uni wissen 04

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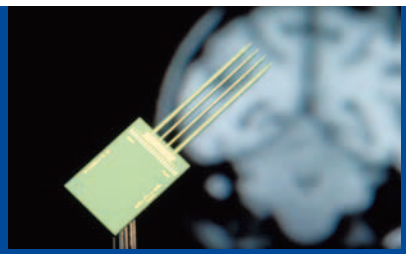
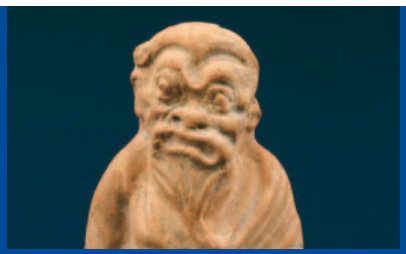
In Shape in Space

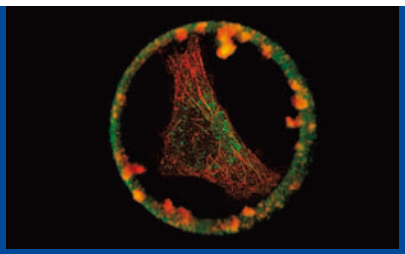
Sports scientists test exercise equipment for astronauts



Tiny Tools:
Microsystems engineers develop sensors for brain research



Classical Comedies:
Philologists analyze fragments of Greek comedies



Enemy Entities:
Biologists study how bacteria invade human cells

UNI FREIBURG

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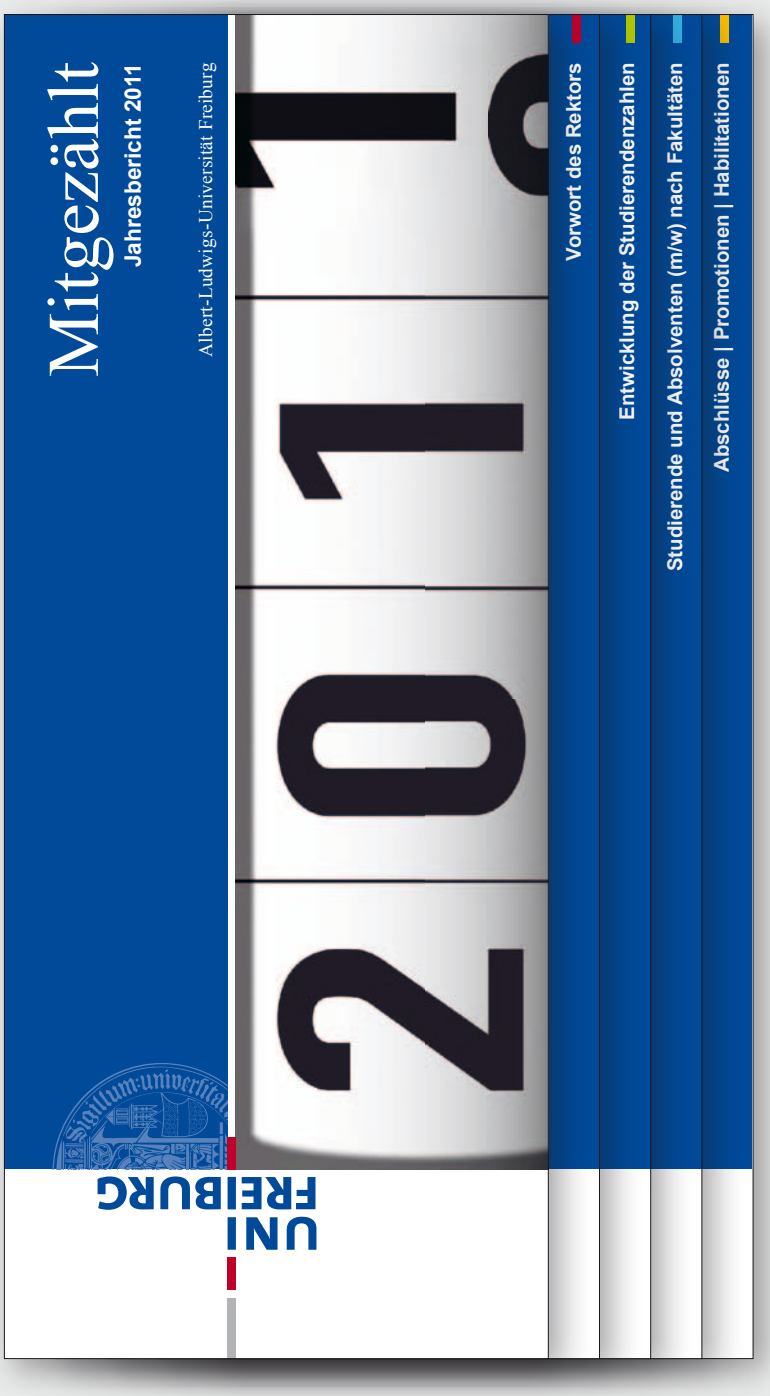
uni'wissen '04

Yearly Report 2011: The Numbers Stand for People

The positive development of the University of Freiburg cannot be represented by means of numbers alone, because the numbers stand for people and their achievements. All the same, the university would like to give you an idea of these developments in compact form. The detachable yearly report presents data and facts from the past year (1 Oct. 2010 – 30 Sept. 2011)



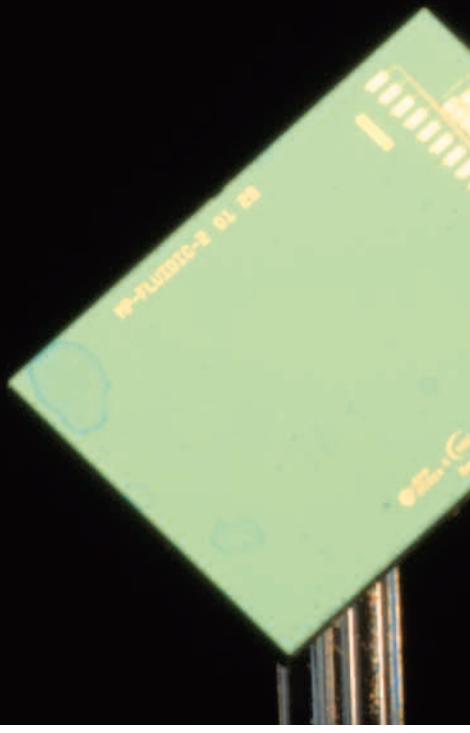
Read the yearly report here:
www.uni-freiburg.de/go/jahresbericht_2011

Contents

Small Size, Big Effect

Scientists Use Neural Probes to Record Communication between Nerve Cells

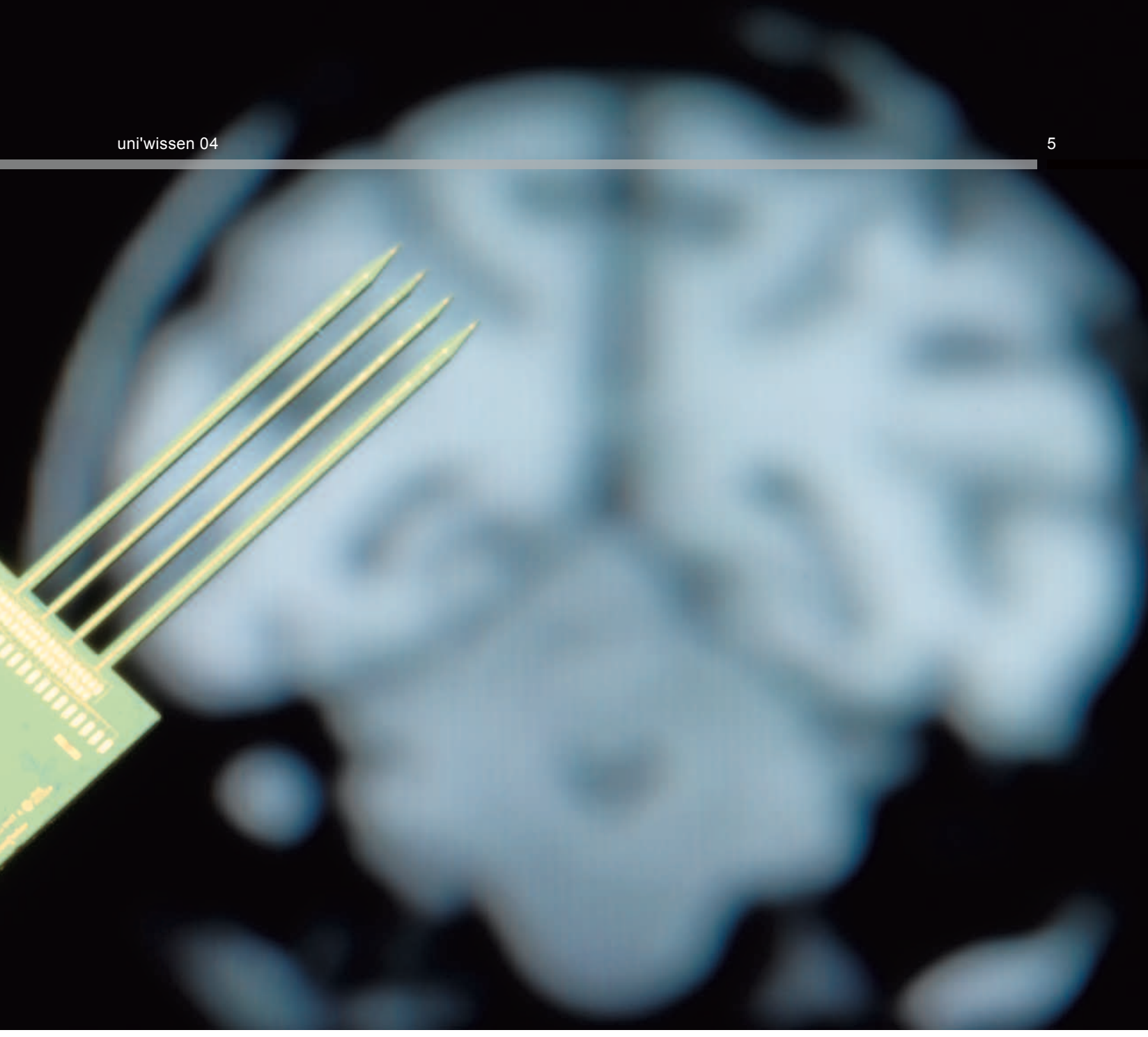
by Anita Rüffer



They listen in when nerve cells communicate with one another: neural probes planted permanently in the brain.
Photo: IMTEK/Müller

What is going on in this rat's head, anyway? It shows symptoms of epilepsy, of that the researchers at the Epilepsy Center of the Freiburg University Medical Center are certain. But where in the rat's brain is the transmitter that's interfering with the signals and causing some of its nerve cells to interrupt the highly specialized, independent signal processing, and why is this happening at all? Instead – this much is known about the disease – the cells are sending their electronic pulses at the same time and in the same rhythm. As a consequence, the rat loses control over the regions of its body connected to the nerve cells and experiences epileptic seizures. 700,000 people suffer from epilepsy in Germany alone and are familiar with this "storm in the brain." Epilepsy is the most common brain disease. The scientists are conducting experiments on animal models to find out how to prevent a seizure by sending the right electric signals in the right place in order to induce the nerve cells to return to their normal rhythm.

Many exciting questions of the neurosciences, medicine, and biology would still be awaiting an answer if it weren't for microsystems engineering. "We deliver the scientific tools necessary to find out what is happening in the brain," explains Dr. Patrick Ruther, research assistant under Prof. Dr. Oliver Paul at the Laboratory for Microsystem Materials. Ruther, one of 20 assistants at the De-



partment of Microsystems Engineering (IMTEK), just came back from an operation at the Epilepsy Center. Employees of the center planted a tool of this kind, a so-called neural probe, in the rat's brain. The conventional wire probes used in many research institutes around the world to study the brain from the inside seem like dinosaurs in comparison to these delicate little instruments with a big effect. They have a single sensor at their tip and are guided to various parts of the brain – with the constant danger of irritating the brain tissue and even causing permanent damage. The neural probes developed at IMTEK are planted permanently in the brain. They look like tiny forks with a highly flexible handle and rigid prongs. Thanks to the soft handle they move along with the brain mass, thus minimizing the danger of irritating the tissue. The scientists introduce them into the brain tissue with great precision using tools equipped with tiny suckers. Attached to each of the four-millimeter-

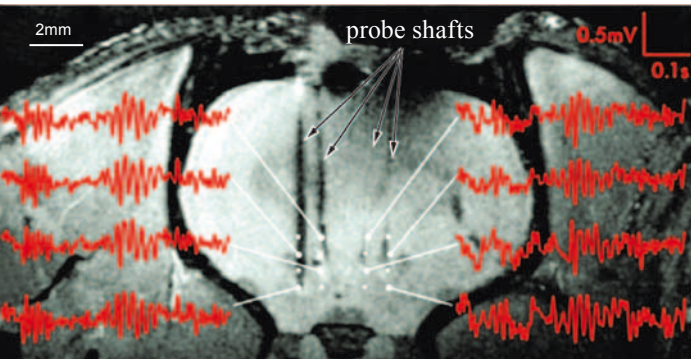
"We deliver the scientific tools for finding out what goes on in the brain"

long, hair-thin "prongs" or shafts are up to 200 electrodes that "can make a detailed recording of all of the whispering between the nerve cells," explains Paul. "This allows us to pick up more signals with a single measurement." The signals are passed along the shaft to tiny contact points

on razor-thin conductor paths. From there they reach the outside by way of a highly flexible ribbon cable or a wireless connection.

More Than Just Random Noise

Another reason why the body's control center is no longer terra incognita for neuroscientists is the development of external measuring methods like electroencephalography and magnetic resonance imaging. "They provide us with a comparatively large-scale image of what happens inside," says Paul. Ruther likens such methods to a microphone held up in front of a big crowd of people. "It picks up a general murmuring and other random noise, but you can't hear individual voices." This is precisely what the invasive methods are supposed to detect. The scientists apply entire networks of electrodes directly to the cortex to obtain more precise results. The electrodes on the neural probes are spaced approximately one-twentieth of a millimeter from one another, a distance which corresponds roughly to the spaces between nerve cells. By registering the electric current that passes from one nerve cell to another, the researchers can "listen in" to what the neurons have to say to each other. Probes are still used primarily for pure research, but in the near future they could open up many new possibilities for clinical practice – for instance in further refined deep brain stimulation for patients suffering from Parkinson's disease, a technique with which 75,000 patients around the world have already been successfully treated.



Electrodes in action: The magnetic resonance image shows a rat's brain with implanted probes from the Department of Microsystems Engineering. The red curves show the behavior of electrical signals (in millivolts) over time (in seconds), as measured at various positions. Image: University of Cambridge/Holtzman

The great advancements in research in this area are the result of NeuroProbes, a four-year project funded by the European Union that ended in 2010. In addition to neuroscientists and clients from industry, the 14 partners from ten European countries also included technology experts like those at Oliver Paul's laboratory. IMTEK received 2.25 million of the 13 million euros in funding for the project. Patrick Ruther was in charge of technological coordination. According to Paul, NeuroProbes clearly reached its goal, namely to end European dependence on American providers: "We have caught up with and even passed them in some areas." As far as he knows, no one else has succeeded in installing 200 electrodes on a shaft with a width of only 0.1 millimeters. The fact that IMTEK employs specialists for optics, fluidics, and electronics who know how to produce custom-fitting probes from CD-sized silicon disks using chemical methods like the dry etching technique played out to the scientists advantage.

Even a Hair's Breadth Off is Too Much

The probes are not ready made but always customized to client specifications. Research groups from Charité in Berlin, the Max Planck Institute in Frankfurt, and the universities of Tübingen, Cambridge, Freiburg, and even Berkeley order probes from IMTEK. The University of

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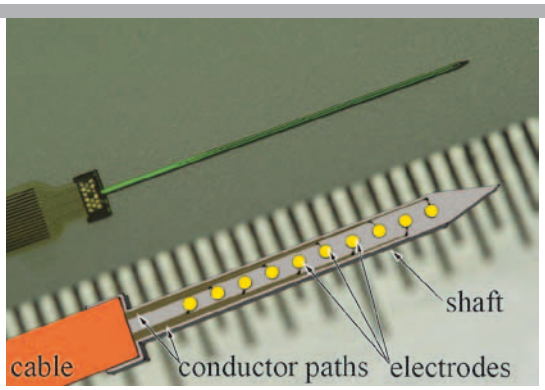


This nine-millimeter-long probe registers electric current between nerve cells with electrodes and passes the signals along the shaft on conductor paths.
Image: IMTEK/Ruther.

Cambridge, for example, is using them to investigate the development of addiction and impulsivity. Scientists in Freiburg are studying how and where in the brain epilepsy develops. “We have to make measurements in different areas of the brain and adapt our probes to their dimensions,” says Paul. This can mean varying the amount and length of the shafts or the number of electrodes affixed to them. In the end, the suppliers cannot afford to be even a hair’s breadth off with their product.

Along with the faculties of biology and medicine as well as the Department of Computer Science, the Department of Microsystems Engineering is in the running for the second round of the Excellence Initiative with the research cluster “BrainLinks – BrainTools.” Oliver Paul and his colleagues Prof. Dr. Wolfram Burgard and Prof. Dr. Ulrich Egert will function as the team coordinators. Their vision is to control nerve signals to the point where visual or aural prostheses, artificial limbs, or speaking aids can be made to communicate directly with the brain and perform more and more sophisticated tasks. Controlling machines with thoughts – that, as Oliver Paul admits, is a task that “will require close ethical supervision.”

Prof. Dr. Oliver Paul
is professor for materials of microsystems engineering at the Faculty of Engineering of the University of Freiburg. He studied physics at the ETH Zurich, where he earned his doctorate with a dissertation on surface magnetism. Following stations at the Fraunhofer Institute for Solar Energy Systems and the ETH Zurich, where he worked on highly efficient silicon solar cells, silicon technology for microsystems engineering, and physical microsensor technology, he was offered a chair at the Department of Microsystems Engineering (IMTEK) of the University of Freiburg in 1998. He served as academic dean of IMTEK from 1998 until 2002 and as director of the department from 2006 until 2008. He currently serves as academic director of IMTEK’s central technology center.

Dr. Patrick Ruther
is a research assistant at the Laboratory for Microsystem Materials. He studied physics at the University of Constance and earned his doctorate in mechanical engineering in Karlsruhe. He served as technological coordinator of the European Union-funded project NeuroProbes and has continued this research focus at the Laboratory for Microsystem Materials since the project ended. Besides neural tools, he works with new production techniques for microsystems and sensors that can measure force and torque.

Enlightenment thinking and the metric system: All people have the same rights therefore, units of measurement should be the same for all goods. Photos: katz23, milosluz (all Fotolia)

A Kilo of Freedom

Historian Peter Kramper is Studying How the Metric System Changed the World

by Benjamin Klaußner

Emblem of standardization: The International Bureau of Weights and Measures was founded in 1875 in Paris to oversee the installation of standard measurements and weights. Image: Wikimedia Commons

What is more, a liter of milk or a liter of water? Today, every child knows that a liter is always a liter, no matter what the content is, but in the 18th century people were just as convinced that this is not so: A gallon of beer can't have the same volume as a gallon of wine, because these are two different kinds of liquid. In 1750 a gallon of beer in England was about 800 milliliters more than a gallon of wine.

The introduction of the metric system put an end to this way of thinking in the space of just a few generations. The units meter, kilogram, and liter brought about a revolution in the way we think about distance, mass, and volume. Dr. Peter Kramper is conducting research for his habilitation thesis at the Department of History and the Freiburg Institute for Advanced Studies (FRIAS) on how new systems of measurement shaped the European nations between 1750 and World War I. His thesis focuses on standardization in Europe, with an emphasis on Germany, France, and Great Britain. He asks what units of measurement existed, how they developed, and why they ended up being standardized. He is not only interested in the scientific and administrative side of the problem, but also in economic, social, and cultural aspects: "There was an economic and a cultural logic of measurements in the early modern period that changed radically in the 19th century." He unearths answers to his questions at archives and libraries: in pamphlets, scientific publications, or administrative acts. Also informative is the literature of the Enlightenment: Arguments for or against standardized measurements took on propagandistic qualities, says the historian – particularly in France.

Units Based on Nature

The French revolutionaries introduced the metric system in 1789. Kramper calls it "a systematically constructed system of units of a rationalistic simplicity." It was based on nature – a meter was originally the ten-millionth part of the distance from the North Pole to the equator along the degree of longitude on which Paris is located. The liter and the kilogram were derived from the meter. The elements of this system have a logical connection with each other based on the number ten. The decimal system makes the units scalable: The Greek prefix "kilo" makes the unit larger, the Latin "milli" makes it smaller. The idea comes from the Enlightenment and follows the theory of natural law, says Kramper: "All people have the same rights and the same foundation." The units should thus be the same for all goods – whether wine or beer, bread or coal.

Enlightenment intellectuals were delighted with the new system, but the majority of the population simply ignored it. Paris had to take "great pains to get its civil servants to implement it." In retrospect, it was only logical to bring order into the confused mess of units for area, weight, and length. It seems illogical and impractical to us

"Even in the 19th century, precise measurements weren't a matter of millimeters but of hundreds of thousandths of millimeters"

that, for instance, in 1850 a mile was around seven-and-a-half miles long in Prussia, more than nine in Saxony, and less than five in Switzerland.

250,000 Local Units for Length

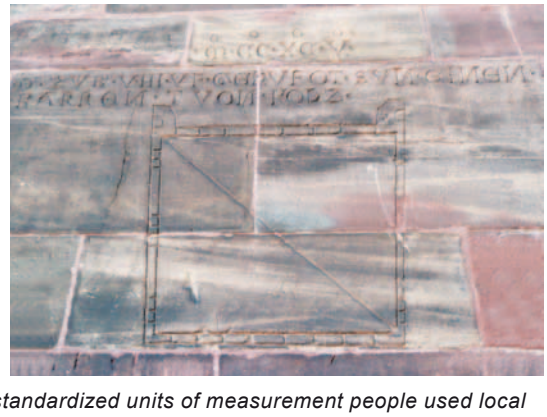
The profusion of different systems of measurement for length was particularly confusing: 800 different ones were in use in France alone, and on top of that there were over 250,000 variations of units like cubit, mile, foot, and fathom. Local differences were sometimes enormous: The cubit, for instance, could be between 40 and 120 centimeters long. The standard measurements were described at central locations in the cities, such as on the northwest buttress of the spire of the Freiburg Cathedral, where the town's old measurements are chiseled into the stone. Even neighboring cities often used different units with the same name. But that didn't bother people in the slightest: They knew the system in use at their local market, explains Kramper, and merchants used large collections of weights and measures and conversion handbooks.

The measurement system introduced by Enlightenment thinkers had trouble gaining a foothold at first. England and Prussia introduced their own standards – the Prussian foot and the British yard simplified the situation to some extent. The system finally began to gain widespread acceptance around the middle of the 19th century due to the convergence of economic, political, and societal developments.

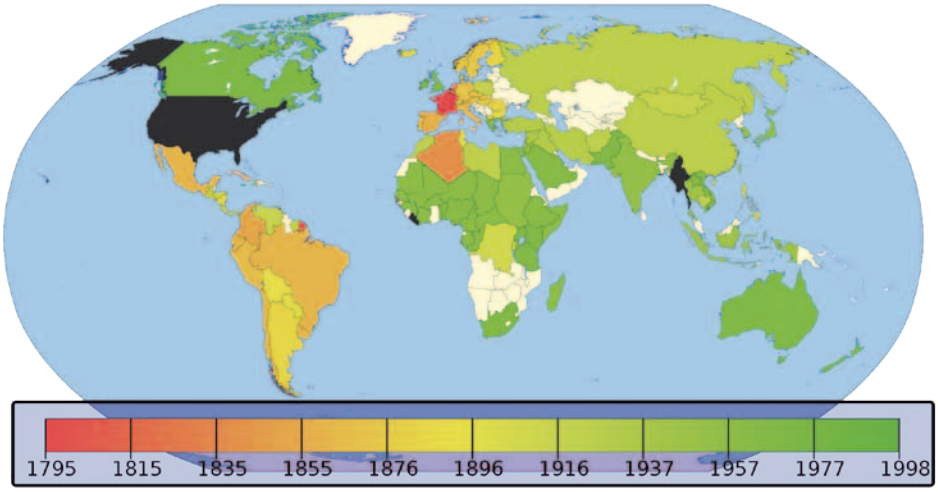
Uniform standards brought advantages for industrialization. In the mid 19th century the use of machines and the division of labor were becoming more and more important for production processes; companies were producing mass products for growing markets. "For things like coal, it was not absolutely necessary to have standardized units," explains Kramper, "but the mechanical production of cotton fibers or chemicals was a completely different story." Having a unified numbering system for the thickness of strands of cotton greatly simplified production, as did fixed units for electrical energy or standardized screws. Many companies based their units on the systematic metric system.

Meter and Kilogram as Symbols of Independence

Science also demanded a unified and exact system of measurement. "Precise measurements were especially important for measuring the earth," says Kramper. As this involved enormous distances, small errors in the basic unit could distort the results of measurements in a big way. "Even in the 19th century, precise measurements weren't a matter of millimeters but of hundreds of thousandths of millimeters." In addition, many young nations adopted the metric system as a way to distance themselves from the old regime: for example former Spanish or Portuguese colonies in Latin America or Japan, which succeeded in making the transition from a feudal to a constitutional state after the Meiji Restoration in 1868. In Germany, the smaller states demanded the introduction of the metric system after the formation of the German Empire in 1871 in order not to have to adopt the units of the powerful state of Prussia.



Before the introduction of standardized units of measurement people used local units, like the 54-centimeter-long "Freiburger Elle" (left) or the "Freiburg Zuber-Maß," which corresponds to 182.26 liters. The inscription over the drawing reads: "Eight Zuber (= tubs) in a heap should make a Karren (= cart) of charcoal"; the "Karren" was the next larger unit in the system. The two units of measurement can be found on the northwest buttress of the Freiburg Cathedral.
Photos: Klaußner



Used almost everywhere: The map shows when each nation adopted the metric system (light areas: no data available). Only Liberia, Myanmar, and the USA (black) have yet to adopt the system. Image: Wikipedia Commons

In 1875 Paris founded an international institution to oversee the installation of standard measurements and weights: the International Bureau of Weights and Measures. In the same year, representatives from 17 countries signed the Meter Convention. Nations from all over the world met in Paris to discuss the final definition of metric standards. In 1889 a prototype kilogram and a prototype meter were made. Even workers and farmers now supported the adoption of the metric system: Their original rejection of the new system stemmed from the fact that they had often been disadvantaged by changes made in the past. Now they profited from the change, because their products could be controlled with standardized devices calibrated by the government. When a check weigher is used to record the amount of cloth a weaver produced in a day, for instance, it is more difficult for his employer to cheat him out of part of his pay.

Fixed Units Replace Rough Estimates

The "societal transformation process" had become irreversible by the 20th century, says Kramper. Not only did the meter, the kilogram, and the liter replace the old units, they also heralded in a new way of thinking. "Premodern units of measurement were often based on estimates," explains the historian. Using hectares to define land ownership, for instance, would have been too abstract and wouldn't have revealed anything about the composition of the land. A farmer who measured land in morgans – an old German unit of measurement based on the amount of time it took to plough a certain area – knew right away how much of a plot of land he could till in the space of a morning and could estimate how difficult it would be to cultivate.

Thus, agrarian societies did not think in fixed units measurement: If a farmer sold a bushel of wheat, the amount was only a rough estimate. A bushel was larger in good times and smaller in bad times, it could be added to or taken away from – and still remained a bushel. People associated units of measurement with particular products rather than with amounts. "Early modern units of measurements were always thought of in concrete terms," says Kramper. "I still have trouble understanding this concept." The people had a picture of a loaf of bread, a vat of butter, a pile of apples in their imagination. "Today, on the other hand, we see the things already packaged in our minds." Whether we are thinking about a liter of milk, a half a kilo of sugar, or a kilo of muesli, the terms we think in are standardized and abstract – and we thus find it completely logical that a liter is always a liter. So have we lost the art of concrete thinking? Not entirely: When we ride on the train, we think in hours rather than in kilometers. "And I of course don't measure my coffee break in minutes but in the amount of time I need to enjoy my coffee."

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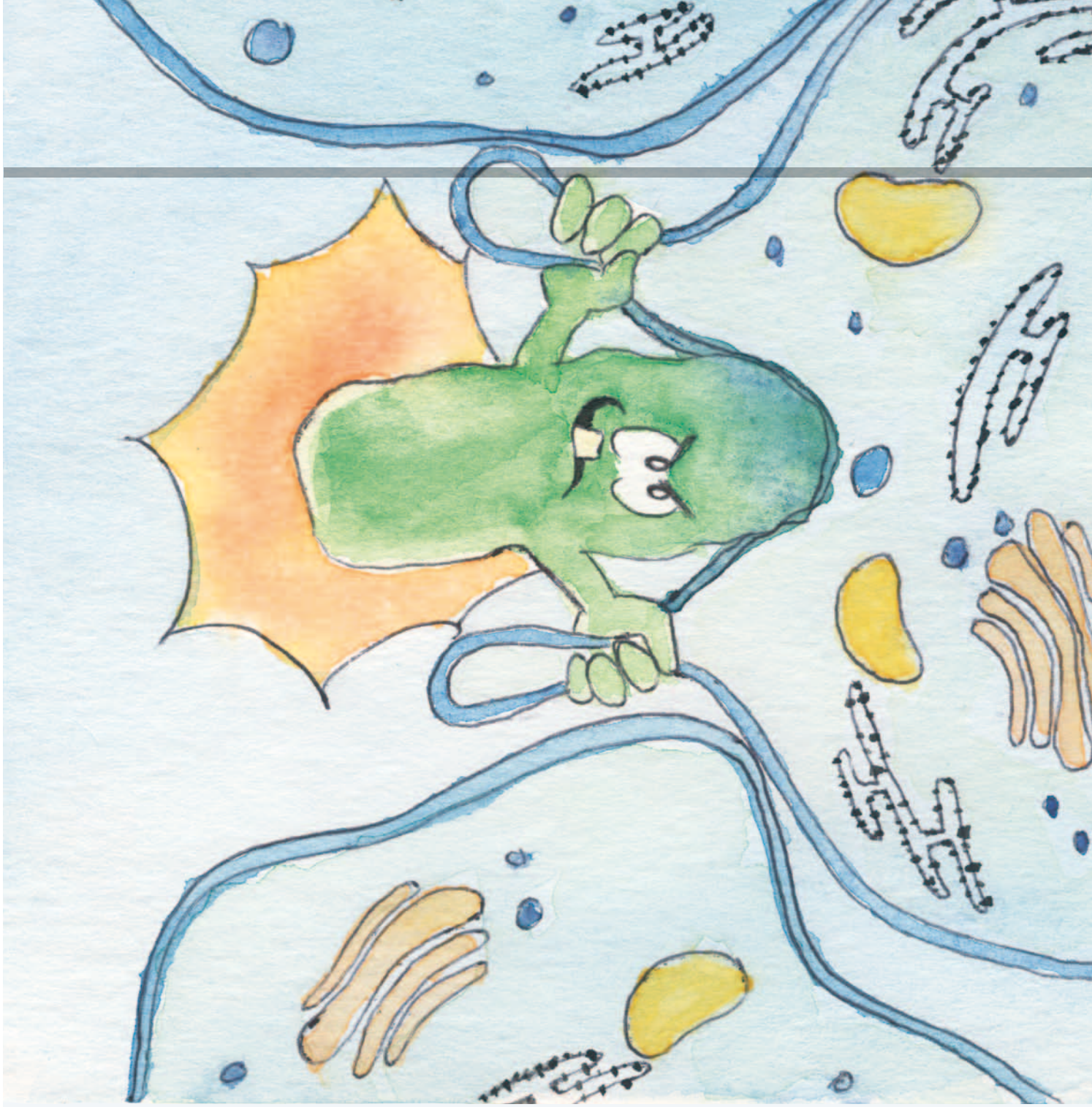
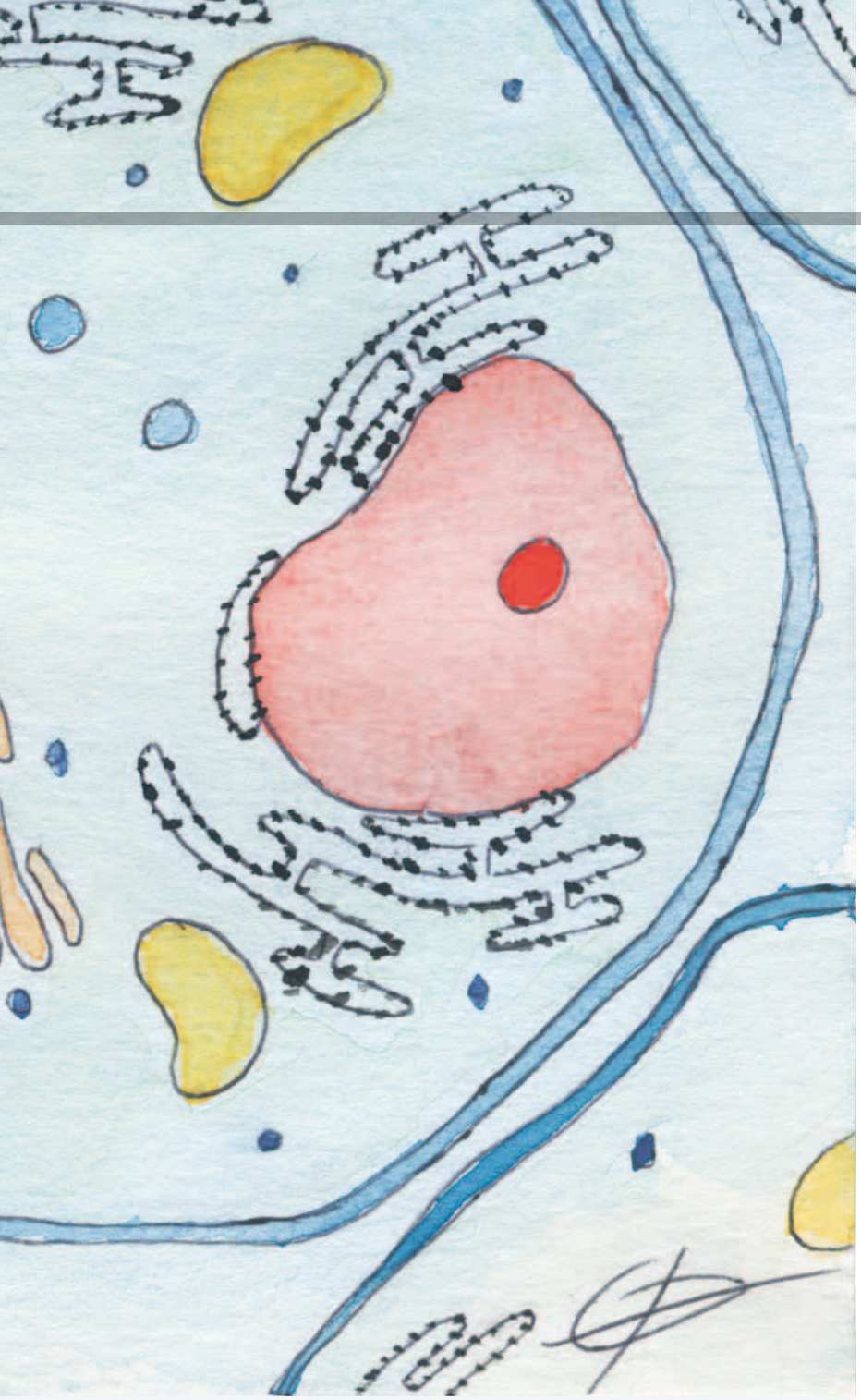
Dr. Peter Kramper *studied early modern and modern history, political science, philosophy, and the history of economics in Mainz, Freiburg, and London. In 1999 he completed his master's in the history of economics at the London School of Economics. From 2000 to 2006 he worked as a research assistant under the Chair for Economic and Social History at the University of Freiburg. He received a prize for his dissertation from the Gesellschaft für Sozial- und Wirtschaftsgeschichte (Association for Social and Economic History). In fall 2006 he began work on his habilitation thesis: "The Battle of the Standards: Measuring, Counting, and Weighing in Western Europe, 1750–1914." Between October 2010 and September 2011 he was a junior fellow at the Freiburg Institute for Advanced Studies (FRIAS).*



Beware of Cellular Hijackers

Winfried Römer is Researching the Pathogen Pseudomonas Aeruginosa at the Centre for Biological Signalling Studies

by Eva Opitz



Brutal invasion: A bacterium breaks into a defenseless cell. Drawing: Becker

The pathogen that goes by the name pseudomonas aeruginosa is microscopically small and very dangerous. It is one of the most feared hospital germs, as it is notoriously difficult to treat with antibiotics. However, not only does the bacterium present a threat in hospitals but also in daily life: “Humans can come into contact with the germ in the water, for instance while taking a shower or digging in damp garden soil,” says junior professor Dr. Winfried Römer. Pseudomonas can behave peacefully for an indefinite period of time and then suddenly wreak havoc. The scientist is investigating how bacteria invade human cells and cause disease at the Centre for Biological Signalling Studies (BIOSS) of the University of Freiburg. A weak immune system or damaged skin increase the risk of infection. “Then, in a second wave, the pathogen can cause a secondary infection that can even lead to death.”

The Bacterium Fights Its Way into the Cell

In order to determine how the bacterium fights its way into the cell, Römer is studying the complex mechanism by which it makes contact with the cell membrane and then works its way inside, for instance into a lung cell. The bacterium first needs a substance it can latch onto, a so-called receptor. “Cell membranes consist primarily of lipids and proteins and are a highly dynamic system,” says Römer. They are an ideal landing platform for pseudomonas aeruginosa. “The initial contact is an interaction between the bacterium’s own lectins – which are sugar-binding proteins – and sugars on the membrane of the cell. This initial contact with the receptor on the cell surface is a weak binding. The pathogen then proceeds to recruit more receptors until an entire cluster of them build a strong binding.” They forms tube-shaped invaginations that reach far into the cell. “Contrary to previous belief, we have been able to

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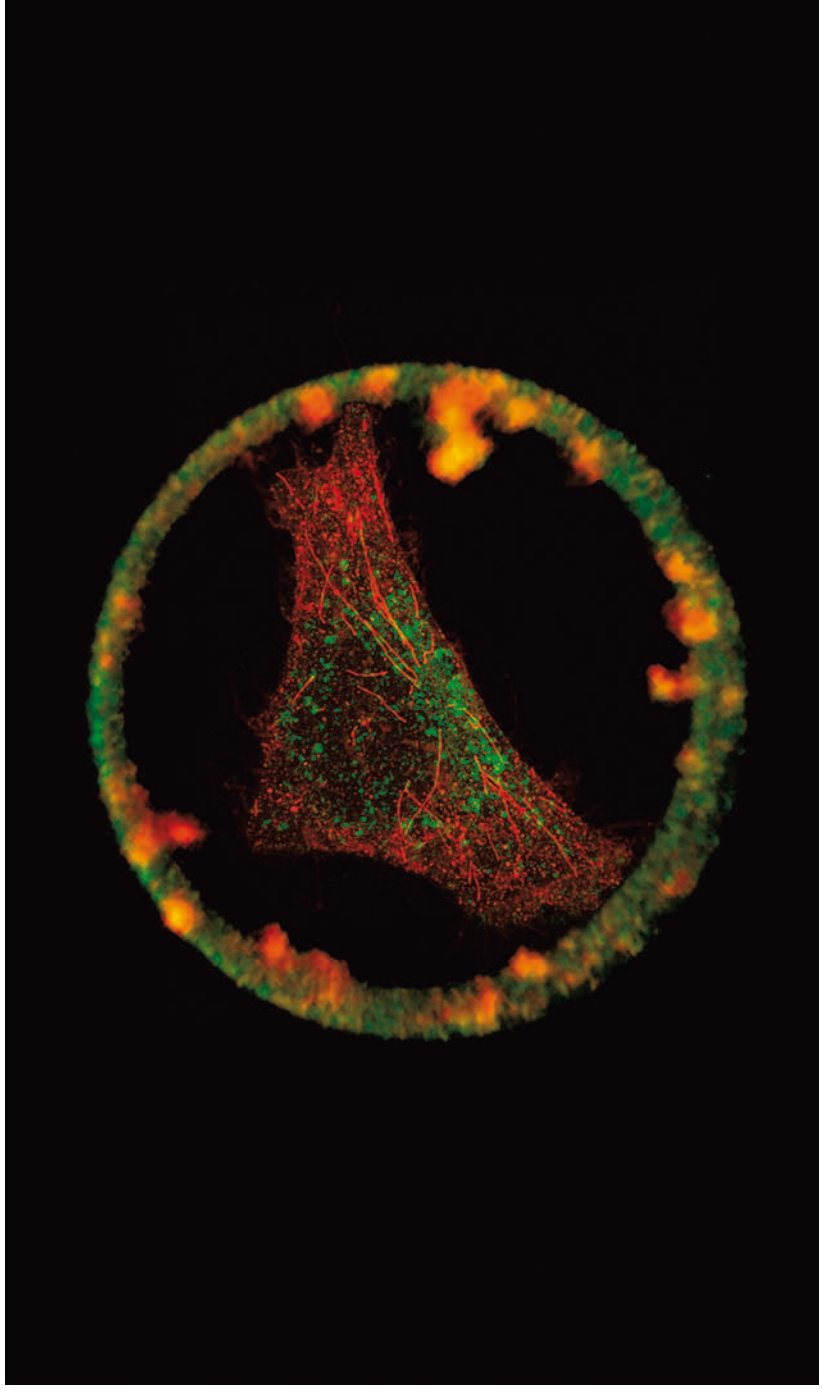
show that some pathogens and pathogen products, such as certain poisonous substances, can play an active role from outside of the cell," explains the signaling researcher. Previously, processes like that in which the cavities are formed were believed to be caused by the cell's own proteins alone. "Hardly any research has been conducted on how these proteins admit poisonous substances into the cell independently." Membrane lipids play a decisive role in this process. They are responsible for keeping the cell membrane stable, flexible, and partially permeable. When the bacterium binds to this membrane, signaling processes are triggered, which in turn attracts structural proteins that make the growing tubes with the bacteria split up into tiny bubbles inside the cell. The pathogen has now finally reached the inside of the cell.

"The transitions from toxin to virus and from virus to bacteria constitute enormous increases in complexity and magnitude for research"

As a postdoc at the Curie Institute, Winfried Römer conducted his first experiments in this area not with bacteria but with poisonous substances, so-called toxins. "The transitions from toxin to virus and from virus to bacteria constitute enormous increases in complexity and magnitude for research," says the researcher. "It is important to start with simple systems before tackling the more complex ones." Using viruses introduced as pathogens, Römer and his colleagues were able to demonstrate that the path described above is the main path of infection and that it depends on special lipids. The goal of all of his experiments is to learn more about endocytosis, the absorption of molecules into the cell, and the immense cellular machinery this process sets in motion. The scientist is convinced that pathogens from outside are not the only bacteria that make use of the cellular apparatus. In a few years, when he has unraveled the individual steps of endocytosis and their various microbial and cellular factors, he hopes to also be able to identify molecules from the body that use this path to enter cells. "At the moment we are using the pathogens as a means to an end, as hijackers that take control over the machinery of the host and manipulate it to make an infected cell out of a healthy cell," says Römer. His research is facilitated by the fact that most pathogens are specialized in using lectins to attach themselves to cell membranes with sugar. Experiments have shown that the pathogen does not bind with the host cell when modified bacteria without lectins are used. "There is more and more evidence that bacterial lectins are absolutely necessary for a successful invasion of the cell."

The Human Cell Is a Good Hiding Place

The experiments on the first steps of the cell invasion are already underway, as are those on the behavior of the pathogen once it has entered into the cell. It adapts to the micro-environment inside of its bubble and "avoids fusing with the compartments of the cell like the plague." Particularly dangerous for the pathogen are lysosomes, organelles that eliminate waste by destroying everything that doesn't belong in the cell. "Our hypothesis is that the pathogen uses



A toxin (in red) attaches itself to a membrane and creates a tube-shaped cavity in the cell. Here, the process is taking place in an artificial bubble, a liposome.

Juniorprofessor Dr. Winfried Römer *studied chemistry, biology, and secondary education in Regensburg from 1996 to 2001. In 2004 he earned his doctorate at the Institute of Analytical Chemistry and Chemo- and Biosensor Technology of the University of Regensburg. From 2004 to 2008 he worked as a postdoc at the Curie Institute in Paris, France. Afterwards, he served as a research assistant at the Centre national de la recherche scientifique (CNRS) and the Curie Institute. In April 2011 he accepted a junior professorship at the Institute of Biology II and the Cluster of Excellence BIOSS, Centre for Biological Signalling Studies, of the University of Freiburg. His research interests include fundamental research on how bacteria and toxins enter into the human cell.*

this tactic to hide in the cell, where it can escape from the body's immune reaction," says Römer. "We are concentrating initially on the first step of the process by which the pathogen enters the cell – its first contact with a lung cell." Seconds afterward, signaling processes are activated in the cell. "We want to find out how the signal is generated and which signal is responsible for which process." The scientists have set their sights on the entire cascade of signals.

The Search for Inhibitors

Even though the interaction between pseudomonas aeruginosa and lipids from the host cell's membrane form the core of the research, Winfried Römer and his signaling researchers are also developing strategies to prevent the bacterial invasion. They know that every cell also has means of defense at its disposal. The scientists are thus searching for specific inhibitors that can take a stand against the invaders. "The final step of our research will be to identify these small molecule inhibitors." However, they have to be neutral and cannot become dangerous for humans. Römer believes that it will be possible use them to block the lectin-dependent cellular intake of the pathogens right from the start. "Once we have characterized the inhibitors, we will know how to prevent an infection, and this would constitute a milestone in research." And it would finally rob pseudomonas aeruginosa of its power to frighten us.

A Puzzle for Philologists

Most Ancient Greek Literary Texts Exist Only in Fragmentary Form. Researchers at the University of Freiburg are Now Piecing Them Together

by Annette Kollefrath-Persch

Scary statuette: The long-armed, closely fitting costume identifies the figure as an ancient Greek actor. The grotesque face represents a comedy mask, not the actor's real face. Photo: Archaeological Collection of the University of Freiburg, Inv. S 404

"Editing these documents will help us throw new light on the history of ancient Greek literature"

Lost texts are the object of much conjecture. Perhaps the most prominent example is – thanks to Umberto Eco's novel The Name of the Rose – the lost second part of Aristotle's Poetics, which dealt with comedy. Indeed, the losses are particularly great in this central genre of world literature: The only complete ancient Greek comedies we possess are eleven plays by Aristophanes and one by Menander. However, there are also extensive fragments and textual accounts. Some works are preserved in less than 60 different fragments, others in up to 500. Neither their content nor their significance for the history of literature has been properly ascertained, and none of them is available in a German translation.

Prof. Dr. Bernhard Zimmermann from the Department of Classical Philology of the University of Freiburg and his research group aim to change this with the project "Commentary of Fragments of Greek Comedy." They will have time enough to do so: The Heidelberg Academy of Sciences and Humanities has agreed to fund the project for a period of 15 years. Zimmermann and two research assistants have been editing the fragments since January 2011, and the group is advertising two positions for doctoral researchers in 2012. The classical philologist is excited about the potential findings of the project: "Editing these documents will help us throw new light on the history of ancient Greek literature." Collected in eight volumes, the large mass of fragments will give literary historians a much more comprehensive overview of the comedies of this epoch. Existing secondary literature relies solely on the known twelve works by Aristophanes and Menander, which is probably less than one percent of the entire corpus of classical Greek comedies. Zimmermann believes that there is a high likelihood that our conception of the genre as a

Comedy translation 101: The philologists are studying the language, metrics, and measure of the fragments.
Photo: Freiburg University Library/Historical Collections

Menander, depicted here on a wall painting from Pompey, and Aristophanes are the only poets from ancient Greece from whom we possess complete comedies.
Photo: Irelli et al. (Ed.) (1990): Pompejanische Wandmalerei. Stuttgart (Taf. 33)

whole is correspondingly skewed. His goal is thus to paint a new, perhaps completely different, picture of the classical Greek comedy.

Antique Authors Are Simply Forgotten

The comedies, which are only preserved in fragmentary form, were written between 400 BC and the birth of Christ. The research group plans not only to reconstruct the content of these works and translate them, but also to find out when and why they were lost. Contrary to popular belief, explains Zimmermann, the works were not lost due to the destruction of libraries by fire but to developments in cultural policy. By studying documents of the time, the philologists can determine when an author was still being quoted in schools, speeches, and daily life and reconstruct the point at which he was evidently no longer known. This gives the researchers an overview of the comedies themselves as well as insight into the cultural and educational policy of the times.

"Aristophanes and Menander used to be the only two known authors, but now we know the names of 258 Greek comic poets"

The work resembles the task of completing a difficult puzzle: The classical philologists have to analyze and classify the fragments before they can interpret and translate them. In the course of their work, they encounter three different types of fragments: The first type consists of short textual allusions, sometimes consisting only of single words or verses, from classical authors quoting directly from the original works. The second type of fragment is papyri from the time in which the comedies were written, and the third is so-called palimpsests, parchment manuscripts in which – since parchment was very expensive and difficult to produce – the original text has been scratched out and overwritten with a new text, often with Christian content. The overwritten text can be made visible again with the help of modern laser technology. International research teams are currently combing through libraries around the world in search of hidden texts preserved in this way. They have already discovered the ending of one comedy and the beginning of another. The content of both of the fragments is now being analyzed in Freiburg.

Rolls of Papyrus from the Garbage Dump

However, Zimmermann procured most of the textual sources for his research project at the British Museum in London, England, which houses the world's largest collection of ancient comedy fragments – antique rolls of papyrus that British researchers found while excavating an old garbage dump in Egypt in 1877. The documents were conserved in dry sand and were thus still legible. These fragments also included the previously unknown comedy Dyskolos ("The Grouch") by Menander, preserved in its entirety on an entire roll. A literature enthusiast bought it and allowed it to be published for the first time in 1954. The other papyrus manuscripts have been edited and published as well. The researchers in Freiburg have access to the fragments on the Internet and in volumes being published periodically. By travelling to England, they can also work directly with the originals. Zimmermann

does not believe that any more lost manuscripts will be found in Egypt, since the earth there has become damp due to the construction of the Aswan Dam. If ancient papyri were buried there, they are now destroyed.

Students Practice on the Fragments

The archaeological finds and the work the research group has completed so far have already produced initial findings. "Aristophanes and Menander used to be the only two known authors, but now we know the names of 258 Greek comic poets, who wrote a total of more than 1000 plays altogether," says Zimmermann. This is changing our picture of the genre completely: "In literary histories, Aristophanes is generally regarded as being the comic poet who was alone responsible for shaping the genre with his political comedies. In our first two commentaries, which have already been published, we demonstrate that the situation was much more complex: There were forms of non-political comedy as early as 400 BC, such as burlesques, sketches, and women's and slave comedies."

Since working on fragments is methodical and linguistically diverse work, it makes a good practical exercise for young philologists just cutting their teeth in the field. Students are thus being integrated into the research project. They are given short texts of up to 20 lines each to practice on and learn the foundations of philological work and literary study: In translating the comedies they hone their skills in the Greek language, metrics and measure, and in reconstructing and classifying the fragments they learn the societal background of the texts. In addition, they have to compare the handwritten sources with one another in order to reconstruct the original text as faithfully as possible.

Further Reading

The researchers participating in the project "Commentary of Fragments of Greek Comedy" report regularly on their work and their latest findings in their weblog at http://www.surprising-science.de/einzelforschungsprojekte/griechische-komoedien/.

Zimmermann, B. (Ed.) (2011): Handbuch der griechischen Literatur. Band 1: Die Literatur der archaischen und klassischen Zeit. München 2011 (on Greek comedy: p. 664–800).

Zimmermann, B. (2006²): Die griechische Komödie. Frankfurt/M.

The students and scholars in Freiburg are also profiting from the excellent reputation the research project enjoys at English and American universities. In September 2011, Prof. Dr. Douglas Olson, recipient of the Humboldt Research Prize from the University of Minnesota, USA, arrived at the University of Freiburg, where he will stay for a year. He was attracted to Freiburg by Zimmermann's project. The papyrologist Prof. Dr. Dirk Obbink from Oxford, England, will also come to Freiburg to teach students how to work with papyri. For July 2012, Zimmermann and his team are planning a compact course in which students will work with parts of the puzzle of comedy fragments with researchers from around the world.

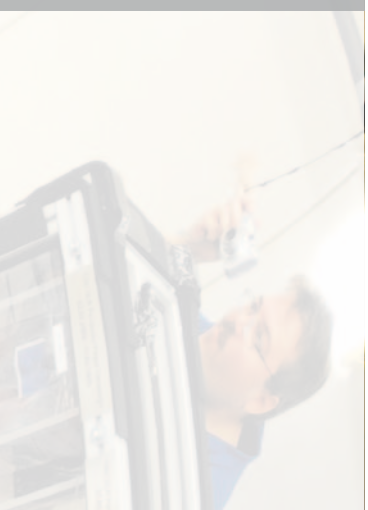
Project director Zimmermann is optimistic about what the coming 15 years will bring to light, but he is not blind to the fact that such a long-term project demands great perseverance on the part of the researcher: "After eight or nine years there might not be any more new discoveries, and our work will consist primarily in taking stock of all of the works. But not everything that has been found to date has been edited yet – so there might very well still be some surprises in store for us."

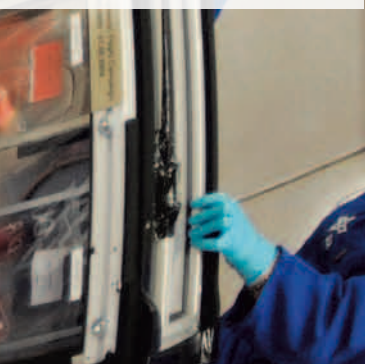
Prof. Dr. Bernhard Zimmermann *studied classical philology at the University of Constance, where he also completed his PhD and his habilitation thesis. Following stations in Constance, Zurich, and Düsseldorf, he was appointed as professor for classical philology at the University of Freiburg in 1997. He has also been a member of the board of trustees of the foundation "Humanismus heute" since 2000. In February 2011 he was elected as chairman of the German Classical Philologists' Association. His scholarship on topics including Greek tragedy, the comedies of Aristophanes, Epicure, Sophocles' Oedipus Rex, and Greek comedy has been translated into many different languages. He is currently supervising the publication of a new handbook on the history of Greek literature, the first volume of which appeared in 2011.*

In Shape in Space

Researchers at the Institute of Sports Science and Physical Education of the University of Freiburg Are Testing Exercise Equipment Designed to Help Astronauts Stay in Shape in Space

by Nicolas Scherger





Science at zero gravity: Researchers perform experiments on parabolic flights to determine whether nerves and muscles react the same way in a weightless environment as they do under the influence of gravity. Photo: Hoffmann/Multhaupt DLR

Countdown. Full throttle. The pilots steer the airplane up into the sky, at a 45 degree angle. The gravity inside the plane is twice as strong as on the Earth's surface. Even just lifting one's foot off the floor is a chore. Then the rush of acceleration begins to subside. The gravitation diminishes, and the passengers begin to lose contact with the floor. "There is no up or down; it's similar to being in water, only there isn't any resistance at all," says Ramona Ritzmann, doctoral candidate at the Institute of Sports Science and Physical Education of the University of Freiburg. The airplane continues to ascend for a brief moment and then starts to fall. After two and a half kilometers the turbines spring into life and pull the machine back up. In the blink of an eye, the gravity is as strong as it was during the ascent. The weightlessness lasted a total of 22 seconds. The pilots bring the airplane back into a horizontal position, thus completing the parabola, and then immediately initiate a new one. They repeat the maneuver up to 30 times, giving scientists the chance to conduct experiments in a zero-gravity environment: to grow crystals, to investigate the properties of materials – or, like Ramona Ritzmann, to test prototypes of exercise equipment designed to keep astronauts in shape during a journey into outer space.

The crew of the International Space Station (ISS) is already required to exercise three hours a day, for instance with steppers or exercise bicycles. Even so, the astronauts cannot walk unaided after returning to Earth. They lose an average of ten percent of their muscle mass and one percent of their bone substance each month, particularly in the legs and the upper body, because the muscles no longer exert enough pressure on the bones. "The bodily functions degenerate because they are not placed under any strain in a weightless environment. It's like an elderly person who lies in bed all day without moving," explains Ritzmann. Astronauts also lose the ability to maintain a proper posture under the influence of the Earth's gravity. However, the international space agencies are planning missions to Mars on which astronauts will be in space for three years at a time, says Prof. Dr. Albert Gollhofer, Director of the Institute of Sports Science and Physical Education: "The exercise methods currently in use are not sufficient for such a long journey."

Interplay between Nerves and Muscles

Gollhofer is head of a Freiburg research team that is developing new approaches for exercise in weightless environments. The team includes experts for bones, muscles, and the circulatory system, among other things. The scientists are investigating the interplay between nerves and muscles. Every movement starts with a signal from the nervous system. These signals may be sent by the brain, as in the case of conscious movement, or they may be sent involuntarily by the sensors in the locomotor system. "We want to reach a more precise understanding of the source of movements and use this knowledge to improve exercise methods," says Ritzmann. The sports scientist measures neuromuscular adjustment mechanisms in test subjects trying out new exercise machines. "This allows us to determine how effectively the exercises activate the nerves and muscles."

> "The bodily functions degenerate because they are not placed under any strain in a weightless environment"

However, the machines are only suitable for use in space if the body reacts to them in a weightless state in the same way as it would under the influence of gravity. The purpose of the parabolic flights is to provide evidence of this. "The 22 seconds of weightlessness are sufficient to determine whether the muscles are controlled by the nervous system in the same way," says Ritzmann. She has taken parabolic flights to try out the exercise machines herself: "So far it seems as if the muscles exhibit comparable activities in a state of weight-

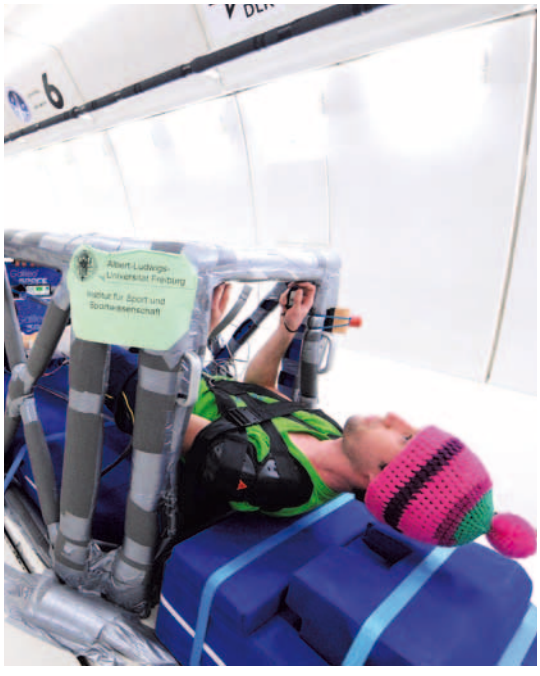
lessness." Further flights are planned for 2012 and 2013. Then the researchers will only need to prove that their methods have a long-term effect. They are thus preparing a so-called bed-rest study, in which a dozen volunteers will lie in bed for several weeks under medical supervision. "The team of test subjects will not consist of average people but potential astronauts: healthy, physically fit, and physically stable," explains Gollhofer. They will be split up into two groups: One will test the exercise methods and the other will not exercise at all. In the end, the scientists will perform physical examinations and compare the two groups.

The Machines Simulate Gravity

The research team is testing three exercise methods: whole body vibration, jumping, and balance control. All three are based on the principle of simulating the gravity that is missing in space with the help of exercise machines. The exercisers lie on their backs, their feet on a rectangular board. The machines are equipped with straps or a vacuum system that places pressure corresponding to the strength of gravity from the shoulders to the feet. In the case of whole body vibration, the board under the feet is on springs. When it vibrates, it triggers reflexes that activate the muscles. "We want to provide as many stimuli as possible so that the muscles contract and relax again in rapid succession," explains Gollhofer. This improves the exerciser's condition and strength, especially in the legs and the upper body. Studies indicate that bedridden patients can use these exercise methods to retain at least part of their bone structure and muscle mass. This has little to do with the fat-burning belts typically seen on infomercials, says the sports scientist: "There is a lot of garbage on the market."

"When astronauts land on Mars, it is very important for them to have a functioning sense of coordination"

Jumping exercises are an especially effective means of training the muscles and the bones – not just in the legs, but in the entire body. "We believe that this is the most efficient way to exercise," says Ritzmann. Lying in a supine position, the test subjects push up against the artificial gravity simulated by the board under their feet. The goal is for the muscles and nerves to exhibit the same activity pattern as they would with normal jumping exercises and thus achieve the same training effect. The device is not comparable to the bodybuilding equipment found at fitness studios, explains the doctoral candidate, where the exerciser pushes the board down with



Whole body vibration, jumping, and balance control: The exercisers lie on their backs, their feet on a rectangular board. The machines simulate gravity by placing pressure on the shoulders.
Photo: Hoffmann/Multhaupt DLR

What goes up must come down: The pilots follow a flight path resembling a parabolic arc, thus enabling scientists to perform experiments in a zero-gravity environment for the space of 22 seconds.
Image: Novespace

his feet against the resistance of weights. Finally, in the balance control exercises the board on springs under the feet swings back and forth, forcing the exerciser to counteract the vibrations with movements – also under the influence of simulated gravity. This exercise is designed to help astronauts retain their coordination, says Gollhofer: "When astronauts land on Mars, it is very important for them to have a functioning sense of coordination. After all, there is also gravity on Mars."

The University of Freiburg researchers are developing the exercise equipment in cooperation with the space agencies and partners from the private sector. At present, they are testing the systems one by one. "But ideally, we'd like to develop a single device with which the astronauts can do all three exercises," says Ritzmann. Not only would this save space but also time: Even a well-trained athlete would be worn out after about 20 minutes of vibration training or several dozen jumps. In two or three years, estimates Gollhofer, the exercise equipment developed in Freiburg could be flown to the ISS for testing. In addition, many projects intended originally for space research end up giving birth to technical innovations with applications in everyday life. For instance, the exercise equipment could also be used for rehabilitation therapy or for prevention on Earth, particularly for older people with only limited mobility. They are not, on the other hand, suitable for high-performance sports: "Top athletes require training programs that are tailored more precisely to their needs."

Prof. Dr. Albert Gollhofer *has served as professor at and director of the Institute of Sports Science and Physical Education of the University of Freiburg since 2000. He studied physical education, performance psychology, and physics at the University of Freiburg, earned his doctorate in 1986, and completed his habilitation in 1993 with a study on exercise variation and motor coordination. He then accepted a post as professor for sports science with an emphasis on applied biomechanics at the University of Stuttgart. From 2005 to 2009 he also served as president of the sports science organization European College of Sport Science. His research interests include neuromuscular adaptation mechanisms, motor control, and biomechanics.*

Ramona Ritzmann *is working toward her doctorate at the Department of Human Movement Studies of the University of Freiburg and at the Institute of Exercise and Movement Science of the University of Potsdam. She studied at the University of Freiburg from 2001 to 2008, where she completed the First State Examination in the fields of sports science and mathematics in 2007. One year later she completed her magister degree in the same two fields. She conducts research in the area of biomechanical movement analysis and on the functioning of the nervous system during exercise in a zero-gravity atmosphere.*

Further Reading

Visit www.surprising-science.de/einzelforschungsprojekte/raumfahrforschung/ to view a gallery with more pictures taken during the research project. Sports scientist Ramona Ritzmann explains what is happening on the photos.

Kramer, A./Ritzmann, R./Gollhofer, A./Gehring, D./Gruber, M. (2010): A new sledge jump system that allows almost natural reactive jumps. In: Journal of Biomechanics 43/14, p. 2672–2677.

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Pizza and fries in new packaging: Pieter Samyn is conducting research into completely biodegradable packaging materials. Photos: Dalmatin.o, gradt, Nyshko, ExQuisine, Ally (all Fotalia) Montage: qu-int

Coatings from Nature

Materials scientist Pieter Samyn is Developing Plastics with New Properties from Natural Components

by Jürgen Schickinger

The Earth is swimming in garbage. An average of 13,000 pieces of plastic waste are floating on every square kilometer of the ocean surface. Innumerable bags, cups and containers made of or coated with plastic are piled up along countless coasts, on roadsides, and at rest areas. They will take hundreds of years to decompose in nature. What's more, the supply of petroleum used to make this long-lasting material is dwindling. Dr. Pieter Samyn from the Institute of Forest Utilization and Work Science (FOBAWI) of the University of Freiburg is looking for ways out of this dilemma. The 2011 Robert Bosch Junior Professor wants to replace some plastics derived from fossil fuels with biopolymers made of renewable resources. By applying a biologically based coating to paper, for instance, he can give it new properties and make it watertight or permeable for water, fat, air, and other substances.

"Conceivable innovations include packaging that helps foods keep longer because less oxygen escapes through them"

"Conceivable innovations include packaging that helps foods keep longer because less oxygen escapes through them," says Samyn. Or pizza cartons and bags for French fries that don't allow any fat to seep through. Samyn is positively bursting with ideas. His materials are oil free, compostable, and durable. The 33-year-old uses biopolymers – polymers occurring naturally in living organisms like corn or other agricultural products – as renewable raw materials for his compounds and combines them with small wood components. But no tree must be sacrificed for the production of Samyn's new materials: The wood particles he uses are byproducts of paper production which were previously only burned up to produce energy. In addition, his materials do not include any substances that are harmful for the environment. Older coatings, on the other hand, often contain fluorine and are difficult to recycle since they can no longer be separated from the cellulose fibers of the product they are applied to. Finally, his approach also saves raw materials and makes the products lighter, because the materials scientist has found a way to apply much thinner coatings that also function much better. This is made possible through the use of wood components that are only 100 to 200 nanometers long – a nanometer is one millionth of a meter.

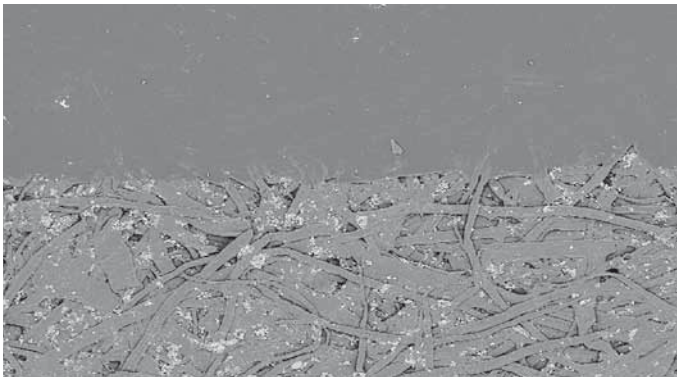
Closing the Gap between Lab and Factory

The project convinced an international committee led by Prof. Dr. Klaus Töpfer, formerly German Federal Minister for the Environment and director of the environmental program of the United Nations – and as a result Samyn was awarded the 2011 Robert Bosch Junior Professorship for the Sustainable Use of Natural Re-

“For us it is an opportunity to gain control over the entire process chain, from the tree to the final product”

sources. Thanks to the million euros in prize money and additional backing from the University of Freiburg, Samyn now has enough funding to support a research group for the coming five years. His research involves chemistry, physics, engineering, materials science, and other neighboring fields. It is still quiet in his laboratory. The shiny new spectrometer and the few other apparatuses smell like they just came out of the box; the beakers and other research implements haven’t even been touched yet. Samyn is still looking for collaborators for his group – such as a doctoral candidate from one of the contributing disciplines.

“The junior professorship is an incredible opportunity for me to conduct my own research and plan for the long term,” says Samyn with a gleam in his eye, only to warn immediately afterwards against excessive expectations. He will have to begin from square one, as it were: “Materials research is a new field of work for us.” Traditionally, FOBAWI has been active in the area of wood quality and logistics, the path from the forest to wood. The institute has only been working with new materials in the past two years, he explains: “For us it is an opportunity to gain control over the entire process chain, from the tree to the final product.” However, Samyn estimates that it will be three to four years before he develops a reliable method for coating paper, cardboard, or certain textiles with biopolymers combined with wood-based nanoparticles – and even then only on a laboratory scale, where he can apply the fluid coatings to the materials with relative ease.



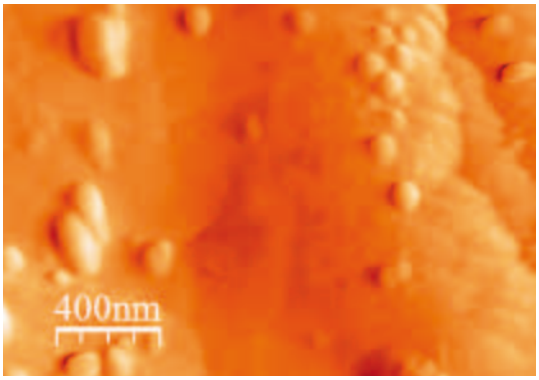
Surface comparison: This microscopic image shows packaging paper with uncoated (lower half) and coated cellulose fibers.

In industrial papermaking, on the other hand, 1500 meters of paper per minute roll off the production line. “That requires completely different application techniques,” explains Samyn. “In order to close the gap between the lab and the factory we will need to acquire detailed knowledge of the flow behavior of new biomaterials.”

Less Material, Better Properties

The subject of Samyn’s research is complex – and so are his materials. The manufacturing industry needs pulp for cotton, diapers, compresses, and paper. For each ton of pulp, a ton of black liquor and around ten kilograms of cellulose with shorter fibers are created as byproducts. “These fibers can be broken down chemically and used to produce further materials,” says Samyn. In order to achieve this, he is cooperating with a neighboring research group led by his colleague Prof. Dr. Marie-Pierre Laborie. The chemical processing leads to shorter cellulose nanoparticles. These so-called “whiskers” are between 100 and 200 nanometers long. The cellulose chains of the whiskers are arranged in a very regular pattern, almost like in a crystal structure. The reactive groups of the chain are placed such that they easily enter into reactions with other materials. It is therefore possible to mix these nanoparticles with other materials to create a composite material. “But unfortunately the cellulose particles also tend to clump together and are thus often not arranged very nicely,” says Samyn, who is working on a way to improve the arrangement of the materials.

Samyn is trying to solve this problem by controlling the surface properties of the whiskers. In order to do this, he combines the cellulose particles with a second type of nanoparticle based on vegetable oil. “I have a lot of experience with these particles,” he says. Besides, they exhibit very good properties in paper coatings. The particles are already produced, but the combination with biologically based materials from agricultural products is new. The nanoparticles are integrated into a composite matrix of these biopolymers. A technique of this kind is already being used for simple applications. For instance, lactic acid polymers – so-called polylactides – can be



Nanoparticles give materials new properties: The little bubbles cover up the cellulose fiber, which runs from the bottom to the top of the picture, and make it water-resistant.

used to produce cups, bags, and films that are partially biodegradable. However, the materials Samyn plans to produce will provide better protection against certain substances than their predecessors and should ultimately be completely compostable. The junior professor can control what a coating does and allows or doesn't allow by varying the type of nanoparticle used for it: If steam were allowed to escape from the carton, the pizza wouldn't have the consistency of a damp rag upon delivery, and paper cups would retain their form better when hot coffee is poured into them. In the future it will even be possible to equip packages like milk cartons and yoghurt containers with chemical sensors that change color to warn consumers that the content is spoiled.

Wood as a Source of Inspiration

Samyn is also conscious of the potential dangers of nanotechnology. "Our products won't emit any individual particles," he says. "Each of them will be processed in a fluid substance and embedded firmly in the biopolymer matrix." Even if the coating breaks, the microscopic particles will remain in them. In addition, Samyn is developing new processes to enable the coating to close itself again if it does break. In particular cases, it would also be possible to cover the coating with another coating made exclusively of polymers in order to prevent the nanoparticles from coming into contact with foods. "We are keeping tabs on potential risks and safety in our laboratory work, but we need to grasp the opportunity the properties of this new class of materials present."

However, first he will need to conduct research in order to find the ideal mix of coatings from cellulose particles, protective particles, and biopolymers. "The goal is to achieve as much functionality as possible with the thinnest possible coating and the lowest possible proportion of nanoparticles," explains Samyn. This will involve determining which plants can be used to produce the best whiskers, since they can differ in form, reactivity, and the length of their chemical cellulose chains. The end product must be a homogeneous coating that is easy to work with. Samyn is using the natural composition of wood as a source of inspiration to combine the components in a new way. "In the best case we will be able to use the wood fiber lignin, the largest component of black liquor, as a biopolymer matrix." So there is enough to research, to test, to experiment with. Being able to work on this project without financial worries for the coming five years is a solid basis for achieving these goals, as Samyn finds. For the future, he hopes to contribute to creating a world in which supermarkets and fast food restaurants only use sustainable packaging and bags: "It's time to close the cycle between earth, plant, and product."

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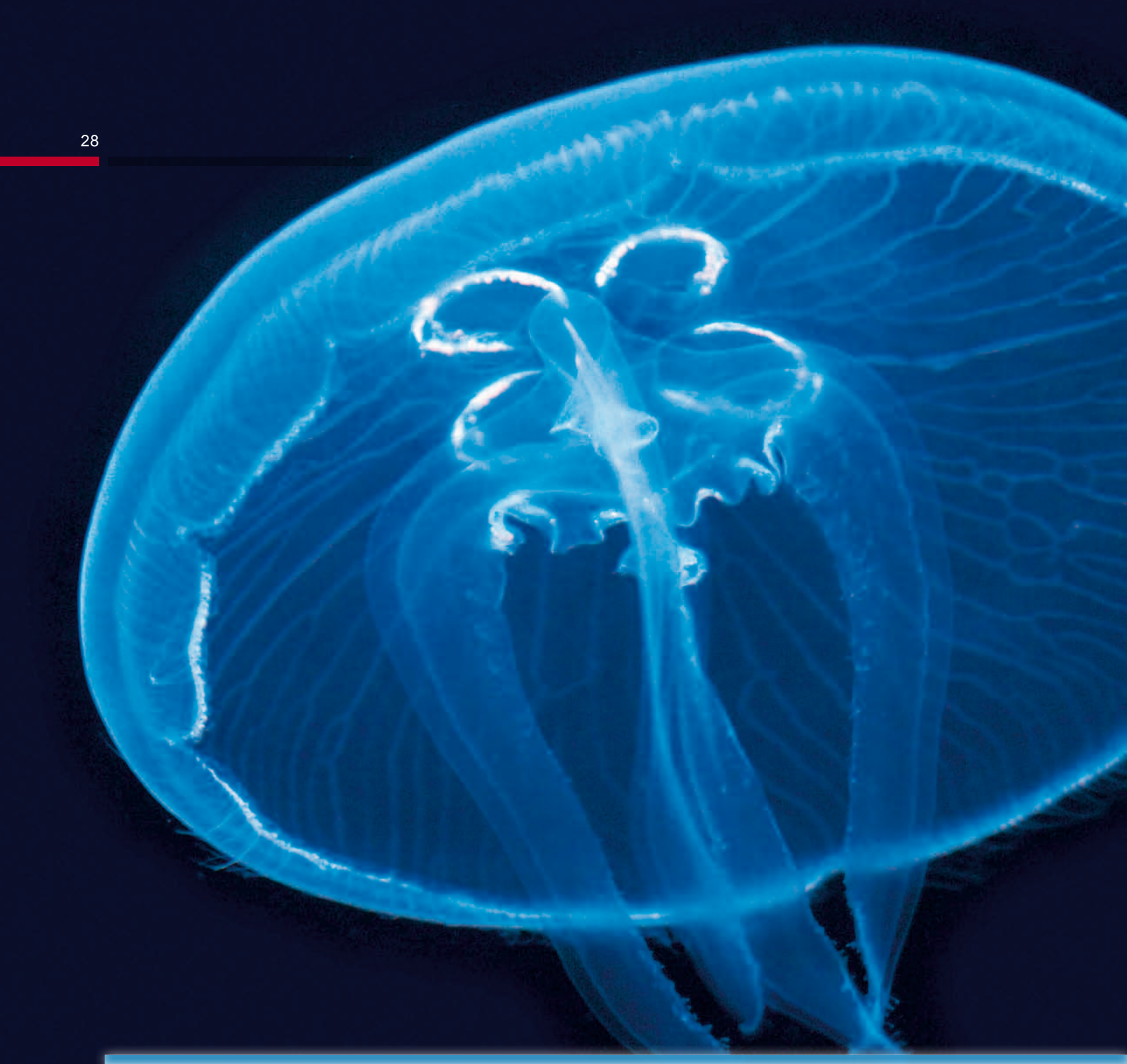
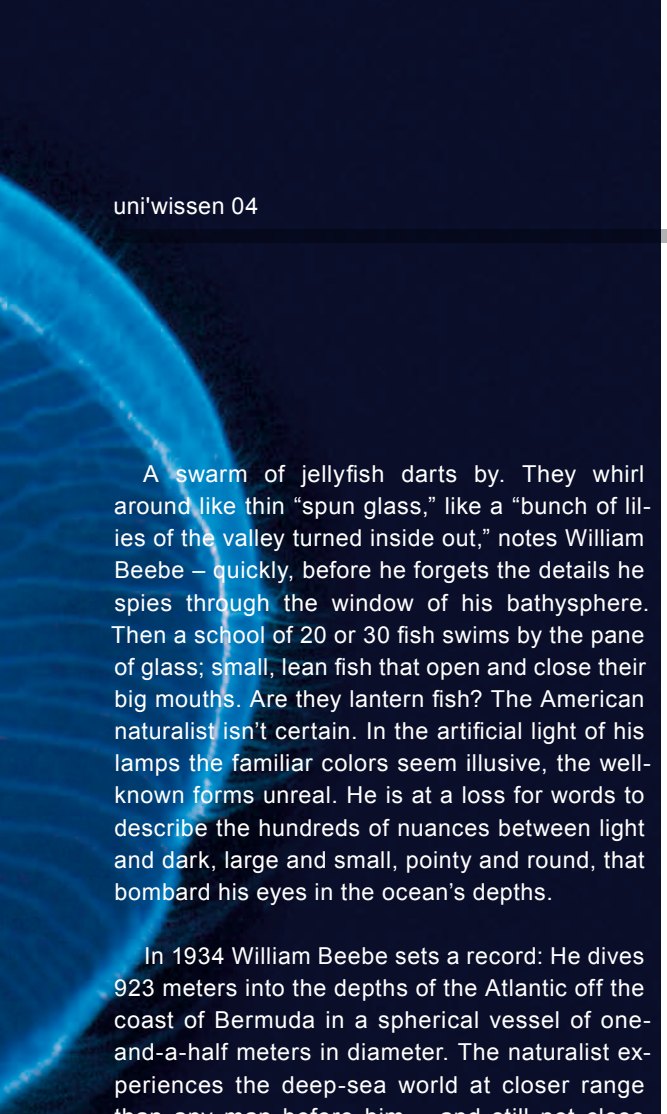
Junior Professor Dr. Pieter Samyn *was born in Belgium in 1978. He studied materials engineering at the University of Ghent, where he completed his dissertation on mechanical phenomena in friction between plastics in 2007. He then came to the Department of Microsystems Engineering in Freiburg, where he conducted research into chemical aspects of adhesion phenomena until 2008. After an interlude in Belgium, he returned to Freiburg in October 2010 to head a research group under Prof. Dr. Marie-Pierre Laborie at the Institute of Forest Utilization and Work Science. In March 2011 he accepted the Robert Bosch Professorship for the Sustainable Use of Natural Resources.*



Mystery Behind a Pane Of Glass

Media and Cultural Scientist Natascha Adamowsky is Studying Modernist Depictions of the Sea as a Miracle

by Rimma Gerenstein



"Spun glass" in the darkness of the sea: Naturalist William Beebe observed exotic creatures from his bathysphere. Photo: mirpic/Fotalia

A swarm of jellyfish darts by. They whirl around like thin "spun glass," like a "bunch of lilies of the valley turned inside out," notes William Beebe – quickly, before he forgets the details he spies through the window of his bathysphere. Then a school of 20 or 30 fish swims by the pane of glass; small, lean fish that open and close their big mouths. Are they lantern fish? The American naturalist isn't certain. In the artificial light of his lamps the familiar colors seem illusive, the well-known forms unreal. He is at a loss for words to describe the hundreds of nuances between light and dark, large and small, pointy and round, that bombard his eyes in the ocean's depths.

In 1934 William Beebe sets a record: He dives 923 meters into the depths of the Atlantic off the coast of Bermuda in a spherical vessel of one-and-a-half meters in diameter. The naturalist experiences the deep-sea world at closer range than any man before him – and still not close enough, says Natascha Adamowsky, professor of media and cultural studies at the University of Freiburg. For her current project she is studying depictions of the sea as a miracle and a mystery from the end of the 19th to the beginning of the 20th century: How did film directors portray the exotic creatures of the deep seas? What does Jules Verne's description of a battle between humans and giant octopuses in his novel Twenty Thousand Leagues under the Sea tell us about modernist culture? And why did the sea hold such a fascination for people – not just scientists and artists but ordinary people, who came in droves to see exhibitions featuring things like sea horses preserved in alcohol?

The Darkness of the Sea as a Sign of Human Limitations

Among other things, Adamowsky is analyzing drawings of mussels and corals from textbooks, artistic representations that depict an exotic deep-sea dream world, underwater films, novels, and accounts of expeditions – like Half Mile Down, the book Beebe wrote about his trip into the depths. "The naturalist discovered a lot of things on his expeditions, but he was never able to experience what it really looks like down there," says Adamowsky. "The eternal darkness of the deep sea is not made for the human eye. In order to see anything, we have to make light." But there are fishes, and then there are fishes: Fish look different in artificial light than they do in the eternal darkness of their habitat. The problem remains even today. Even the most advanced equipment cannot reveal what the creatures do in the dark. Beebe, for instance, drifted around like an air bubble in a world in which there are no air bubbles: What sounds reached his ears were only faint and distorted; the sea creatures sped by his vessel so fast he could hardly make them out – and this represented the height of modern technology. His account of the expedition reveals the frustration of a scientist who had reached his limits: "Our vocabularies are pauperized, and our minds drugged," wrote the naturalist. Beebe's deep-sea expeditions illustrate clearly that success and failure are two sides of the same coin.

The media and cultural scientist finds these accounts interesting for two reasons: First, they illustrate the fact that there will always be a gap between the object and the researcher – a paradigm for the basic dilemma of science: "Everything we know about the sea comes from the media and machines. They only provide us with snapshots, snippets, data. The world itself will always remain inaccessible," explains Adamowsky. If one wants to understand the history of the miracle of the sea, one must also consider how the information was gathered and the way in which it was transmitted to the public. In the mid 19th century, for example, the aquarium became a popular medium. Museums in Germany, France, England, and the USA presented the miracles of the deep sea behind panes of glass. The enormous tanks had glass walls and transparent tops. "The people felt like they were really strolling around with the exotic creatures on the

"Everything we know about the sea comes from the media and machines. They only provide us with snapshots, snippets, data. The world itself will always remain inaccessible for us"

Beebe dove 923 meters into the depths of the sea in a spherical iron vessel. But his lamps couldn't throw light on what the bottom of the sea really looks like. Photo: Steidl/Fotalia

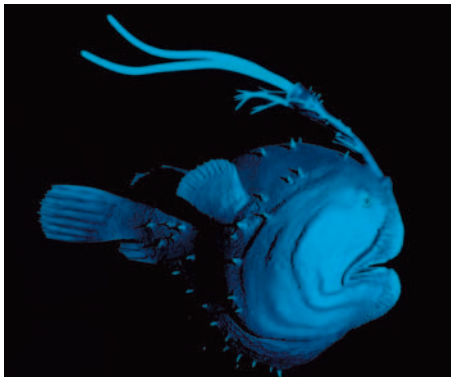
sea bed," says Andamowsky. However, an aquarium is not a miniaturized ocean but an artificially created cosmos: "The keepers have to feed the fish, make sure they reproduce, that they don't gobble each other up – but life in nature consists of just that: eating and being eaten."

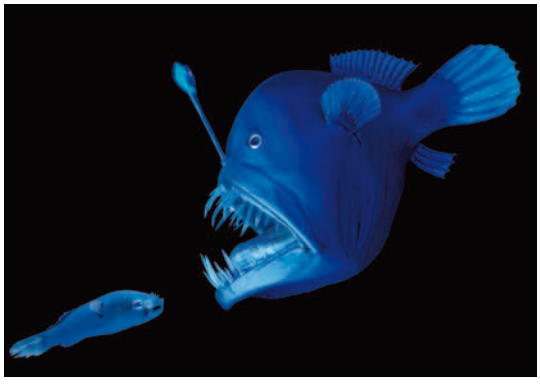
"Even in the modern age, at a time when clever contemporaries professed to have explained all miracles away through the power of the intellect, people still talked about things in terms of miracles"

The second interesting thing about William Beebe's accounts is that they reveal how contradictory the exploration of the seas was: The more mysteries researchers explained during their expeditions, the more they were confronted with new unexplained phenomena. Discovering a new fish was a relatively straightforward process, but explaining how it reproduces, what it feeds on, and what feeds on it were questions that were not so easy to answer. "It will never be possible to unravel the mysteries of the underwater world completely through sight and discovery," concludes Natascha Adamowsky.

From the End of the World to the Bottom of the Sea

The researcher made especially curious findings while studying historical technical magazines and textbooks. It makes no difference whether the text dealt with trains, telegraphs, or electricity: "Even in the modern age, at a time when clever contemporaries professed to have explained all miracles away through the power of the intellect, people still talked about things in terms of miracles." What Adamowsky discovered is that what had changed was only the places in which people expected to find miracles. In the Middle Ages people had assumed them to be at the end of the inhabited world – in jungles where cannibals devoured their enemies and monstrous dragons ripped people to shreds with their claws. However, in the 15th century the blank areas of the map started to disappear: Christopher Columbus discovered America by accident, Vasco





Fangtooth, football fish, and black seadevil: Naturalists discovered new fish but every new discovery raised more questions. Photos: Traenkner/Senckenberg Research Institute and Natural History Museum

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da Gama landed with his fleet in India, James Cook set sail for New Zealand and reached Australia, David Livingstone crossed Africa and explored the Kalahari Desert. "In the 19th century, it was no longer plausible to assume that there were miracles at the end of the world, because the end of the world didn't exist anymore."

Instead, Adamowsky argues that there was a fundamental transition: In the 19th century, people started looking for miracles on the vertical axis rather than on the horizontal axis. The airplane in particular was described in scientific and popular literature as the ultimate miracle. It was believed that the power of flight would enable humankind to one day transcend the barriers of space and time. This "classical miracle," the conquering and exploration of the wild blue yonder, was the topic of Natascha Adamowsky's habilitation thesis, completed in 2009 at Humboldt University in Berlin. In 2012 she plans to publish her book on the sea, the other end of the axis of modern miracles, in which she describes how the underwater world inspired and irritated us in the modern age.

In Search of the Primordial Cell

For example: In the 19th century archaeologists discovered the skeletons of gigantic dinosaurs that once ruled the earth but then died off for seemingly unexplainable reasons. "This discovery was deeply unsettling," says Adamowsky. "It gave birth to the topos of the lost world, which was equated to the lost paradise. It was suspected that the origins of life were located at the bottom of the sea. Thus, the history of ideas intersected with the process of geographical conquest." What one now expected to find at the bottom of the world's oceans wasn't monsters and leviathans but the "answer to the biggest question of all": the primordial cell, the origin of life. After all, all living beings crawled out of the water. The British biologist Thomas Henry Huxley brought on the climax of the miracle euphoria. He claimed to have discovered the primordial soup, a kind of protoplasm – in samples from the bottom of the ocean conserved in alcohol. But the question of the origin of life was not so easy to answer: The chemist John Buchanan demonstrated in the same year that the alleged primordial soup was nothing but a deposit of calcium sulfate created when sea water is mixed with alcohol.

When Natascha Adamowsky swims in the sea, by the way, her thoughts do not turn to giant octopuses and primordial soup. But she does think back on something she once saw at a deep-sea exhibition in Hamburg: A tiny cube of sugar was placed next to an enormous blue cube – a reminder of how much humans know today about the deep sea and how much remains a mystery.

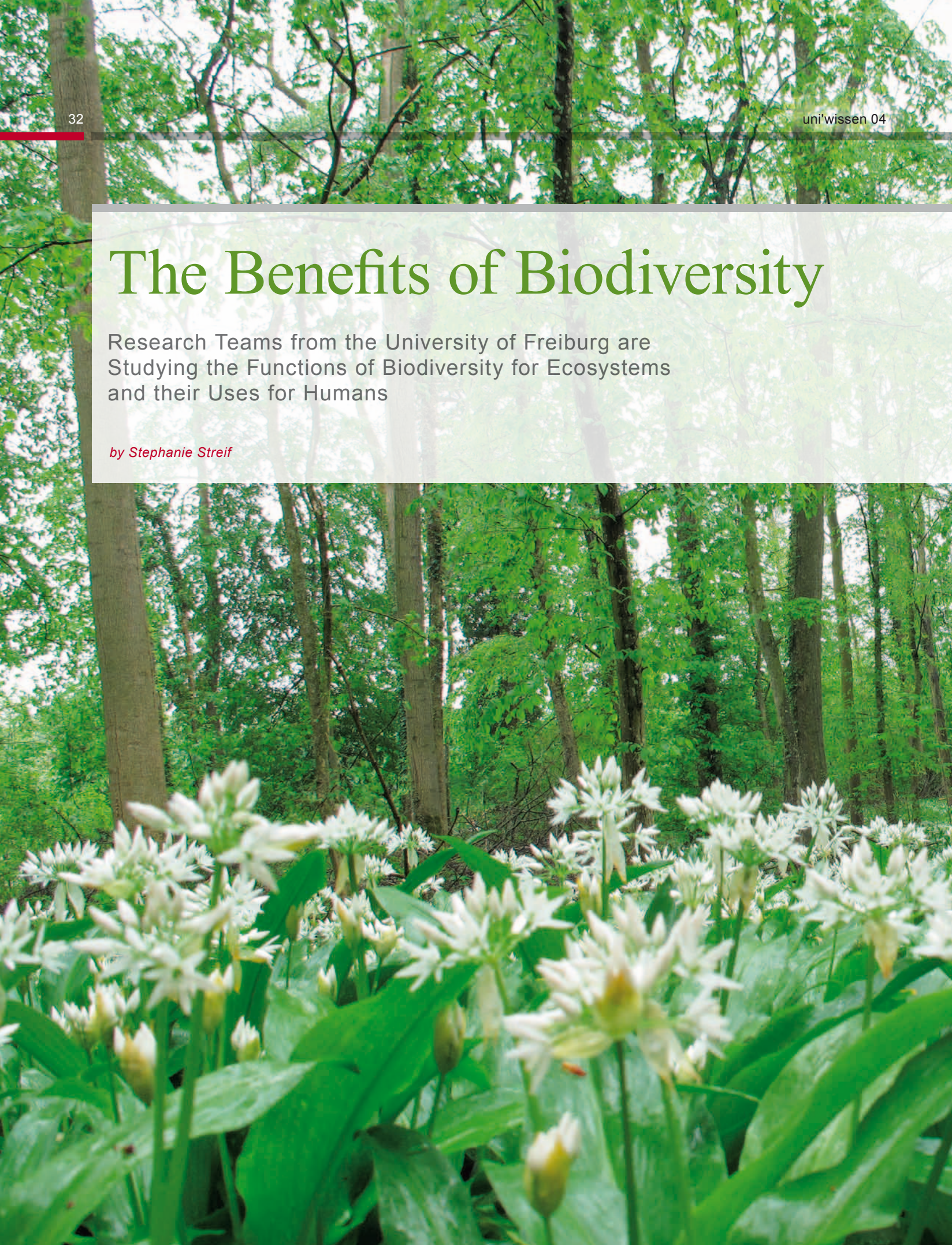
Deep see adventure: Jules Verne's novel 20,000 Leagues under the Sea fascinated readers in the 19th century. Photo: Wikimedia Commons

Prof. Dr. Natascha Adamowsky *studied at the Berlin University of the Arts. In 1998 she earned her PhD from the University of Siegen with a dissertation on game pieces in virtual worlds. In 1999 she accepted a position at the Department of Cultural Studies at Humboldt University in Berlin, where she completed her habilitation thesis on the miracle in the modern age in 2009. Since 2011 Adamowsky has served as professor for media and cultural studies at the University of Freiburg. Her research interests include media aesthetics and knowledge culture, practice as research/theory as practice (the epistemology of participation), the dispositive of finding and showing in artistic and scientific research processes, the mobility of digital technology, and ubiquitous computing applications in the mode of the game.*

The Benefits of Biodiversity

Research Teams from the University of Freiburg are Studying the Functions of Biodiversity for Ecosystems and their Uses for Humans

by Stephanie Streif



One forest, many disciplines: Forest scientists, hydrologists, and biologists address the topic of biodiversity from various perspectives and compile their findings.

"We want to find out how society could react to climate change for its own protection"

The causes may differ – rain forest clearings, the use of pesticides, or the cultivation of monocultures – but the outcome is always the same: The intensive use of ecosystems leads to the extinction of countless species. However, the scientific community has completed a paradigm shift since the 1990s. Instead of limiting their perspective to the consequences human action has for biological diversity, biologists are now focusing increasingly on how biodiversity makes the ecosystem more beneficial for humans, for instance in the face of global warming. It has long been an uncontested fact that humankind cannot survive without the services rendered by ecosystems. They provide building materials, food, medicines, and the very air we breathe – and they protect the ground against erosion and purify the water we drink into the bargain. However, not nearly enough research has been conducted on this topic, particularly on the forest. It's easy to cover up a meadow and make it into experimental green space, but conducting experiments on a forest is a more complicated affair.

Several groups of scientists at the University of Freiburg are working hard to close this gap. FunDivEurope (Functional Significance of Forest Biodiversity in Europe) is a project launched with funding from the European Union in 2010 whose purpose is to investigate the effects of biodiversity on wood production and quality, carbon storage, water quality, and a host of other functions in six regions selected as being representative of various types of species-rich forest. In another project funded by the German Research Foundation (DFG), a European-Chinese research group is studying the influence of a diversity of trees and shrubs on ecosystem functions in the subtropical forests of China. The goal of both of these projects is to deliver concrete recommendations for action – on agriculture and forestry, among other things. Research is also being conducted at so-called biodiversity exploratoriums in the three areas in Germany: Schorfheide, the Swabian Alps, and Hainich. The DFG provided funding to establish the three extensive long-term study areas in order to promote German biodiversity research. Each exploratorium has three test areas containing forests with different levels of biological diversity – from high to medium to low.

Dead but Useful

Prof. Dr. Jürgen Bauhaus, Director of the Institute of Silviculture of the University of Freiburg, is studying dead wood and the species of fungus that grow on them in the test areas. Dead wood contains much of what the ecosystem will need again later – nutrients, for instance, or biomass. Most species of fungus that live on dead wood may be found in non-forested beech forests, much more than in coniferous forests. Plus, the wood decomposes faster in areas in which there are more species of fungus. However, Bauhus is not interested in studying "biodiversity for its own sake. We are just observing the processes and analyzing how friendly or harmful they are for the environment, including aspects like the formation of greenhouse gases, which are generated during the entire decomposition process."

Hydrologists from the University of Freiburg are also conducting research at the exploratoriums. They are collaborating with botanists from the University of Halle and plant physiologists from the Leibniz Center of Agricultural Landscape Research in Müncheberg to determine whether forests with a high level of biodiversity are more resistant to the effects of climate change than those with a low level of biodiversity. "We are not asking whether biodiversity is neces-

sary or not. Rather, we are looking for concrete patterns," explains Prof. Dr. Markus Weiler, Director of the Institute of Hydrology. "What interests us is a naturally occurring extreme drought. We thus need an extremely low level of precipitation for the experiment." In order to simulate such climatic conditions, the research team built half-open roofs of various sizes under the crown growth in their experimental plots.

The project was launched at the beginning of 2011. In the spring the original state of each plot was documented, and in the summer the roofs were built. In order to enable a direct comparison, the team left control plots in which everything remained untouched. The three research groups are all – each within the context of their own discipline – investigating the impact extended drought has on the forest ecosystem. Weiler and his team, for instance, are studying how the soil structure changes: Will there be cracks in the ground or more water-repellent material? Will the flow paths along the roots change? And will the drought influence the transpiration of plants, i.e., how they give off water vapor? In order to answer these questions, the team needs sensors. They have placed 25 of them in the ground and in the trees of each plot. Among other things, the sensors measure the amount of precipitation, the air and soil temperature, the moisture content of the soil, and the flow of sap in the trees. "The point is not to make predictions," says Weiler. "We want to find out how society could react to climate change for its own protection."

Covered up: The researchers are simulating drought in the forest with half-open roofs under the treetops. The picture shows how the roofs are built.

Less Diversity, More Ticks?

Prof. Dr. Michael Scherer-Lorenzen would like to conduct research at the covered plots in the exploratorium in a second project phase starting in 2014 in order to answer further questions: How great is the impact of diversity and drought on the nutrient intake of the plants? And which plants complement each other best? The University of Freiburg biologist already participated in the Jena Experiment begun in 2002, which found evidence for a relationship between changes in biological diversity and important ecosystem functions. "We don't just want to determine the role biological diversity in the forest plays for the functioning of ecosystems; we also want to quantify its goods and services," explains Scherer-Lorenzen. What the Jena Experiment found is that "species-rich meadows can recover more quickly from severe drought and are less susceptible to drought when there is too little precipitation several years in a row." In addition, in many cases mixed forests have a higher productivity than monocultures. Productivity refers to the production of biomass that can later be harvested and sold. On the meadow this means hay, in the forest wood.

There are many – sometimes unusual – ways to approach the topic of biodiversity: For a project scheduled to begin in 2012, Scherer-Lorenzen has joined forces with medical researchers at the university. Using the example of Lyme disease, they aim to provide evidence for the con-

In the Jena Experiment scientists studied meadows with different amounts of biodiversity and found out how changes to biological diversity and functions of the ecosystem are linked. Photo: Weigelt

sequences a loss of biodiversity can have – in this case presumably more ticks and thus also more infections, among other things. It seems only logical that approaching the topic of biodiversity from the perspective of a variety of disciplines and compiling the results can be a profitable endeavor. Indeed, an international research group recently collected and compared the results of a large number of experiments on biodiversity, including those conducted in Freiburg by Scherer-Lorenzen and his team. And they all indicate that more biodiversity will be necessary if our ecosystems are to survive in a world that is changing ever more swiftly.

Prof. Dr. Jürgen Bauhus
is professor for silviculture and dean of the Faculty of Forest and Environmental Sciences of the University of Freiburg. He studied in Freiburg, Vienna, and Göttingen. He earned his initial degree in forest science in 1989, his doctorate five years later. As a postdoc Bauhus spent two years at the Department of Biology, Chemistry, and Geography of the University of Quebec in Canada. Between 1996 and 2003 he worked at the Australian National University as a senior lecturer in the areas of silviculture and tree physiology. In 2003 he accepted the Chair for Silviculture in Freiburg and developed a research program on the relationships between the structure, composition, and function of forest ecosystems and their control. In addition, he is a scientific advisor to the German Federal Ministry of Food, Agriculture, and Consumer Protection on agricultural policy.

Prof. Dr. Michael Scherer-Lorenzen
has served as professor for geobotany and experimental plant ecology at the University of Freiburg since 2009. He is coordinator of the research project FunDivEurope. His career began at the University of Bayreuth, where he earned his doctorate in plant ecology in 1999. At the end of the 1990s he worked simultaneously at the Max Planck Institute for Biogeochemistry in Jena and as a scientific advisor to the federal government on global change. In 2000 accepted a position as director at the Institute of Biodiversity in Friedrichshafen. In 2001 he returned to research at the Max Planck Institute for Biogeochemistry, and in 2003 he moved to the Institute of Plant Sciences at the Swiss Federal Institute of Technology in Zurich. In 2000 he was awarded the Horst Wiehe Prize for the Promotion of Ecological Research by the Ecological Society of Germany, Austria, and Switzerland.

Prof. Dr. Markus Weiler
studied hydrology in Freiburg and earned his doctorate at the Institute of Hydrology and Water Management at the Swiss Federal Institute of Technology in Zurich. He has served as professor of hydrology at the University of Freiburg since 2008. Prior to accepting this position he worked abroad – first as a postdoc at the Oregon State University in the USA, later at the University of British Columbia in Canada. He returned to Germany within the context of the program "Return of German Scholars from Abroad," coordinated by the German Scholars Organization on behalf of the Alfried Krupp von Bohlen and Halbach Foundation. In 2003 he received the Dean's Award for Outstanding Achievements from the Oregon State University and the New Opportunity Fund from the Canada Foundation for Innovation.

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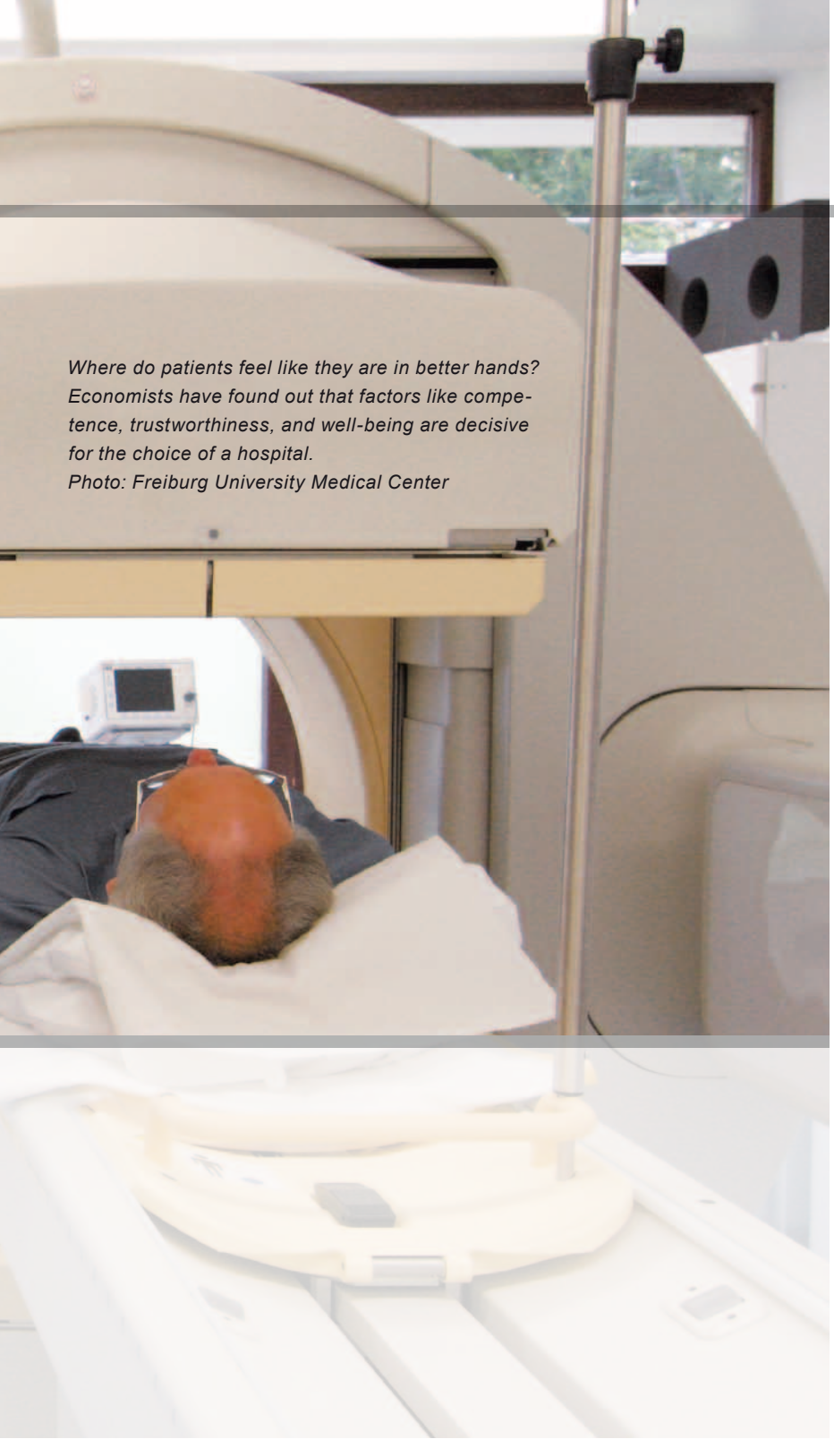
What Patients Want

Economists Have Discovered Better Marketing Strategies for Nonprofit Hospitals

by Katharina Wetzel

Hospitals compete for patients – whether they are run as private, public, or nonprofit institutions. Even though health care providers are subject to certain restrictions in how they advertise, every hospital wants to market its products and services in the best way possible. Dieter Tscheulin, holder of the Chair in Business Administration at the University of Freiburg, and his team have found out that nonprofit hospitals in particular could profit from an improved advertising strategy. The experts for marketing and the health care market studied the role of nonprofit status for the choice of a hospital in a year-long project. The project was led by habilitation candidate and research assistant Dr. Florian Drevs. Research assistant Ann-Kathrin Seemann was responsible for collecting the data and analyzing the results.

The research team conducted an experiment: They recruited 200 test subjects and asked them to assume the role of a patient looking for a hospital to have their appendix removed. In order to determine what preferences the subjects had,



Where do patients feel like they are in better hands? Economists have found out that factors like competence, trustworthiness, and well-being are decisive for the choice of a hospital.
Photo: Freiburg University Medical Center

the team showed them websites of fictive hospitals, some of them privately run, others public, and still others nonprofit organizations. The researchers found out that most patients do not take this factor into account at all as a criterion for choosing a hospital. What's more, the hospitals themselves don't emphasize their form of ownership as a selling point either, although it can have great influence on the quality of care. "Private hospitals have to operate the most efficiently," explains Tscheulin. Their primary goal is to maximize profits. Nonprofit health care facilities, on the other hand, are only interested in covering their costs, while their primary goal is to help patients. As charitable organizations they also enjoy preferential tax treatment. As a rule, hospitals run by states or cities are also primarily interested in providing optimal care.

Customers Assign Human Characteristics to Companies

The researchers did not attempt to determine which type of hospital – public, nonprofit, or private – is best. Rather, they only wanted to find out what influence the form of ownership of a hospital has on the patient's decision to seek care there. They found out that ownership can indeed be a factor in how people perceive a hospital and in which hospital they end up choosing. This choice is often influenced by stereotypes: "In marketing we view businesses as personalities," explains Drevs, because customers often assign human characteristics to companies. The factors Drevs determined to be important for the choice of a hospital include warmth, well-being, competence, and trustworthiness. The factors that were most important for the participants in the study were competence and trustworthiness. Seemann emphasizes that these are subjective perceptions that do not necessarily reflect reality – but this makes them no less relevant for marketing.

> "Many patients regard the idea of profit in the health care sector with suspicion"

The test subjects perceived each type of hospital in a different way: While they rated private hospitals as highly competent but not very trustworthy, their perception of nonprofit hospitals was the exact opposite. The results for public health care facilities were not as clear-cut; they landed somewhere in the middle.

The team drew the following conclusion from their findings: "Nonprofit hospitals should start using their ownership status as a selling point. Even a single sentence on their website can be enough," says Drevs. Currently, most nonprofit health care facilities hardly mention their charitable status at all, because many of them are afraid to be perceived as being less competent

under certain circumstances. Many private hospitals, on the other hand, have already found appropriate marketing strategies. They typically focus on the areas in which they have particular expertise on their homepage. According to Drevs, it would not be advisable for these hospitals to place more emphasis on their form of ownership, because it is more difficult to convince patients that a private company is trustworthy. "Many patients regard the idea of profit in the health care sector with suspicion," says Tscheulin. Nonprofit hospitals, on the other hand, have an advantage on this point – an advantage that they are not yet taking optimal advantage of. In times of increasing distrust toward health care, charitable hospitals should be more vocal about the fact that their main interest is to do something good. At the present time, one-third of all hospitals are run as nonprofit organizations. Their share of the market has remained constant for years.

"Nonprofit hospitals should start using their ownership status as a selling point"

However, good marketing alone is not enough: "Advertising always only has influence up to a certain point," says Drevs. A hospital cannot compensate for poor care with good advertising. Ideally, the expectations and preferences of the patients should be in line with the hospital's actual performance. The researchers now plan to present their findings to confederations representing nonprofit and confessional hospitals. They are also currently in demand as speakers at conferences. Some nonprofit hospitals will likely follow their recommendations in the near future. In the meantime, the researchers are already planning their next project: They want to extend their study to include other forms of inpatient treatment. The results could be relevant for hospitals as well as for many other health care facilities.

Prof. Dr. Dieter Tscheulin *studied economics and business administration in Gießen and Kiel. In 1990 he received his doctorate from the University of Lüneburg and worked until 1993 as a junior professor at the University of Namur in Belgium. He has taught and researched at the University of Freiburg as a professor for business administration since 1993. His research focuses on the health care sector and marketing management at companies. Tscheulin has taught at numerous national and international universities as a visiting professor. He also serves as a consultant for several companies and as co-editor of ZögU, a journal for public and nonprofit organizations.*

Ann-Kathrin Seemann *studied economics in Freiburg. She has worked under the Chair for Marketing and Health Management since 2010, first as a student assistant and tutor and since 2011 as a research assistant. Seemann's research on types of hospitals from the point of view of the patient goes back to her diplom thesis. She aims to delve deeper into this topic in her doctoral dissertation.*

Dr. Florian Drevs *studied economics in Göttingen and Freiburg. He has served as a research assistant under the Chair for Marketing and Health Management since 2004. His dissertation dealt with ongoing reforms in health care policy and their consequences for health care providers. In addition to collaborating on various research projects, Drevs is working on his habilitation thesis, which he plans to finish by 2012.*

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