-how make the SFB into a unique selling point for the University of Freiburg," says Schüle. Numerous articles in specialist journals testify to the success of the research. "In the coming years, I hope we receive the opportunity to work together in a single building or an institute of medical epigenetics." The field of epigenetics has a bright future, of that he is certain.

www.sfb992.uni-freiburg.de

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PT – Payroll and income tax
CT – Corporate income tax

Creating Competition, Offsetting Disadvantages

Greater fiscal autonomy after the Swiss model could help the German states to reduce their debts

by Nicolas Scherger

The German states should set their own tax rates; clear-cut rules create a level playing field for the strong and the weak: More competition should create incentives for reducing debt, says the Freiburg economist Lars Feld.

Illustration: Svenja Kirsch

"The result is that only Bavaria and Saxony have a sustainable budget."

Competition generates pressure. It requires commitment, top performance, a willingness to try out new ideas. The risk of failure is great. That is why no one wants competition. But for Prof. Dr. Lars P. Feld this is no argument: "It's not about what someone wants but about what produces good results." That also goes for the German states. The economist demands that they be given more freedom to set their own tax rates. "Tax competition would force them to manage their money better, and that would have a positive effect on public finance."

The Federal Republic of Germany has amassed more than 2,000 billion euros in debt, but the absolute amount does not say much, as Feld stresses. The key figure is the debt-to-GDP ratio. It places the country's debt repayment status in relation to its gross domestic product (GDP) – the total value of all goods and services produced in a country during a single year. In Germany the ratio is currently at roughly 80 percent. How dynamically it develops depends essentially on three factors: the interest rate on loans, the economic situation, and the efforts of the government to reduce the deficit. "When the debt in the numerator grows faster than the GDP in the denominator, because the interest rates are higher than the economic growth and the government fails to consolidate the debt, then we have a problem." This is precisely what Feld determined to be the case for the entire German public finance system – the federal government, the states, the municipalities, and the social insurance scheme – in a study published in 2013: "The dynamics of the debt ratio in the Federal Republic have been so great since the 1970s that the public finances are no longer sound."

Now the Freiburg economist and economic sage of the German federal government has spoken up again – with two new studies on how the debt situation developed in the individual states. "The result is that only Bavaria and Saxony have a sustainable budget." Three other states – Hamburg, Hesse, and Baden-Württemberg – are

"There are dozens of examples of how the states squander their money."

not far behind. Feld tested the states' fiscal health in four steps: He began by studying the development of their debt ratio and the relation between revenue and spending in each of the fiscal years. Then he considered their primary balance – revenue without earnings from interest minus spending without interest payments. "This indicates whether the government has determined that it needs to run a budget surplus to ward off the debt dynamics driven by the growing interest burden." Finally, he analyzed the factors responsible for increasing the debt – such as inflation, economic growth, or the development of interest rates.

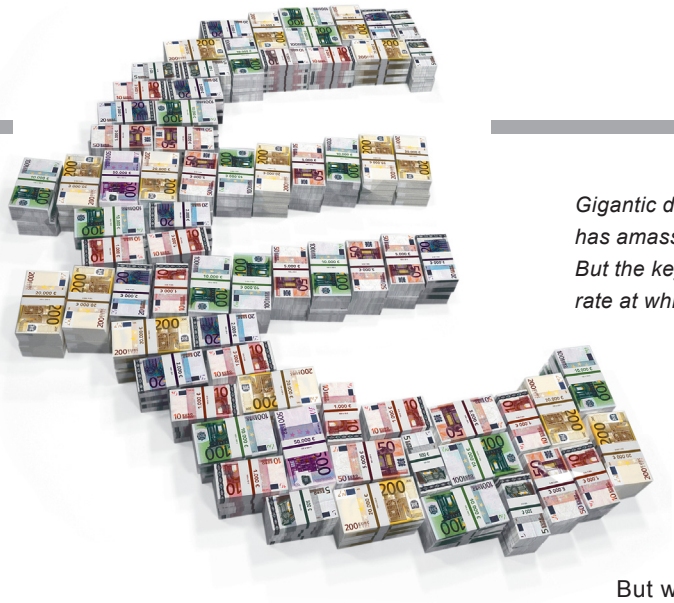
"In the end, we determined that most of the states react insufficiently to an increase in debt," summarizes Feld. This is true although the financially weaker states profit from the financial equalization scheme between the Federal Government and the states and although conditions are favorable for counteracting the negative dynamics of the debt-to-GDP ratio: Economic growth has exceeded the interest rate for the past three years – which has only been the case for an extended period of time once in the history of the Federal Republic, in the years of reconstruction after the Second World War, and is thus rather an exception. "Germany is the winner of the euro crisis. It is seen as a safe haven and gets cheap credit on the capital market, the economic upswing endures, tax revenue increases." In addition, the German states need to change course: From 2020 on they can no longer finance their spending with loans. That is the condition of the so-called debt brake, an amendment to the German constitution Feld supported, "the most rigid regulation of its kind in the world next to that of the Swiss, on which it is modeled." So why are the states still having so much trouble with it? Their biggest problem, according the economist, is their lack of fiscal autonomy.

Two have their finances under control (green), three are close to it (yellow), and the other eleven (red) are far from having a sustainable budget: Most of the German states are not doing enough to curb their rising debt levels. *Illustration: Anja Kaiser/Fotolia, Kathrin Jachmann*

Budget Cuts Aren't Enough

At present, the German states can only reduce their debt by cutting their spending. Feld sees more than enough places for them to start. "There are dozens of examples of how the states squander their money: construction projects like Stuttgart 21, the Elbe Philharmonic Hall in Hamburg, or the Berlin Airport, all of which have become much more expensive than originally planned, or subsidies and other forms of economic development." But in his opinion, budget cuts aren't enough. For one thing, politicians hoping to be reelected are reluctant to pass unpopular budget cuts. Instead, they prefer to attract voter support with their own, occasionally expensive projects. Second, large parts of the budget are virtually set in stone for the short term. "Personnel costs, for example, make up around 40 percent of the budget. It's not possible to save money on government employees from one day to the next."

On the other hand, the individual states have only little influence on tax revenue. The only tax rate they can set freely is that for land transfer. "However, it makes up such a small part of the budget that the revenue it generates is almost a



Gigantic deficit: The Federal Republic of Germany has amassed over 2,000 million euros in debt. But the key factor is not the amount of debt but the rate at which it is growing. Photo: Atelier W/Fotolia

trifle." The joint taxes, which are allocated to the federal, state, and municipal governments, make up about three-fourths of the states' revenue. They are set by the two houses of the federal government, the Bundestag and the Bundesrat, the latter of which is composed of members of the state governments. Thus, the states do have a say but are not allowed to deviate from decisions made by the entire parliament. The joint taxes include payroll and income tax, 42.5 percent of which goes to the state governments, and corporate income tax, which is split up evenly between the federal government and the states.

"My proposal is for the states to first raise part of their revenue from these taxes themselves with the help of a surtax and then continue to receive the rest from a common source," explains Feld. A gentle introduction to the model would ease the planning process and ensure that the tax rates – and therefore the revenue – do not drift too far apart from the outset. The part of the revenue the states are responsible for raising could be increased with time, stiffening the competition by degrees. In addition, this system would also be compatible with a financial equalization scheme. This scheme could not be based on the tax revenue of the states, however, because that would defeat the whole purpose of the competition. Rather, the goal would be to level out differences in the initial conditions of the states by way of an equalization of resources. If the GDP per capita is less in one state than in another, the basis in the former for raising taxes will also be lower. An equalization of resources could counteract this inequality, regardless of how high the tax rates and the revenue in the individual states actually are in the end. Hence, instead of harmonizing the results, it would provide for equal opportunity and thus fair competition. In this way, it would still be possible for a poor state to generate more revenue with the help of a high tax rate than a rich state with a low rate – while at the same time receiving equalization payments.

But what would happen if the states all try to outdo each other in the competition for low tax rates because they want to be attractive places to do business and live – so much so that they can no longer fulfill their public responsibilities and endanger the welfare state? Such fears set the tone of the discussion in Germany. Feld, on the other hand, again points to Switzerland, as with the debt brake. For him Switzerland is both a model and an object of research. He observes that the tax competition there is intense and very effective. "The Swiss cantons are always coming up with new ideas on how to gain the upper hand. Even as early as the 19th century there are wonderful episodes in which, for instance, Basel-Land complains about Zurich." The government thus needs to continually adjust the scope for fair competition. But apart from isolated mistakes, says Feld, Switzerland profits from the competition between the cantons, because these mistakes will be corrected on election day at the latest: "State governments with fiscal autonomy have a greater obligation to account for their actions to the citizens."

www.eucken.de/institut/leitung-lars-p-feld.html

Prof. Dr. Lars P. Feld

has served as professor of economic policy and constitutional economics at the University of Freiburg since 2010 and is the director of the Walter Eucken Institute. He studied economics at the University of Saarland. After earning his doctorate and habilitation at the University of St. Gall, Switzerland, he worked as professor of economics in Marburg and Heidelberg. Feld has been a member of the scientific advisory board of the German Federal Ministry of Finance since 2003, and he was appointed as an expert to the commission of the Bundestag and Bundesrat on the modernization of the financial relations between the federal and state governments in 2007. He has been a member of the German Expert Council for the Assessment of Macroeconomic Development since 2011. His research interests include economic policy, public finance, new political economy, and economic analysis of law.

Photo: private

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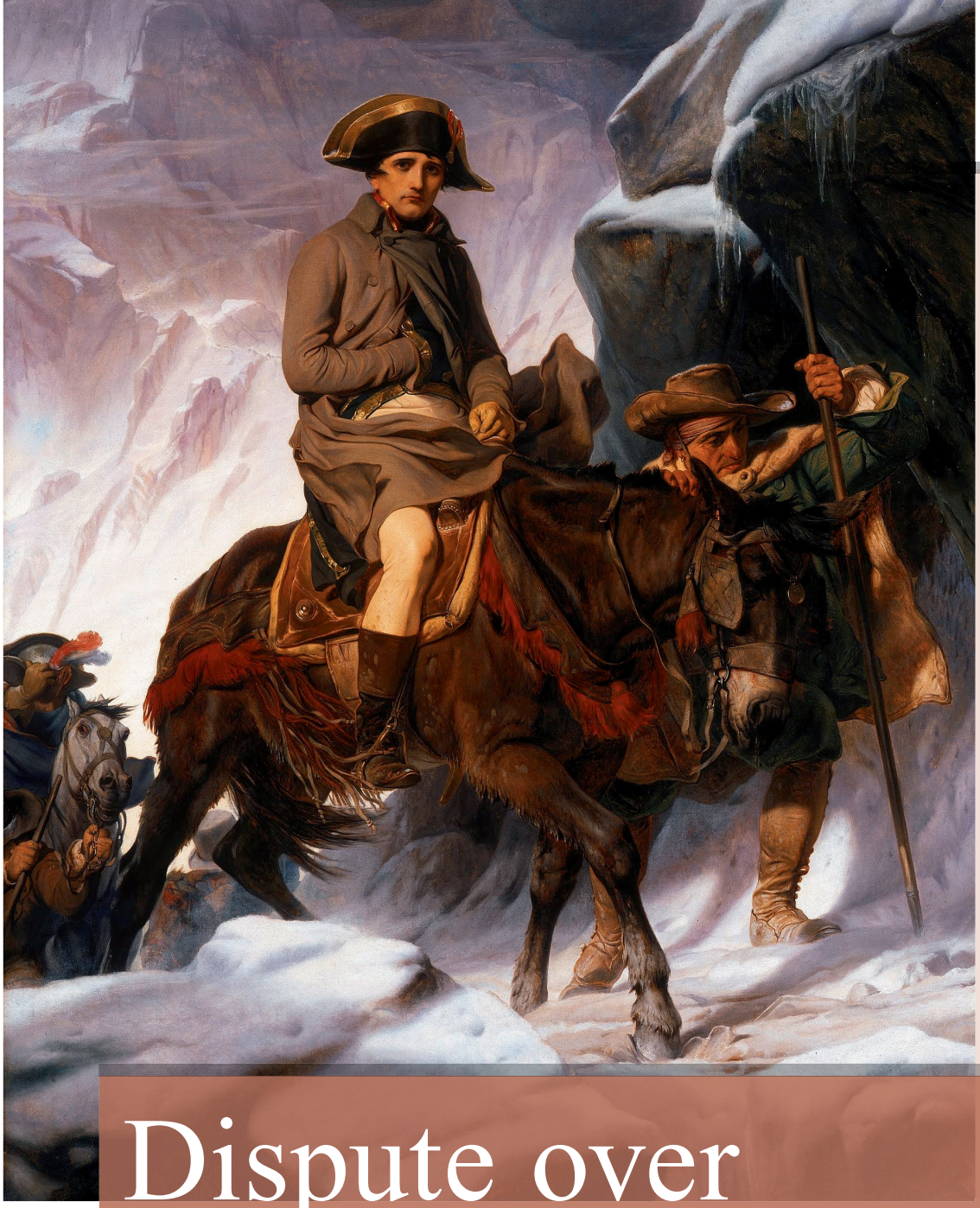


Dispute over a Hero

In the 19th and 20th centuries, political programs of all orientations made reference to Napoleon Bonaparte

by Rimma Gerenstein

One event, two images: The French artist Paul Delaroche portrays Napoleon as a man crossing the Alps at the Great St. Bernard Pass with difficulty, not as a superman (left). The French historical painter Jacques-Louis David, on the other hand, depicts the emperor as a resolute hero in superhuman dimensions (right). Source: both Wikipedia Commons

"What Napoleon himself says is less important than how people talk about him."

Napoleon is tired, and so is his mule. A soldier leads them both through the icy mountain range. The bitter-cold wind lashes them in the face. One false step on the steep, snow-covered path will send the troop plummeting into the depths. The great military leader and emperor suddenly doesn't seem that great anymore. He gazes wearily at the observer. His back is bent, his shoulders slumped. Is this what a hero looks like? The French artist Paul Delaroche portrays Napoleon as a man crossing the Alps at the Great St. Bernard Pass with difficulty, not as a superman – in contrast to the famous propaganda painting by Jacques-Louis David: The historical painter depicts Napoleon in superhuman dimensions – strong, iron-willed, resolute. The horse is bursting with energy, the rider pulling on the reins and pointing the way onward.

What actually happened in May 1800 is that Napoleon crossed Europe's largest mountain range with his army on his second Italian campaign and went on to defeat the Austrians at the Battle of Marengo. How is it that two painters stage the same event in such different ways? Which of the two paintings does justice to the legendary ruler? The answer to these questions doesn't depend merely on the event itself but on who wanted to send what message at what point in time, stress Prof. Dr. Jörn Leonhard and his assistant Benjamin Marquart, historians at the collaborative research center 948, "Heroes – Heroisations – Heroisms: Transformations and Trends from Antiquity to the Modern Age." The center, which is scheduled to run for twelve years, brings together scholars from various disciplines. They conduct research on rulers and saints, gods and demigods, workers, soldiers, citizens, and politicians. They want to find out when, how, and why a society produces heroes and what function they fulfill in their social and cultural environment, because one thing is clear: Heroes are not born but made, and people need to talk, write, and argue about them.

Genius, Great Man, and More

The two historians are studying so-called Bonapartism as a political hero narrative of the 19th century in Germany, France, and Great Britain. "Quite a diffuse phenomenon," they admit. Not even contemporaries could agree on what to understand under the term. "What most of the definitions boil down to is that it is a political program," says Marquart, "whatever its orientation might have been." The key point, however, is that the researchers want to break away from the traditional understanding of the term and the figure Napoleon. "What Napoleon himself says is less important than how people talk about him," stresses Marquart. The historian is thus concentrating on the time after 1821, the year of

the Corsican's death. "We want to find out how political heroism emerges as it is attributed to a protagonist by a society, beyond that person's actual biography," explains Leonhard. The crowning of Napoleon's nephew Louis Bonaparte as emperor with the name Napoleon III in 1852 creates meaning for the society, because the name refers back to a unique individual. In other words: Everyone can associate something with the figure Napoleon, and he is thus an ideal surface for various projections. The result is interpretational struggles and disputes over a hero's legacy, fought out in images, books, and political speeches.

Charisma, Aura, Personality

So what makes up political heroism as personified by Napoleon Bonaparte? "It is a combination of various models," relates Marquart. It involves a charismatic individual who performs superhuman feats in an elementary crisis and who saves the nation, for instance by means of almost unimaginable military triumphs. Napoleon has more than enough to show in both of these categories. He goes down in history as a brilliant military strategist, as the savior of the moderate cause in the French Revolution, who secures liberty, equality, and brotherhood for the people. But what is absolutely essential for a hero is a quality that can neither be measured nor quantified: charisma, aura, personality. "A hero is more than a genius or a great man," stresses Leonhard. "He performs seemingly superhuman feats by virtue of his charisma." At the same time, however, these superhuman feats are a provocation that violates established ideas, traditions, and norms. "That's why the dispute over a hero tends to last so long," says the historian.

On the subject of charisma: In 1851, immediately after the coup d'état of Prince Louis Bonaparte, Napoleon's nephew, the philosopher Karl Marx analyzes in a pamphlet how the rise to power can succeed. In the struggle between monarchy, bourgeoisie, and proletariat, he writes, a vacuum of class power has emerged, enabling the individual to establish himself at the head of the executive. The rise to power of a charismatic individual can be effortless – but in the case of Louis Bonaparte it turned into a farce, scoffs Marx.

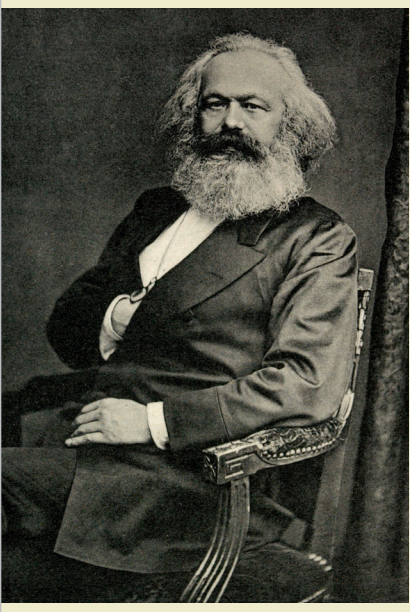
"The prince assumes office with the promise of becoming a new Napoleon," says Marquart. But he lacks the statesmanlike aura of his predecessor: He is no brave military leader, and unlike his uncle he shies away from the battlefield. He is not a good speaker either and is said to have been jeered at now and then during speeches. Even so, the new emperor knows how to make use of his uncle's legacy. He takes up the hero myth and fills it with new content: "Louis shifts the battle metaphor," explains Leonhard. "He no longer fights on the battlefield but against the impoverishment of the masses." He doesn't stylize himself as a military ruler but as a social ruler and an emperor of peace, as the symbol of a new France that is destined to make an impact in the world and that shows solidarity with its Romance-speaking sister nation Italy.

United in the Struggle against Tyrants

While the Second French Empire glorifies Napoleon as a hero, the Germans demonize him. "Napoleon is seen as a tyrant who subjects Prussia to his rule and subjugates Germany," explains Marquart. However, the adversary fulfills an important function: "The struggle against a seemingly superhuman enemy is crucial for the early phase of nation building in Germany," stresses Leonhard. "The focus on internal nationalization requires this strong opposing model.

The emperor and his caricature: Napoleon III has to lean on Lady Parliamentarianism for support, the English magazine Vanity Fair jeers in 1869.
Sources: both Wikipedia Commons

The philosopher Karl Marx analyzes how the rise to power can succeed after the coup d'état of Prince Louis Bonaparte. The rise to power of a charismatic individual can be effortless, he reasons, but in the case of Louis Bonaparte it turned into a farce.



The ‘wars of liberation’ in 1813, for instance, are characterized as forming the beginning of German unification – a beginning rulers deliberately called to mind in 1870 and 1914 as a means of rooting themselves in the tradition of these struggles.” Thus, a nation needs an opposing force in order to shape its own identity – or to reconfirm it. England, free of invasion and foreign rule, takes on a more relaxed attitude toward the legacy of the French emperor. Contemporaries emphasize their own traditions: the parliamentary system adopted in the early modern period and the guarantee of civil liberties. Moreover, they point out that the English already removed the absolutistic Stuart dynasty in the 17th century. “These traditions preclude a monarch from becoming as all-powerful as Napoleon,” underlines Marquart.

> “The struggle against a seemingly superhuman enemy is crucial for the early phase of nation building in Germany.”

What surprises the two historians most about their findings is the persistence with which older heroic figures, counter-heroes, and antiheroes have endured up to the present. They appear in times of crisis, political power struggles, or social and cultural upheaval – sometimes in the form of parodies, such as a political cartoon depicting the head of former Monsieur le Président Nicolas Sarkozy on Bonaparte’s body, and sometimes as an “Everyman’s hero,” like the firefighters who lost their lives in the rubble of the World Trade Center during the terrorist attacks of 9/11. The key point is that democratized societies need heroes too, people whose charisma makes them appear superhuman. “They force the people to take a stance, to act in a certain way,” summarizes Leonhard. “Heroes are figures you have to support or distance yourself from. You can’t just ignore them.”

www.pr.uni-freiburg.de/go/bonapartismus

Prof. Dr. Jörn Leonhard

has served as professor for Western European history at the University of Freiburg since 2006. After studying history at the Universities of Oxford and Heidelberg, he earned his PhD at the latter institution in 1998 with a dissertation on the historical semantics of liberalism in European comparison. Following a five-year fellowship at Oxford, he completed his habilitation in Heidelberg in 2004 with a thesis on the relationship between war experiences and interpretations of the nation in Europe and the USA between 1750 and 1914. In 2004 he accepted a professorship at the University of Jena. In 2010, Leonhard received the State Research Prize of Baden-Württemberg for his work. One of his main research interests is the comparative history of Western Europe in the 19th and 20th centuries.

Photo: FRIAS

Benjamin Marquart

studied history and German studies at the University of Freiburg and Dalhousie University in Canada. In 2011 he began work on his PhD at the collaborative research center 948, “Heroes – Heroisations – Heroisms: Transformations and Trends from Antiquity to the Modern Age.” In his dissertation, Marquart is studying Bonapartism in European comparison during the so-called long 19th century, which is defined as lasting from 1789 to 1914. His main research interest is comparative European cultural history of the 19th century.

Photo: private

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Realistic Route Planner

Future digital navigation systems will be capable of combining several means of transportation and taking into account traffic jams, changes in schedules, and personal preferences

by Claudia Füßler

Planes, trains, and automobiles: Users will be able to freely combine different modes of transportation on their preferred route from A to B.

Photo: Thomas Kunz

"We log in. The route planner recognizes us and knows exactly how we like to travel."

"Let's say you want to travel from Freiburg to Munich. Then enter this here." Prof. Dr. Hannah Best types FREIBURG, then MUNICH. A map of Southern Germany appears on her computer screen, which is projected onto the wall of her office by a video projector. A blue line runs over autobahn A5 to Karlsruhe and then A8 toward Bavaria. A good four hours for 412 kilometers: Google Maps shows the classical route. "But maybe you don't want to take that route but rather pass by Lake Constance, maybe even making a stop in Villingen-Schwennigen," says Bast as she clicks on the line and drags it slowly southward. The route planner reacts immediately, recommending a new route for every millimeter the line moves. The number of kilometers and the probable duration of each new trip appear in parentheses almost instantly.

The fact that Google Maps needs only a fraction of a second to calculate routes is in part due to the research of Hannah Bast. She holds the chair in algorithms and data structures at the Department of Computer Science of the University of Freiburg. Two years ago she received a Google Focused Research Award for her work. The award is worth nearly a million US dollars. According to Google, its purpose is to support areas of research that are interesting for the company itself and for the international computer science scene. A route planner that needs but the blink of an eye to calculate journeys doubtlessly fulfills these criteria.

But lightning-fast computers are not the only reason why Google users see immediately how much time their chosen route will take as they drag the blue line across the screen. "The computer is of course capable of trying out a million possibilities relatively quickly and then suggesting the most sensible and fastest one," says Bast, "but this would take a minute even for the best computers." So instead Bast and her colleagues did a little cheating. Instead of making the computer

faster, they searched for an algorithm that requires less calculations – and they found one, as every user of the route planner can attest.

Taxi to the Train Station, Plane to Rome

The basic principle works, so now Bast and her assistants have turned their attention to the fine tuning. Their aim is to make route planning even more comfortable, more individual, and above all more realistic. Traffic jams and changes in public transportation schedules have a direct impact on trip duration and will thus be shown to the user. In addition, users will be able to integrate personal preferences like "not the quickest route but the one with the best scenery" into their search at the simple click of a button. However, the biggest challenge at the moment is multimodality. The researchers want to enable the user to freely combine different modes of transportation on their preferred route from A to B: a short walk, a train ride, and then the rest by car, or by taxi to the bus station in Freiburg at the start of a trip, from there by bus to EuroAirport Basel–Mulhouse–Freiburg, then by plane to Italy, and finally by train to the city center in Rome. How long would this trip last, when everything is taken into account? If Bast has her way, soon everyone will be able to find out themselves on Google Maps. But this idea can only succeed if all of the companies whose data Google Maps wants to use cooperate: airlines, local transportation authorities, railroad companies.

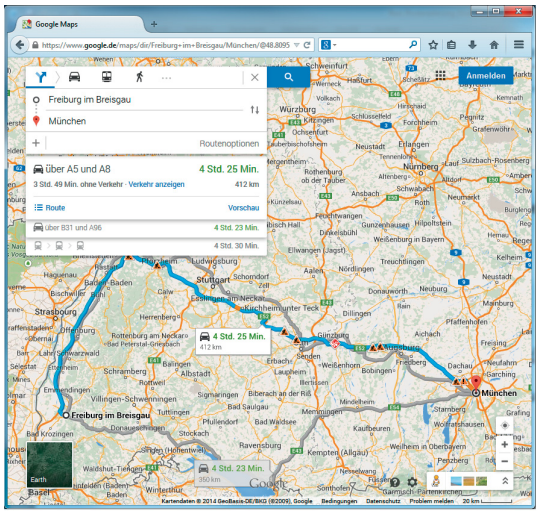
"It's amazing to see all the useful things you can do by programming."

In the USA, route planning of this kind with public transportation already works perfectly. The inhabitants of New York see how long they will be likely to spend in a traffic jam when they take their usual trip by taxi or bus from work to their home – and also whether the subway would be a better alternative or not. "In Germany, companies like Deutsche Bahn and the regional transportation authorities aren't nearly as generous with their data. That is still quite a problem," says Bast. And so, she has to spend a lot of time persuading the responsible protagonists from the private and public sector alongside her teaching duties and her research. At some point, however, the computer scientist is certain that the route planner will also function individually in Germany. "We log in. The route planner recognizes us and knows exactly how we like to travel – for instance that we prefer routes we can cover exclusively by public transportation and by bicycle, or that we like to travel from start to finish by car."

Such practical relevance is one of the things Bast likes about computer science. She studied mathematics and computer science in Saarbrücken. She soon found mathematics too dry and the presentation of computer science, which

The quickest route or the one with the best scenery? Requests to route planners will take into account personal preferences.

Photos: Matthias Buehne, Miredi (both Fotolia)



Google Maps calculates routes in a fraction of a second – thanks in part to the research of Hannah Bast. Source: Google Maps

Prof. Dr. Hannah Bast

studied mathematics and computer science at the University of Saarbrücken and went on to earn her PhD at the same institution. At the Max Planck Institute for Informatics in Saarbrücken she led a research group from 2000 to 2007 and then spent two years as junior research group leader of the institute's Cluster of Excellence. Afterwards, she spent one and a half years conducting research at Google in Zurich before coming to the University of Freiburg in 2009. Besides the award from Google, Bast has also received the Otto Hahn Medal from the Max Planck Society and the Alcatel-Lucent Technical Communication Research Prize for her work. Her research interests include intelligent search engines, route planners, and " everything that leads to something that can be put to good use." Photo: private

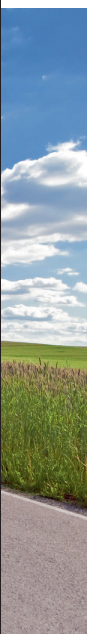
requires a lot of mathematics, too theoretical. What she found fascinating was the idea of combining the two for practical applications. Computer science, she says, is one of the best fields of all: "I also always try to convey that to my students. They can combine computer science with any topic they want to, and after writing a successful program they always have a result that they can present and use" – such as robots, games, or route planners. Bast has been conducting research on this last topic for a number of years. She was already trying to work out possibilities for calculating routes more quickly while working on her habilitation thesis at the Max Planck Institute for Informatics in Saarbrücken. Then, in the course of a year and a half of research at Google in Zurich, she developed the method now implemented in Google Maps that greatly speeds up route planning in public transportation networks.

Programming Intelligent Search Engines

However, the computer scientist also has another professional passion: intelligent search engines. "Look," says Bast, and her fingers fly over the keys of her laptop. Shortly afterwards a long, mysterious-looking list appears on the screen. It is a summary of the search requests for a computer science literature database developed by Bast and her colleagues, the largest in the world. France, USA, Chile, Thailand, France, Korea, Mexico, Germany, Sweden – the requests stream in by the second. The database evidently sees heavy use by people from across the globe. "We planned and wrote the program for the database on our own. It's amazing to see all the useful things you can do by programming."

In 2009, the mother of one daughter decided to accept an offer for a chair at the University of Freiburg. Was this a decision against Google and free enterprise? "In a way it was, because no private company can offer me the freedom I enjoy at the university. Here, no one comes along and tells me what I have to do." In addition, Bast was attracted by Freiburg's computer science program, which enjoys an excellent reputation in Germany and abroad, and also by the city itself, in which she feels quite at home. She likes to sit in her office until late at night brooding over new algorithms. Luckily she was also there when a student who had read "office hours, 10 to 11 p.m." on her homepage appeared in her office shortly before half past ten. She told him she had meant that as a joke, because she finds it silly to keep office hours in the age of email and the internet. Who says computer scientists have no sense of humor?

https://ad.informatik.uni-freiburg.de/staff/bast



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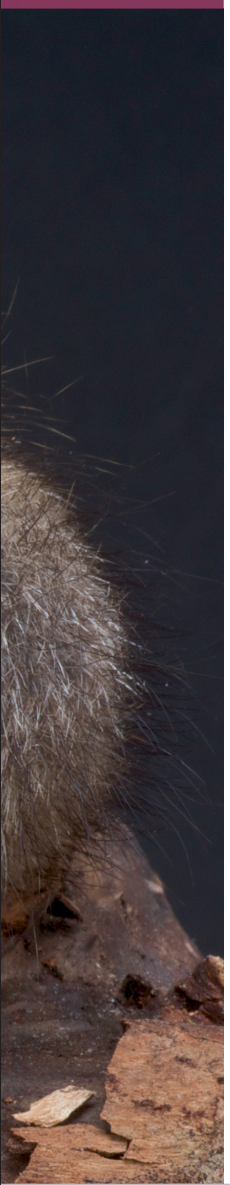
Forensics in the Forest

Freiburg wildlife ecologists are applying methods from molecular biology to maintain biological diversity and promote conservation

by Isabell Wiedle

Shy little guy with a fear of the future: Sooner or later, the dormouse will suffer serious consequences due to the loss of its habitat.
Photo: mgkuijpers/Fotolia



"The result is an increasing loss of genetic variability, leading ultimately to inbreeding."

If you're lucky, you might chance upon such shy animals as the wood grouse, the black grouse, or the dormouse on a hike through the German countryside. However, the populations of these wild animals have grown smaller and smaller in recent years. The main reason is the loss of suitable habitats, owing among other things to the intensification of agriculture and the spread of housing developments. The natural environments of these animals are being broken up, their small populations isolated. Dr. Gernot Segelbacher and his assistants at the Department of Wildlife Ecology and Wildlife Management of the University of Freiburg are investigating the impact of these trends on biodiversity.

In one project, the team studied dormouse populations near Tübingen and Ulm. Segelbacher and his colleagues from the Universities of Hohenheim, Tübingen, and Aarhus, Denmark, investigated whether there is still genetic exchange between the individual populations, even though the habitat has been broken up into several separate areas. The research site near Tübingen was a large unbroken forest, while the one near Ulm consisted of four forest fragments. The researchers marked a total of 380 dormice with microchips between 2001 and 2009. In addition, they took skin samples to determine the genetic fingerprints of the rodents and compared them to each other.

Comparing Current and Historical Samples

The results of the study confirmed the researchers' main hypothesis: In the unbroken forest there was an exchange of genes between the individual populations, whereas the dormice in the site near Ulm were no longer able to overcome the distance between the fragmented ranges and were more or less isolated. "The result is an increasing loss of genetic variability, leading ultimately to inbreeding, which will make it practically impossible for the dormouse to survive in the forest fragments analyzed in the study in the long term," says Segelbacher. Scientific findings like these provide important information for sustainable conservation and sensible land-use planning. They indicate where it is necessary to leave corridors between the ranges of endangered species and where wildlife crossings would be most useful.

The science of conservation genetics now provides noninvasive procedures that allow researchers to take samples from animals without catching them. Segelbacher has developed a method of this kind for indigenous birds like the wood grouse or

Wildlife crossing over an autobahn: Corridors between different ranges of the same species enable genetic exchange.

Photo: picsxl/Fotolia

To obtain the DNA profile of a wood grouse, the researchers collect feathers and fecal samples from the ground. Then they use these samples to map the animal's deoxyribonucleic acid (DNA) in the lab and represent the information graphically in an electropherogram – a genetic fingerprint that looks different for each individual.

Photos: Gernot Segelbacher; Montage: Kathrin Jachmann

the black grouse. It makes use of forensic molecular biology, a field related to forensic medicine: "Instead of looking for a cigarette butt at the scene of a crime we look for feathers, feces, or eggshells. This allows us to create a DNA profile of individual animals." In order to obtain a complete DNA profile from the collected samples, which usually contain only a tiny amount of deoxyribonucleic acid (DNA), the researchers begin by copying the DNA fragments via a polymerase chain reaction. They then apply electrophoresis, a method by which the fragments are separated from one another in an electric field. Since the molecules DNA is composed of vary in size and have different electric charges, they move at different speeds in the electric field. The results can then be represented graphically in an electropherogram, which is unique for each individual. In this way, the researchers can characterize the genetic makeup of each individual animal, just as with humans.

Genetic Diversity within a Species

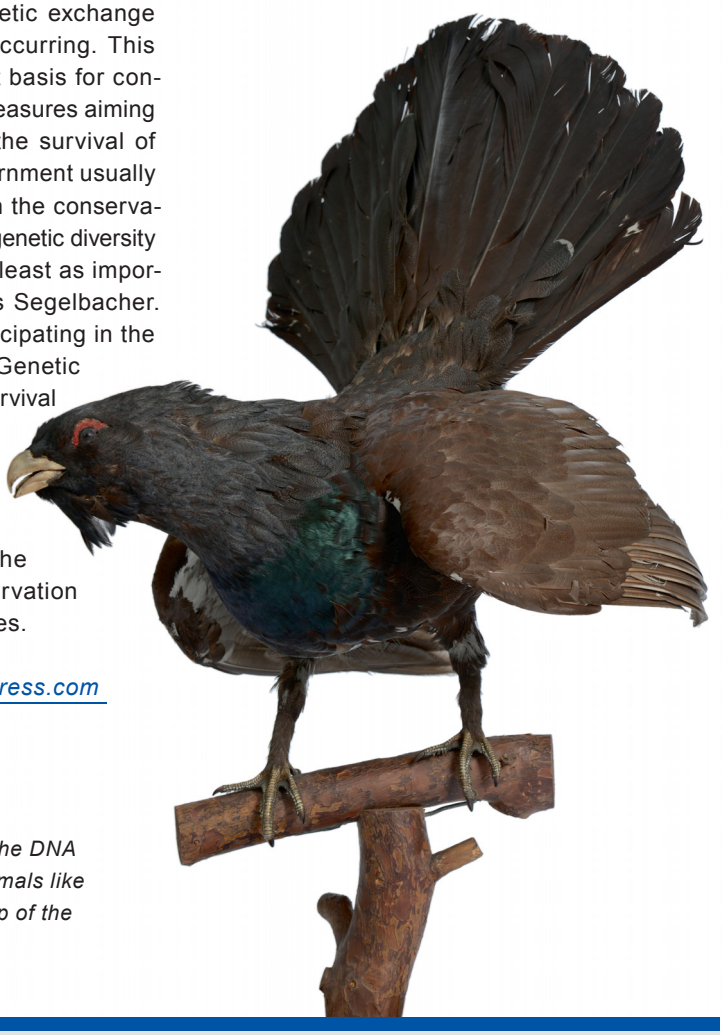
This method can be used to answer important questions of nature conservation, such as determining the size or migration behavior of a population. The molecular method is not only an inexpensive and time-saving alternative to the direct observation of animals by means of radio tracking devices but also has the advantage that it can be used on taxidermically prepared animals and archaeological findings. This enabled Segelbacher to compare current wood grouse samples with historical samples and compile information on the history of the species. For example, he found out there used to be a regular genetic exchange between wood grouses from the Northern and Southern Black Forest that is now greatly diminished.

The case study on dormice shows that populations need to exchange genes with each another in order for the species as a whole to survive. Only with a large amount of genetic diversity do animals remain adaptable, for instance to changing climactic conditions. By comparing the genetic data they have collected with the features of the landscape – such as the forest structure, urban

"Instead of looking for a cigarette butt at the scene of a crime we look for feathers, feces, or eggshells."

development, or roads – the researchers can identify corridors in which a genetic exchange between subpopulations is still occurring. This information provides an important basis for conservation and land-use planning measures aiming to maintain these corridors and the survival of the species in question. "The government usually focuses its conservation efforts on the conservation of species or ecosystems. The genetic diversity within a species, whose role is at least as important, is often neglected," stresses Segelbacher. In order to change this, he is participating in the EU-funded project Conservation Genetic Resources for Effective Species Survival (ConGRESS), which combines research and conservation. The goal is to provide protagonists from the government, administration, environmental organizations, and the media with information on conservation genetics and recommend measures.

http://conservationgenetics.wordpress.com
www.congressgenetics.eu



The scientists can even reconstruct the DNA profile of taxidermically prepared animals like this stuffed wood grouse with the help of the molecular method. Photos: Patrick Seeger

Dr. Gernot Segelbacher *studied biology with an emphasis on zoology, botany, and geology in Tübingen and earned his PhD at the Munich University of Technology in 2002. In his dissertation he studied the genetics of the wood grouse. After a few years conducting research at the ornithological institute in Radolfzell as a postdoctoral research fellow of the Max Planck Institute of Ornithology, he accepted a position as research assistant at the Department of Wildlife Ecology and Wildlife Management at what is now the Faculty of Environment and Natural Resources, formerly the Faculty of Forest and Environmental Sciences, of the University of Freiburg. His research focuses on the application of molecular methods in nature conservation.*

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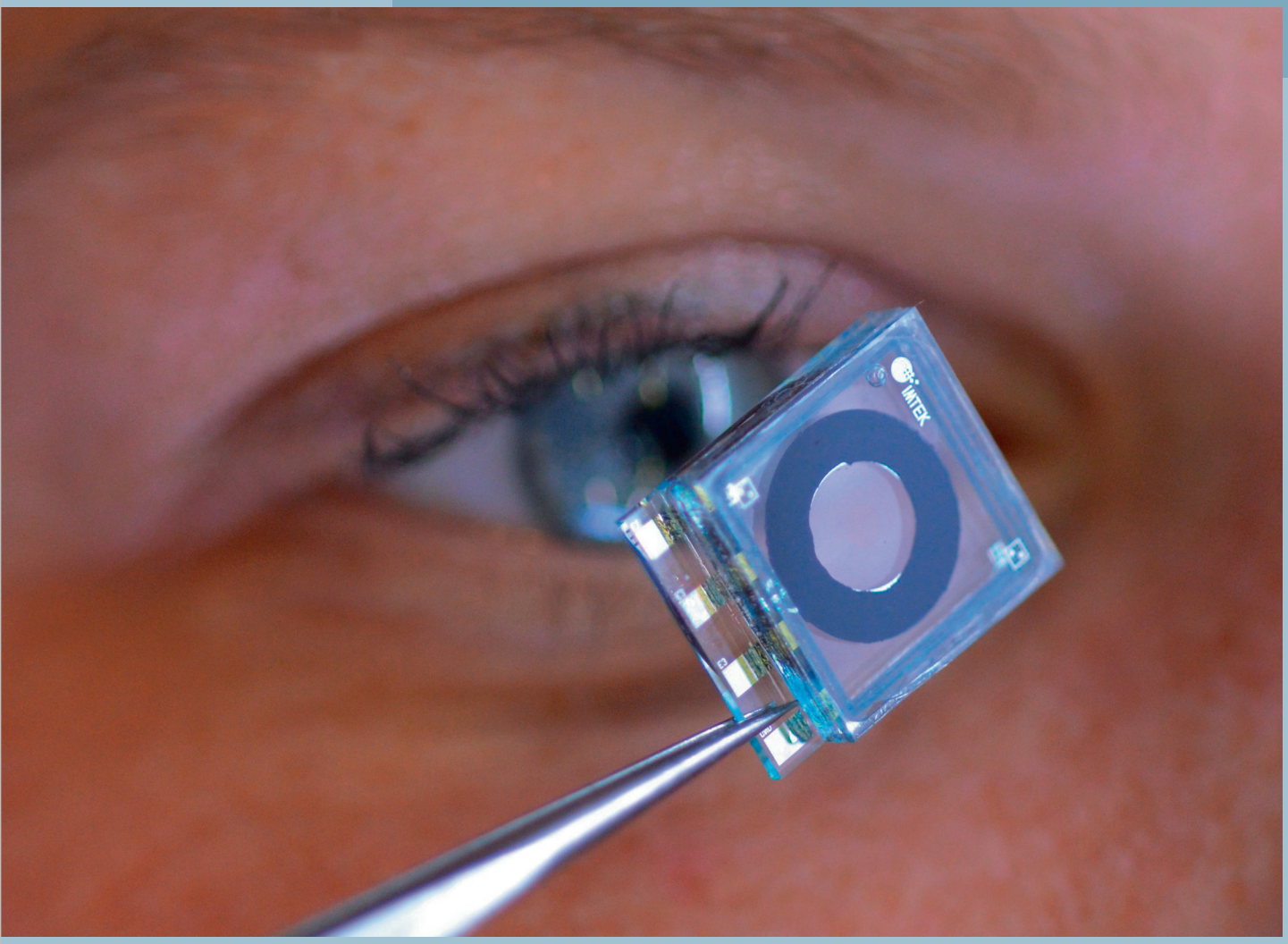
Visit the research portal Surprising Science to find out more about forensic molecular biology and Dr. Segelbacher's research on the migration behavior of birds: www.pr.uni-freiburg.de/go/Zugverhalten

SURPRISING SCIENCE

Inspired by the Eye

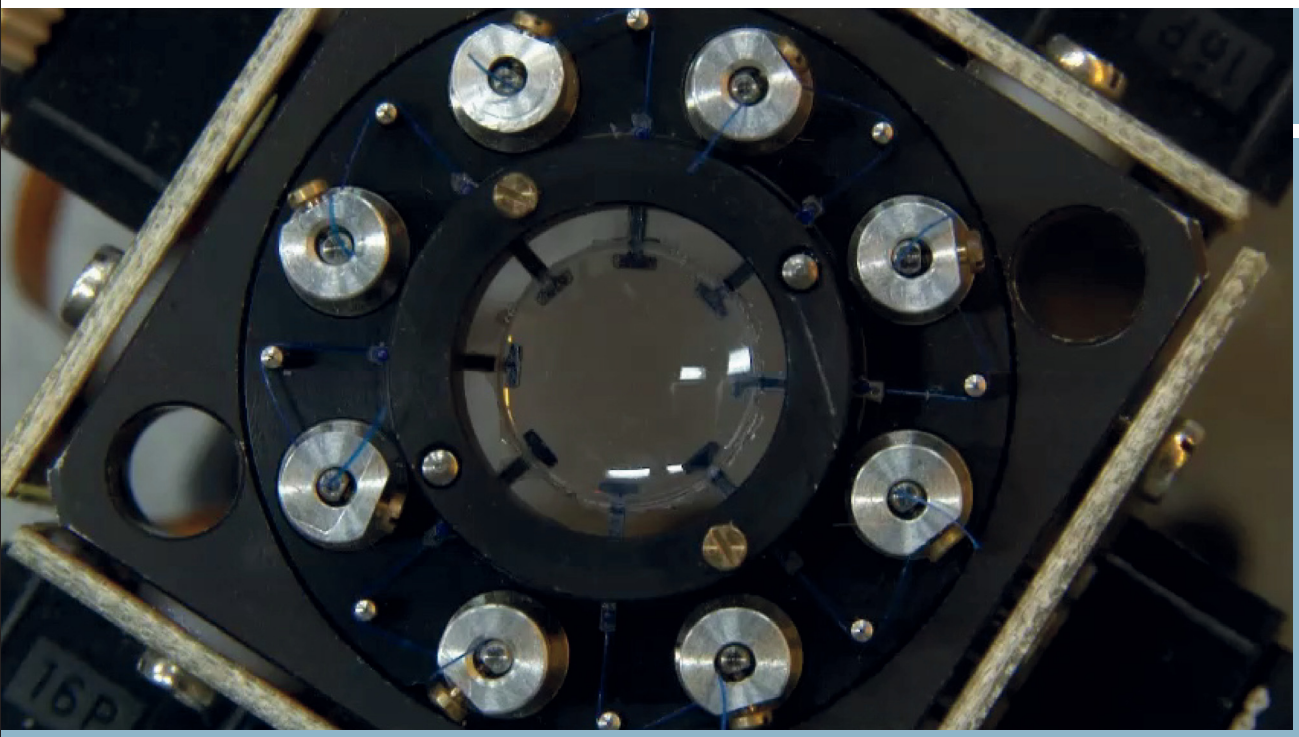
The engineer Hans Zappe and his team are developing a new type of lens and aperture inspired by nature

by Mathilde Bessert-Nettelbeck



"Potential areas of application for this system we see include camera technology, medicine, and microscopy."

Photos: Gisela and Erwin Sick Chair of Micro-Optics



Micromotors change the curvature of the lens by pulling on tiny anchors. This can be used to focus an image.

An imaging system that works like an eye: That is the goal the team at Prof. Dr. Hans Zappe's lab has set itself. Sebastian Petsch is working on a lens, Stefan Schuladen on an aperture. The researchers are experimenting with liquids and plastics in order to develop a technology that comes closer to functioning like the human eye than was previously possible.

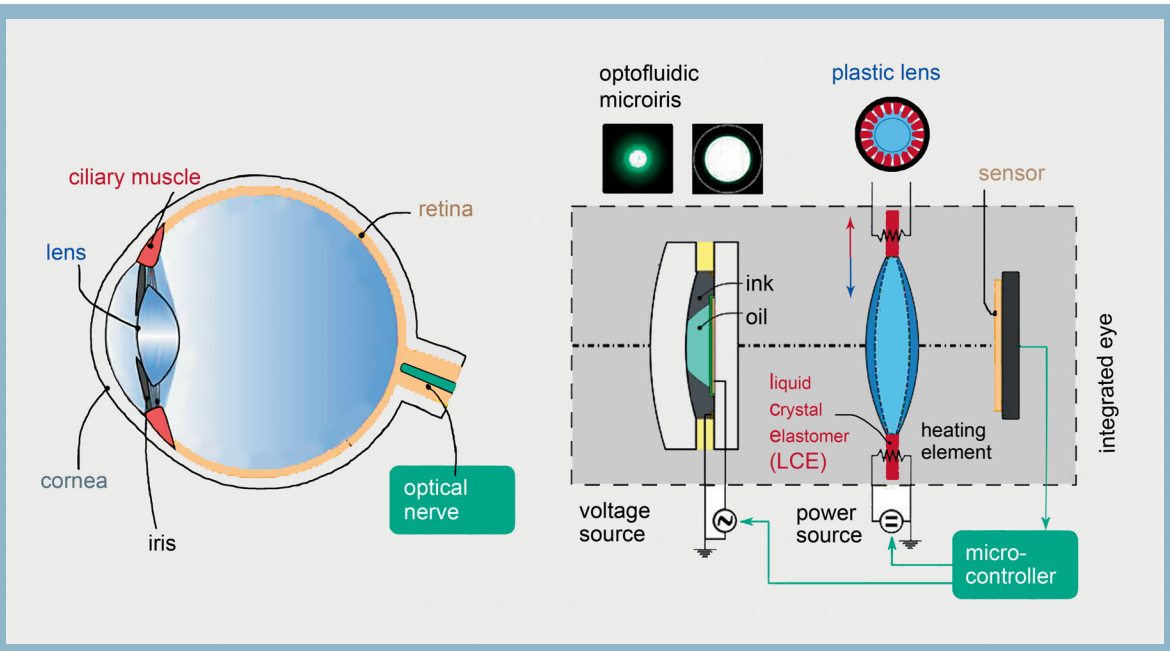
The eye reproduces the environment in various light intensities and colors. The essential structures for this are the lens and the iris, which create an image on the retina. The cells of the retina read this image and pass the information on to the brain. People also try to capture images on photos or videos – and their quality is getting better all the time. With technologies like 3D film or Ultra HD television, the entertainment industry is getting closer and closer to a genuine visual experience. The cameras that produce these images also need a lens to focus light and a system to produce a sharp image. As the eye is the visual system we are most familiar with, engineers take it as a model when designing lenses and objectives. "But until now we did not have materials that imitate the movement of the human lens and iris to replicate the physiology of the eye," explains Zappe, holder of the Gisela and Erwin Sick Chair of Micro-Optics at the Department of Microsystems Engineering (IMTEK) of the University of Freiburg. His team is using the latest microtechnology and flexible materials to develop an imaging system that works like an eye and adapts to different light conditions. In June 2013 Zappa and his PhD students Schuhladen and Petsch succeeded in constructing an initial prototype of an imaging system of this kind.

> "It was possible to set the sharpness and lighting according to the same principle at work in the eye."

Rubber Lenses and Liquid Aperture

The lens system of the eye consists of the cornea, the lens, and the iris. The lens and the iris adapt to light conditions: Muscles deform the flexible lens and change the focal length, allowing a sharp image to appear on the retina. The iris opens and closes to regulate the amount of light that can pass through the lens. In contrast to this flexible mechanism, cameras and microscopes use hard lenses that slide up and down to set the focus. The aperture assumes the task of the iris. It regulates the intensity of the light allowed to pass through and the depth of field. These components take up a lot of space. In comparison to professional camera lenses, some of which barely fit into a suitcase, the eye is a remarkably compact structure.

The Freiburg researchers have now succeeded in imitating the adaptability of the eye in compact form with flexible lenses and apertures. The



In analogy to the structures of the human eye, the integrated eye is composed of an iris (black), a lens (blue), and a sensor (orange). The opening of the iris and the curvature of the lens can be adjusted in the bionic imaging system – like in its model from nature. The optofluidic iris consists of an ink ring embedded in oil. When an electrical voltage is applied, the ring of ink expands: The iris closes and allows less light to pass through. The flexible plastic lens (blue) hangs on muscle-like elastomers (red) that contract when heated by a power source, causing the lens to flatten. In the human eye, the ciliary muscles (red) change the curvature of the lens. The retina (orange) receives the image information and passes it on to the brain via the optical nerve (green). In the bionic imaging system, a sensor (orange) identifies the image information and passes it on to a micro-controller (green), where it is processed to create an image.

Illustration: Gisela and Erwin Sick Chair of Micro-Optics

cylindrical prototype was only four centimeters wide and five centimeters long. Petsch contributed a rubber-like lens that can be deformed with tiny motors, and Schuhladen designed an iris made of controllable liquids. The images taken by an image sensor equipped with the prototype were of excellent quality. “It was possible to set the sharpness and lighting according to the same principle at work in the eye – an initial success,” says Zappe.

“Potential areas of application for this system we see include camera technology, medicine, and microscopy.”

Bottles of ink and electronics are laid out on Schuhladen’s laboratory workspace. He mixes liquids and wires up circuits to create a liquid iris that opens and closes on demand. The iris is made of a clear oil and a black ink. He pours them into a chamber between two sheets of glass equipped with transparent electrical contacts. The liquids do not mix, since one of them is oil-based while the other is water-based. The ink is in a ring within the oil. The liquids stay in place even if you shake the chamber, because they have the same density. By applying an electrical voltage to the liquid on transparent electrodes, a method known as electrowetting, Schuhladen can cause the dark ring to expand and contract. The iris then allows more or less light to pass through.

The challenge for Petsch is to develop a technique for deforming the rubber-like lens. He applies tiny anchors to the sides of the rubber. Micromotors pull the lens apart, making it flatter. This allows Petsch to regulate the focal length in the exact same way the eye does, by changing the curvature of the lens. A stretchable lens like this can also be used to correct imaging errors like those caused by an astigmatism, since it can be bent in an irregular shape. The next step will bring the researchers even closer to their goal of imitating the human eye: They are currently working on a synthetic muscle capable of deforming the lens exactly like an eye muscle. It is made of plastic material, a so-called liquid crystal elastomer (LCE), which shortens with increasing temperatures. This synthetic muscle will assume the role of the micromotors. It was developed by a team at the University of Mainz that is collaborating on the project. Zappe also wants to combine the

optics with another technology that is being studied in several projects at IMTEK – multispectral analysis, which makes minute nuances in color visible. "A system of this kind could be used to detect skin discolorations early on and diagnose cancer more quickly," says Zappe.

Imitating Nature, Improving Technology

The imaging system is bionic because it is a technology inspired by nature. It is not designed to optimize humans, even though it could become more powerful than the human eye in the future. "Bionics has nothing to do with cyborgs," clarifies Zappe. He grew up in the USA in the 70s and still remembers the television series *The Six Million Dollar Man* with the actor Lee Majors. He played an astronaut who had received several prostheses after an accident. This series talked a lot about "bionics," but Zappe's research has another aim: "We are by no means interested in developing eye prostheses or optimizing humans."

Building the imaging system into cameras is not one of the principle aims of the project either. "The first thing is to imitate the natural system. We want to demonstrate the interaction between flexible lenses and irises and the development of an entirely new imaging technology," explains Zappe. At the same time, the lens system illustrates the process of improving optical inventions. For example, the prototype did not remain stable long enough – the liquids in the chamber gradually evaporated. Schuhladen is working on solving such problems at the moment. The team hopes to finish an imaging system for demonstration purposes by the end of 2014. "Potential areas of application for this system we see include camera technology, medicine, and microscopy," says Zappe, "but the most interesting thing about it is the individual components."

www.imtek.de/professuren/mikrooptik/startseite

Prof. Dr. Hans Zappe *earned a degree in electrical engineering at the Massachusetts Institute of Technology, USA, and completed his PhD at the University of California, Berkeley, USA. He then conducted research on electronics, integrated optics, and semiconductor lasers, first at the technology corporation IBM and later at the Fraunhofer Institute for Applied Solid State Physics in Freiburg and at the Swiss Center for Electronics and Microtechnology in Zurich. In 2000 he accepted a position at the University of Freiburg as professor of micro-optics and from 2012 on as holder of the Gisela and Erwin Sick Chair Micro-Optics. He established the German Research Foundation priority program "Active Micro-Optics" and, with colleagues in Hanover, the collaborative research center "Planar Optronic Systems."*

Sebastian Petsch *has been working on his dissertation under Prof. Dr. Hans Zappe since 2011. He studied microsystems engineering at the University of Freiburg. He began developing bionic lenses, focusing especially on controlling them, in his master's thesis, which he completed in 2011. He is a research assistant at the Laboratory of Micro-Optics and conducts research on artificial muscles for controlling micro-optic lens systems.*

Stefan Schuhladen *has been working on his PhD at the Laboratory of Micro-Optics since 2012. He studied microsystems engineering at the University of Freiburg. While working on his master's degree, he spent a year studying biomedical engineering at the University of Michigan, USA, within the context of the cooperation program "Micro Alliance" and with funding from a Fulbright scholarship. He completed his master's degree in 2011. In his dissertation, which he is completing in the German Research Foundation priority program "Active Micro-Optics," he is focusing primarily on optofluidic micro-apertures and apertures inspired by the iris of the human eye.*

Photos: Mathilde Bessert-Nettelbeck

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Visit the research portal Surprising Science for videos and photos of the bionic imaging system: www.pr.uni-freiburg.de/go/mikrooptik

Only three leaves? Then hurry up and replace the cookie cutter to avoid making even more unsightly cookies: This is similar to the way in which cells prevent the production of defective proteins. Photo: Kathrin Jachmann

Quality Control in the Cell

A newly discovered mechanism protects the cell from the production of defective proteins

by Eva Opitz

Proteins consist of amino acid chains and are vital components of the body. They serve as a tool in almost all activities of the human organism. During their synthesis in the cell, they undergo a complicated process that determines what shape they will assume and where in the body they will be deployed. What happens when a piece of this puzzle doesn't fit right? Prof. Dr. Sabine Rospert and her team from the Institute of Biochemistry and Molecular Biology of the University of Freiburg made an astounding discovery in cooperation with colleagues from the USA: There is a mechanism in the cell that prevents the production of defective proteins before they can collect as waste material inside the cell.

> "We asked ourselves what happens when the signal sequence of a secretory protein exhibits mutations."

The origin of proteins, also known as polypeptides, lies in the deoxyribonucleic acid (DNA) of the cell nucleus. Once the information stored for protein synthesis has been transcribed into messenger ribonucleic acid (mRNA), a sequence of so-called nucleotides, it leaves the nucleus and migrates through the cell to the ribosome, the site of the next stage in the process. This stage is called translation, and it is made possible by the ribosome complexes, which consist of large and small subunits. The mRNA makes its way in between the two subunits and passes on the code for synthesizing the polypeptide chain to a transfer ribonucleic acid (tRNA).

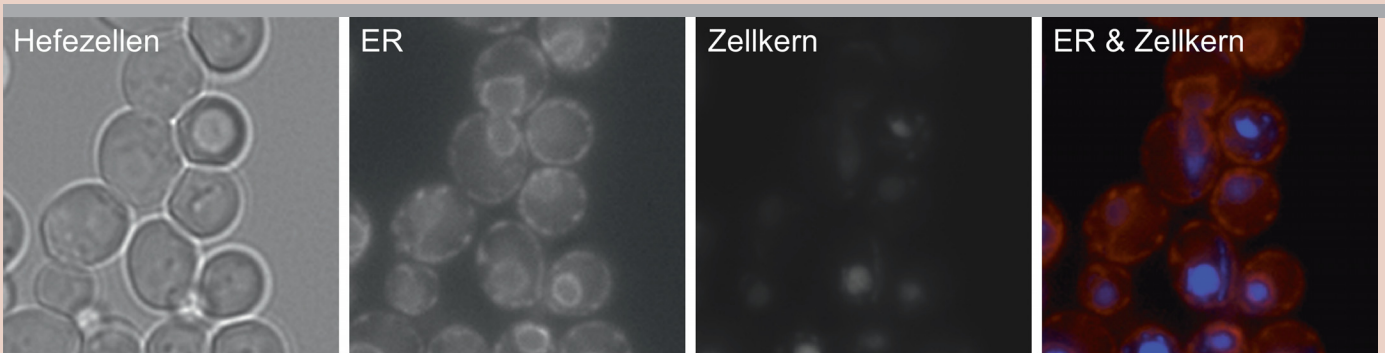
Dynamic Event at the Tunnel Exit

The nearly complete chain leaves the ribosome via a tunnel-like gateway in the large subunit. This is the site of a dynamic event. An assortment of protein biogenesis factors waits for the chain in order to bind to it and send it off in a complex interaction toward its destination, where it will be further modified. "We are studying many protein biogenesis factors, and each of them raises questions that we want to answer," says Rospert. "It is clear that the factors can't all bind at the same time, but which of them binds when and where?" It is known that each factor fulfills a specific function. Now the researchers want to understand how precisely each of these factors knows how its task is regulated. "How can it be that the factors are at the right place at the right time?" asks Rospert. The assorted protein factors waiting at the tunnel exit also include chaperones, which support the proteins in the folding process. "I would even go so far as to characterize these chaperones as midwives, because what they do is essentially to assist in the birth of the proteins."

One of the factors is a signal recognition particle (SRP). If it recognizes a particular signal sequence consisting of amino acids on the growing chain of a secretory protein – such as insulin – it attaches itself to the chain. In this way, SRP stops the translation process to ensure that enough time remains for the chain to bind to a receptor in the membrane of the endoplasmic reticulum (ER). The ER is a component of the cell in which the secretory proteins receive their final folding. The signal sequence splits off, and the receptor helps the protein reach the inside of the ER, where the final stage of its metamorphosis begins.

It has long been known that every cell has a sophisticated quality control system at its disposal. Something can go wrong at each stage of protein biogenesis. In the case of misfolded proteins, the cell deploys a highly effective complex to rectify the situation: the proteasome. It serves as a waste bin for proteins that the control system has identified as defective or even toxic.

However, the scientists are focusing on the interaction between the protein biogenesis factor



Images of the endoplasmic reticulum (ER) and the cell nucleus of yeast cells through a fluorescence microscope: Researchers use fluorescent dyes to reveal the precise localization of proteins and organelles in the cell. In these images, the ER is highlighted by means of a red fluorescent fusion protein, and the deoxyribonucleic acid (DNA) in the cell nucleus is marked with a blue fluorescent dye.

Photos: Sachiko Hayashi

SRP and the signal sequence of the growing chain of a secretory protein at the tunnel exit of the large ribosomal subunit. “We asked ourselves what happens when the signal sequence of a secretory protein exhibits mutations, preventing SRP from binding,” says Dr. Marco Chiabudini from Rospert’s research group. Previously, one would have assumed that the proteasome now steps in and disposes of the misfolded protein in its role as the cell’s own waste disposal system. However, the researchers discovered that the cell identifies the malformation before the disposal problem arises. “The cellular control machine has no means of identifying the mRNA of a mutated secretory protein,” says Rospert. Only the mutated protein itself no longer conforms to the standard. “What’s new about our findings is that we found a mechanism that recognizes the mutation in the protein early on.”

The molecular biologists suspect that this is a general mechanism that is at work in all secretory proteins. To explain their reasoning, Rospert uses the analogy of a bakery with a defective cookie cutter that cuts out hundreds of cookies in the shape of a three-leaf clover rather than the usual four-leaf clover. “Wouldn’t it be wiser to replace the cookie cutter than to go on producing clovers with the wrong number of leaves and throwing them out?” In any case, the cell uses this mechanism to make sure that no defective proteins are produced – the right decision for quality control.

“To our surprise, the defective mRNA with the mutated signal sequence was not translated further,” says Rospert. “Therefore, there had to be a previously unknown link between the mRNA and the cell’s quality control system.” If it weren’t for this trick, the defective protein would be synthesized again and again and thrown into the cell’s own waste bin. “The first one of course lands in the trash, but no new ones are produced.” In several further experiments on human cell lines, the scientists found out that a particular

The Freiburg researchers use dishes with a culture medium to obtain entire colonies of genetically identical cells from a single yeast cell. They use them to determine which factors are involved in the production of proteins.

Photo: Patrick Seeger

"The production of potentially toxic proteins is reduced to a minimum."

Prof. Dr. Sabine Rospert

studied biology and chemistry in Marburg and earned her PhD in microbiology in 1991. She then worked as a post-doc and an independent research assistant at the Biozentrum of the University of Basel, Switzerland, where she completed her habilitation in biochemistry. In 1999 she became a junior research group leader at the Max Planck Research Unit for Enzymology of Protein Folding in Halle/Saale. Since 2003 she has served as director of the Department of Biochemistry II at the Institute of Biochemistry and Molecular Biology of the University of Freiburg's Faculty of Medicine. She is a member of the Cluster of Excellence BIOSS Centre for Biological Signalling Studies and the collaborative research center SFB 746, "Functional Specificity by Coupling and Modification of Proteins." She conducts research on the molecular effect of ribosome-associated protein biogenesis factors on newly synthesized polypeptide chains in eukaryotic cells. *Photo: private*

Dr. Marco Chiabudini

studied biochemistry and molecular medicine in Regensburg and Freiburg. He has been a member of Prof. Dr. Sabine Rospert's research team at the Institute of Biochemistry and Molecular Biology in Freiburg since 2007. After completing his doctorate in 2012, he began researching there as a post-doc. His main research interest is the interaction of the translational machinery with the cellular quality control mechanisms for messenger ribonucleic acids and proteins in the baker's yeast Saccharomyces cerevisiae.
Photo: Patrick Seeger

factor is responsible for this type of regulation. Instead of the known signal recognition particle SRP, a particle by the name of Ago2 from the group of argonaute proteins binds to the ribosome and the chain with the mutations. Ago2 succeeds in establishing a link to the mRNA and initiates the process of breaking down the defective mRNA. "The production of potentially toxic proteins is reduced to a minimum," explains Rospert.

Advantage for the Cell

This in turn has a positive influence on the cell's energy balance, because it no longer has to produce or break down defective proteins. "It is not yet known precisely how the mRNA is broken down upon contact with Ago2," explains Chiabudini. One possibility is that it uses a nuclease, an enzyme specialized in cleaving mRNA molecules. "We are increasingly certain that the mRNA quality control is linked to the control at the protein level," says Rospert. The researchers have understood that the cell replaces the "cookie cutter" to prevent the production of defective proteins. Now they want to find out how this happens – and achieve further insight into what is likely a fundamental mechanism cells use to protect themselves against damage from defective and misplaced proteins.

www.biochemie.uni-freiburg.de/ag/rospert

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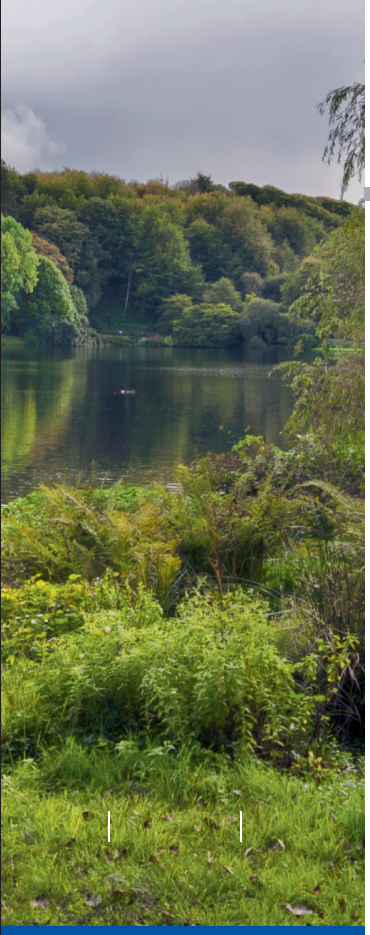
Seclusion – Idyllic but Fragile

How authors portray their own narrative situation in autobiographical texts – and sometimes experience leisure in doing so

by Stephanie Streif

Get me out of the city, the French civil servant and writer François-René de Chateaubriand must have thought when he decided to buy a country chateau with an overgrown garden near Paris. “This limited space seemed suitable for enclosing the hopes I had long entertained,” he notes on 4 October 1811 at the beginning of his memoirs. But before Chateaubriand takes up his quill to set down his eventful life in writing, he looks out at the lush thicket of his garden and describes the abundance of fruit and chestnut trees as well as the as yet small trees he has recently planted himself. Why? Only this place, he notes, has the potential to coax out the feelings hidden in the depths of his soul. The garden becomes a space of memory in which he can write himself into a state of leisure.

As special as this moment of reflection might have been for Chateaubriand, it is quite typical of many authors of the 17th, 18th, and early 19th centuries. However, the topos of the ideal space of seclusion that enables one to experience leisure and reflect on one’s life becomes ever more fragile in the course of the modern age. The portrayal of peaceful moments of leisure in the literature of the past and the present is the topic of the University of Freiburg’s collaborative research center SFB 1015, “Leisure: Concepts, Spaces, Figures.” The goal of the large-scale interdisciplinary project, which encompasses 15 research teams working on 15 subprojects, is to study the cultural history of productive unproductivity until the end of the year 2016. The participating disciplines are philos-



Suspended time: The garden is a place where many authors experience leisure.

Photo: Helen Hotson/Fotolia

ophy, ethnology, sociology, Slavic studies, and psychosomatic medicine.

Reflecting on the Self

One of these subprojects is called "Suspended Time and Narrational Spaces of Seclusion" and includes the Freiburg professors Thomas Klinkert, Romance studies, and Dieter Martin, German studies, as well as the PhD students Anna Sennefelder and Georg Feitscher. They want to find out how authors describe their own narrative situation: Do they incorporate their place of writing into the narrative, and if so, how do they portray it? How does time pass when they are writing? Quickly, slowly? Or are they writing under time constraints and not in a state of leisure? The researchers are investigating how the authors present their narrative and not how leisure is experienced and described in the text. What they are interested in is the identities behind the narratives. Thus, all of the texts the team is analyzing are autobiographical in nature, or, as the Romance scholar Sennefelder puts it, "texts written in the first person in which the narrator reflects on him or herself and narrates. It is then up to the readers to interpret this text as an account of reality or as fiction."

The history of the term leisure is comparatively complex, explains Klinkert. The connotations of the word "otium," the freedom from pressure and activity, were exclusively positive in ancient times. "Negotium," its negation, was understood as forced activity. Starting in the Middle Ages, and even more so with the rise of Protestantism, leisure often came to be associated with laziness, lethargy, or sin. The ambivalence of the term also occupied a lot of authors. One of them was Michel de Montaigne, who described idleness as a state between creativity and threat in an essay written in 1573. "He describes leisure not only as an opportunity but also as something that can give rise to the craziest of ideas," says Klinkert. Even in contemporary German language usage, there is no clear distinction between "Muße" ("leisure") and the negatively connoted "Müßiggang" ("idleness").

Sennefelder and Feitscher are currently combing through seven French and seven German autobiographical narratives by Stendhal, George Sand, Marcel Proust, Günter Grass, Christa Wolf, Thomas Bernhard, and others. While Feitscher is focusing on the 20th century, the texts Sennefelder is analyzing go back to the early 19th century. The PhD students want to demonstrate that the idealized space of leisure becomes ever more fragile over the centuries. Whereas Chateaubriand still situates his first-person narrator in an idyllic space of seclusion, Christa Wolf can only stare in a strained manner at her typewriter in her book *Patterns of Childhood*: "The sheet remained in the typewriter; no one typed on it for nine days," she notes, and in another passage she complains: "The pressure to produce several pages per day can cast a cloud over the days." For Wolf, there is no longer any leisure. In addition, it is striking that the author does not introduce her first-person narrator until the last pages of the novel.

> "Leisure resists being defined in terms of the contrast between work and free time that characterizes existence in modern society."

"The past and the present self are not automatically identical," explains Feitscher. "Rather, it is first necessary to construct the relation between the two in the strenuous process of writing."

In Modernism, Everything Seems Possible

This is just one example of how authors in more recent autobiographical texts explore – and more often than not problematize – the question their own identity. Nothing is idealized anymore in the modern age: Even Stendhal interrupts his dreamy experience of leisure by informing the reader in a brief footnote of how many pages of text he has succeeded in writing in but an hour. Less and less remains of the idyllic space of seclusion – the garden, the island, the library. Up until the 19th century, authors began by describing this space and then went on to fill it out of a feeling of leisure: with facts, thoughts, and emotions concerning their own selves. The process of filling this space was a fulfilling experience. It was as if time stood still, or better: as if it receded into the background. Also typical of this type of experience was that it was not possible to plan in advance what would come out of it. It just happened. Authors continue to draw on this tradition in the present. Günter Grass, for instance, begins narrating in his autobiography *Peeling the Onion* during a

"The sheet remained in the typewriter; no one typed on it for nine days," notes the writer Christa Wolf – for her, there is no longer any leisure.

Photo: spinetta/Fotolia

walk on the seashore. In the present, the quartet of researchers has determined, various narrative models exist side by side – from classical to extremely fragile. This, too, is a quality peculiar to modernism: Everything seems possible.

And the leisure? Then as now, it is not possible to simply conjure it up at will. There are of course certain activities we can engage in to experience leisure, like taking walks, meditating, and writing, but there is no magic formula. "We are not writing self-help books," says Klinkert. "There are already enough of them." Dieter Martin adds: "Studying leisure doesn't just mean investigating thought models of the past but also providing ideas for alternatives" – alternatives to the modern practice of using free time as a means of restoring one's strength for work as efficiently as possible. Leisure is more than free time, says Martin: "Leisure resists being defined in terms of the contrast between work and free time that characterizes existence in modern society." It is adventure enough to delve deeply into texts and bring the social and cultural significance of leisure hidden within them to the surface. This makes the concept of leisure easier to grasp for the general public – even if it will always remain a highly subjective experience.

www.sfb1015.uni-freiburg.de

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Prof. Dr. Thomas Klinkert

studied French and German studies in Amiens, France, and in Munich. After completing his PhD, he moved to the University of Regensburg, where he completed his habilitation in 2001. From 2003 to 2007 he worked there as professor of Romance literature, and since 2007 he has served in the same function at the University of Freiburg. His research focuses on literature and knowledge, literature and historical semantics, the self-reflectivity of literature, literary theory, and literature and cultural memory.

Prof. Dr. Dieter Martin

has taught at the German Department of the University of Freiburg since 2005, first as an adjunct professor and since 2013 as a tenured professor. He studied German and musicology in Erlangen and Heidelberg, earned his PhD in Heidelberg, and then came to Freiburg, where he completed his habilitation thesis in 1998. His research interests include literature and music, textual criticism, edition philology, and reception theory and history.

Photos: Markus Herb

Anna Karina Sennefelder

studied German and Romance studies at the University of Freiburg. She has served as a research assistant at collaborative research center 1015, "Leisure: Concepts, Spaces, Figures," since 2013 and is writing a dissertation under Prof. Dr. Klinkert entitled Suspended Time and Narrational Spaces of Seclusion: Leisure and Authorship in Autobiographically Structured Narrative Texts from Senancour to Proust.

Photo: Conny Ehm

Georg Feitscher

studied communication science and German studies in Greifswald and then modern German literature in Freiburg and Paris, France. He has worked as a research assistant at collaborative research center 1015, "Leisure: Concepts, Spaces, Figures," since 2013. He is writing a dissertation under Prof. Dr. Dieter Martin entitled Suspended Time and Narrational Spaces of Seclusion: Leisure and Authorship as Exemplified by the Autobiographic Narrative Model.

Masthead

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