Special topic: **Research in the Upper Rhine region**

# uni wissen

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# Malleable Minds

## Why human perception is shaped by more than just age, gender, and skin color

Activity in the brain:
How the human body learns and controls movements

Language in flux:
Why many youths like to speak in incomplete sentences

Security in the lab:
Who should decide on the limits of research freedom

UNI FREIBURG

## Yearly Report 2014: 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. 2013 – 30 Sept. 2014).


The Yearly Report 2014 of the University of Freiburg should be attached to this page.
The report is also available on the university website:
**www.uni-freiburg.de/go/jahresbericht_2014**

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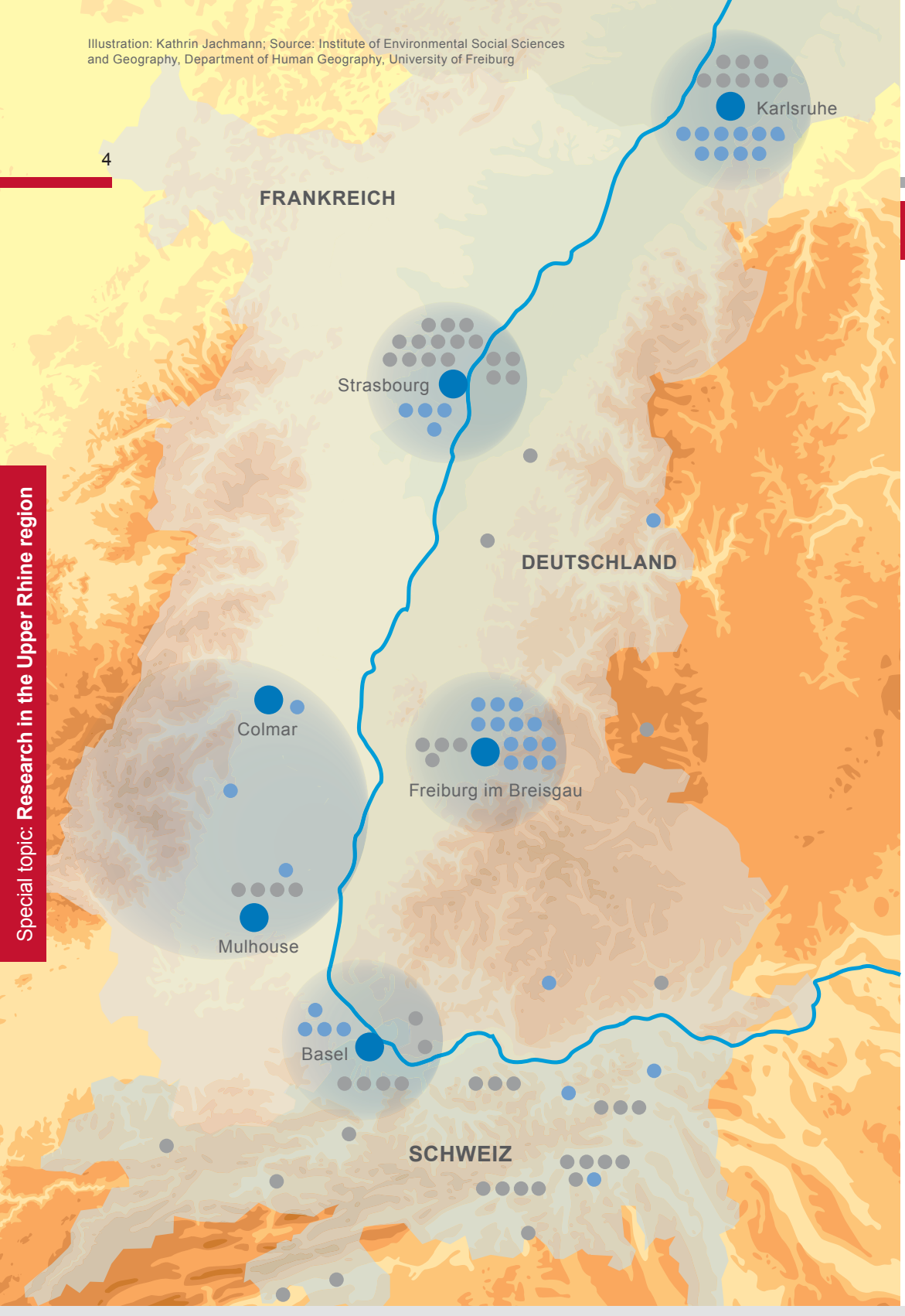



**KARLSRUHE INSTITUTE OF TECHNOLOGY**

Founded in 1825
24,500 students
9,400 employees
www.kit.edu

**UNIVERSITY OF STRASBOURG**

Founded in 1621
45,000 students
5,000 employees
www.unistra.fr

**UNIVERSITY OF FREIBURG**

Founded in 1457
24,800 students
17,500 employees
www.uni-freiburg.de

**UNIVERSITY OF UPPER ALSACE**

Founded in 1975
7,800 students
1,100 employees
www.uha.fr

**UNIVERSITY OF BASEL**

Founded in 1460
13,200 students
2,800 employees
www.unibas.ch

## The European Campus

**5 universities**
115,000 students
15,000 lecturers and researchers
11,000 doctoral candidates
A total annual budget of 2.3 billion euros
5 research networks
21 ongoing research projects
5 binational doctoral research groups
16 international degree programs

Moreover, the “Upper Rhine Trinational Metropolitan Region” includes an additional **50 research institutes** and **63 higher education institutions.**

- Universities
- Research institutes
- Other higher education institutions

**The University of Freiburg and its partners on the Upper Rhine are creating the European Campus**, a common German-French-Swiss higher education area. This uni'wissen dossier introduces the project and presents four examples of cross-border research in the trinational Upper Rhine region.

# Center of Gravity for Cutting-Edge Research

## In the large-scale project European Campus, five universities on the Upper Rhine are consolidating their research strength

*by Mathilde Bessert-Nettelbeck*

If you want to find new insight and develop new technologies, you need to look beyond your own garden fence. Scientists in Germany studying climate change, for instance, cannot afford to limit the scope of their inquiry to their own country with regard to knowledge, methods, and insight. To produce results that are relevant on a global scale, they need access to international literature and infrastructure as well as contact with colleagues from around the world.

But at the same time, education and research need to overcome barriers and bureaucratic hurdles – even though the vision of a united Europe has been realized in part with the European Union, the euro, and the Schengen Agreement. A strong regional network can help researchers to consolidate scientific resources and surmount linguistic and national boundaries. In order to achieve this, the universities in the Upper Rhine region are building up a common European Campus in the "three-country corner," with the Universities of Freiburg and Strasbourg leading the way.

The Upper Rhine Plain is not just at the center of Europe in a geographical sense: The strengths of the region include its economic clout, its scientific potential, and the innovations that emerge from its many research institutions and universities. It is thus also of central significance with regard to industry and research. "Our vision is a 'zone franche' for science and research, a place for innovation in which the universities and research institutions complement each other and create synergies in research and instruction," explains Prof. Dr. Hans-Jochen Schiewer, Rector of the University of Freiburg.

### Proven Partnerships

The idea for the European Campus builds on proven partnerships for research and teaching between France, Germany, and Switzerland: In 1989 seven German, French, and Swiss universities teamed up to form the "European Confederation of Universities on the Upper Rhine" (Eucor). Today the confederation includes the University of Freiburg and the Karlsruhe Institute of Tech-

*Hans-Jochen Schiewer, Rector of the University of Freiburg, wants to establish the European Campus.*
*Photo: Baschi Bender*



nology on the German side, the University of Basel on the Swiss side, and the Universities of Strasbourg and Upper Alsace in Mulhouse and Colmar on the French side of the Rhine.

## "Our vision is a 'zone franche' for science and research."

When it comes to securing funding for their projects, researchers from the Eucor alliance are at a great advantage: The cross-border cooperation qualifies them for a number of prestigious funding programs. In order to ensure that the researchers can devote their concentration to their projects rather than dealing with funding issues, the coordination units at the universities have taken over part of their administrative responsibilities. Junior researchers have the opportunity to earn a binational doctoral degree and receive grants to attend the yearly summer schools held by the confederation. Students can select between 19 cross-border degree programs coordinated by Eucor. In addition, they can take lecture courses and seminars from the regular curriculum of all member institutions to fill gaps in the course offerings of their home university. They have access to all libraries and can use the resources of all of the universities. Graduates of the Eucor degree programs are awarded with a double or even a triple degree.

Another forum for cooperation is the organization "Upper Rhine Trinational Metropolitan Region" (TMO), which combines politics, industry, and research. Hans-Jochen Schiewer has served as Eucor president since 2013 and is thus spokesman of the "research pillar" of the trinational metropolitan region, which also includes further research institutes and higher education institutions. He aims above all to more closely integrate the region's research institutions: "We want to make the geographical junction of the Upper Rhine into a center of gravity for cutting-edge research with international appeal." The result will be an unparalleled research area for European researchers. As the flagship project, the Eucor universities and further partner institutions will establish a large-scale research infrastructure focusing on bioinnovations to create new incentives for collaboration. Also planned is a virtual center of competence on sustainability.

**Government Backing**

At an executive committee meeting in December 2013, the Eucor members resolved that the

> "We are creating a whole that is greater than the sum of its parts."

first step into the future is to find a legal form for the European Campus. In order to apply for funding together, whether from the German Research Foundation, the Swiss National Science Foundation, the French National Agency for Research, or the European Commission, the European Campus must be registered as a legal entity. "But we can't build this bureaucratic bridge over the Rhine all on our own: We need the backing of government and society in all three nations," explains Schiewer.

In July 2014, Baden-Württemberg's minister president Winfried Kretschmann and the Alsatian regional council president Philippe Richert issued a joint statement signalizing their support for the "creation of a 'European Campus' on the Upper Rhine, with the goal of building up a science and research area without 'walls and borders' and with international attraction, appeal, and visibility." The State of Baden-Württemberg is providing 130,000 euros in funding for the project. The Region of Alsace is contributing 60,000 euros and has promised to supply an additional 60,000 euros over the *Initiative d'excellence* (IDEX), the French version of the German Excellence Initiative. The decision in September 2014 to accept Switzerland as a partially associated member in the European Commission funding program "Horizon 2020" will also make it easier for the partner institutions in Basel to participate in the European Campus.

A suitable legal form has been found: The Eucor universities are currently in the process of founding a European Grouping of Territorial Cooperation (EGTC). "There has never been a legal entity of this kind combining five universities across national borders," emphasizes Schiewer. "The Eucor universities are establishing a European Campus – with its own identity and its own funding opportunities. At the same time, they will not relinquish the qualities that make each of them unique. We are creating a whole that is greater than the sum of its parts."

*www.eucor-uni.org*


*Pioneers on the Upper Rhine: The Universities of Freiburg, Basel, Mulhouse/Colmar, Strasbourg, and Karlsruhe (from left) are creating the European Campus.*

*Photos: Peter Mesenholl, University of Basel, Giséle Jactat/GC Emotions, University of Strasbourg, KIT*


*Barbaric North, civilized South: Thor attempts to destroy a Gothic cathedral with his hammer. This anti-German propaganda image from France was made during the First World War (left). The picture Carl Doepler drew of the god in his costume designs for the inaugural Bayreuth Festival in 1876 (below) is entirely different.*

*Sources: gallica.bnf.fr / Bibliothèque nationale de France, Klassik Stiftung Weimar*

# Gods, Heroes, Barbarians

## The images of the North constructed by European literary historians differ – depending on the place of knowledge production

*by Anita Rüffer*

A white map of Europe hangs on the wall of Prof. Dr. Joachim Grage's office at the Freiburg Institute for Advanced Studies (FRIAS). The map is speckled with red dots – concentrated mostly in Germany, the French border regions, and the Scandinavian countries. The dots represent European universities at which it is possible to make out a growing interest in Nordic languages and literatures starting in the mid nineteenth century. What Grage is interested in is the geographical aspect, because the images of the North constructed by scholars are not the same everywhere. "Knowledge production is linked to concrete places," says the professor of North Germanic philology at the University of Freiburg. "Images of the North are modified to fit in with specific contexts." They are motivated by academic networks, traditions, the spirit of the times, nationality, and political interests.

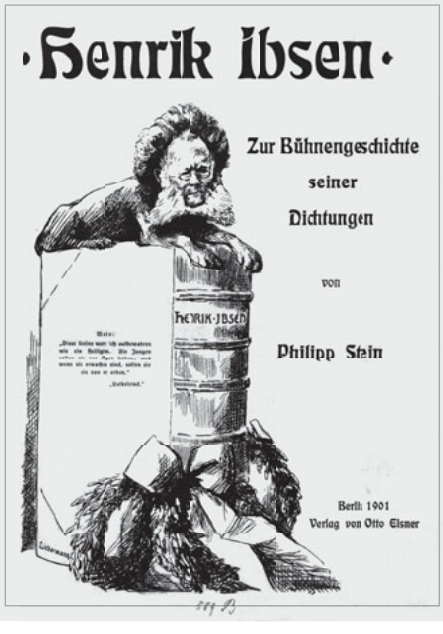
"Knowledge production is linked to concrete places."

The University of Freiburg has the goal of establishing a European Campus on the Upper Rhine in order to use its geographical location for the joint production of knowledge. For Grage, this campus has long since become a reality: Together with Dr. Thomas Mohnike, head of the Institute of Scandinavian Studies at the University of Strasbourg, he is conducting the joint research project "Building the North with Words: Geographies of Scientific Knowledge in European Philologies 1850–1950." The space for the project is provided by FRIAS and the Strasbourg Institute of Advanced Studies (USIAS), which was established on the model of the former institution. Grage and Mohnike are fellows of both excellence institutes. However, they have been collaborating – and passing valuable snippets of knowledge on to each other – for much longer.

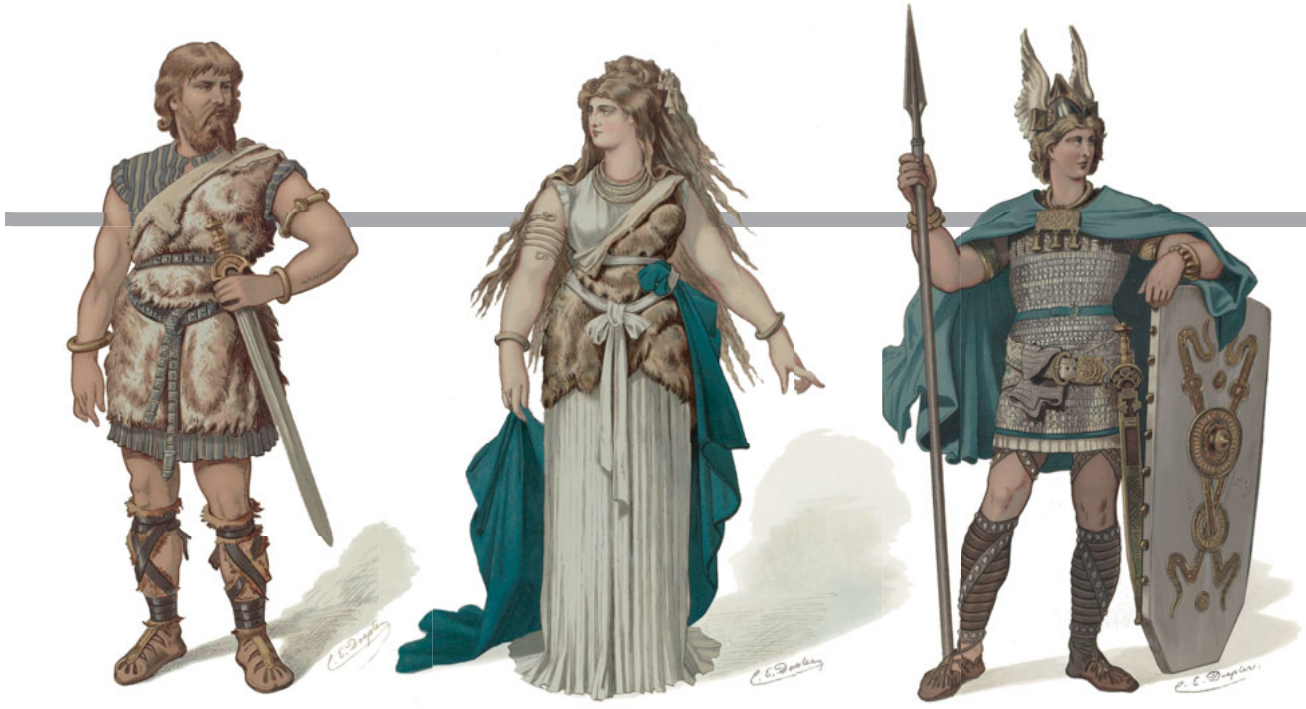
**Propagandistic Motives**

There were times when practices like this would have been unthinkable in their fields of research. Strasbourg in particular, with its changing national and ideological affiliations over the centuries, illustrates clearly what the two researchers are driving at with their project: "The professors appointed by the university changed depending on whether it belonged to France or Germany, and so did the image of the North they taught," says Mohnike and presents an illustrated broadsheet printed in the Lorrainian town of Épinal in 1915: It shows the Germanic god Thor in a militaristic pose, laden with a sword and lance and brandishing a giant hammer over the demolished Gothic cathedral at his feet. He is introduced as "the most barbaric of the old Germanic deities." The propagandistic motive is clear: In the clash between France and Germany in the First World War, the civilized South – or France, represented by the Gothic cathedral – is pitted against the destructive, hammer-swinging Thor, a representative of the North associated with the uncivilized Germany.

The medieval Icelandic manuscripts of the two "Eddas," which recount tales of gods and heroes and are among the best-preserved sources of so-called Germanic mythology, served as the basis for explaining what actually constituted Germanic – as opposed to Gallic or Celtic – identity. The broadsheet of Épinal makes use of these sources and ideas to shape a French national identity among the Alsatian people and firmly establish a sense of belonging in the public consciousness. "The generally accepted knowledge of ancient Germanic civilization is adjusted to fit local needs," explains Mohnike. He is astounded




*Henrik Ibsen, the Nordic Sphinx: The Norwegian dramatist was revered by literary scholars as a mythic figure.*
*Source: Bayerische Staatsbibliothek Munich, call number: L.eleg.g. 100 u*



*Father Siegmund, mother Sieglinde, son Siegfried (from left): Carl Doepler took inspiration from archaeological findings in his costume designs for the inaugural Bayreuth Festival in 1876 with the first complete performance of the* Ring of the Nibelung.

*Source: Klassik Stiftung Weimar*

at how different the constructions produced in Paris, Berlin, Strasbourg, or Copenhagen are, despite the fact that they are all based on the same source. An illustration like that from Épinal would have been unthinkable under the Nazis. The motive behind their interest in Nordic people and everything Germanic was to propagate a cultural and national Germanic identity: Everyone who didn't correspond to this ideal was segregated from the rest of society and persecuted. "Only few read the texts in the Icelandic original," suspects Mohnike. He has determined that the reason why elements from them nevertheless became so well known was in no small measure due to the popular operas of Richard Wagner. The composer is said to have studied the Norse myths in detail before writing them. Archaeologists also played a role in their popularization: Carl Doepler took inspiration from archaeological findings in designing costumes for the inaugural Bayreuth Festival in 1876.

Comparative philologists of the 19th century constructed trees of Indo-Germanic languages showing how the Germanic, Slavic, and Gallo-Romance speech areas formed from common roots, diverging ever further from one another. Mohnike diagnoses two opposing trends: "The great histories of community and shared identity stabilize the narrative of identity. When they are adjusted to fit local needs, they are also separated from their original historical context."

At the same time, this narrative was joined by another image of the North created by European literary studies: On the one hand, explains Grage, these scholars also emphasized Germanic roots, "but on the other hand, the same academic discipline discovered modern Scandinavian literature." Authors like the Dane Jens Peter Jacobsen, the Swede August Strindberg, or the Norwegian Henrik Ibsen explored the pressing societal issues of the times in their texts: the place of women, economic and social problems, religious questions. These writers achieved their breakthrough around the year 1870 – not just in Scandinavia.

The great dramatist Henrik Ibsen in particular took the German stages by storm. Ibsen scholars characterized him as a kind of Nordic Sphinx: as a great riddle, as a mythic figure, as the product of a nation shaped by magnificent nature and landscapes. At the same time, they used his work to fashion an image of Norway as a country


*Karlsson-on-the-Roof, Pippi Longstocking, Emil of Lönneberga, and the Bullerby children (from left): A series of stamps commemorating the 80th birthday of Astrid Lindgren features well-known characters created by the children's book author, whose stories influence many people's image of Scandinavia today.*

*Photo: rook76/Fotolia*

of modernity and progress – as a contrast to the old-fashioned countries of the South. German philology, says Grage, claimed Scandinavian literature as its own, citing a kinship due to the people's common roots: "Since the languages are related," they reasoned, "the people must be related too." The fact that Scandinavian studies were integrated into German studies departments at German universities and did not have their own departments with their own professorships up until the 1970s is a clear expression of this appropriation of Scandinavian literature. France and Belgium, by contrast, maintained a more neutral and comparative view.

The popularity of Scandinavian detective novels, the unconventional female protagonist Lisbeth Salander in Stieg Larsson's *Millennium* trilogy, the model character of Scandinavia with regard to school systems and the welfare state, the Swedish furniture store chain as the yardstick for uncomplicated home decor, Norwegian fjord landscapes as the embodiment of unspoiled nature, the childhood idyll in the stories of Astrid Lindgren – all of this is likely to resonate when Germans think of the Nordic countries today. As Grage and Mohnike show, these images are part of a long tradition. But they do not show the entire picture: "We see what we already know and are confirmed in our preconceived notions."

> "We see what we already know and are confirmed in our preconceived notions."

*www.pr.uni-freiburg.de/go/building-the-north-with-words*

***Prof. Dr. Joachim Grage***

*studied German, chemistry, and Scandinavian philology in Göttingen and Copenhagen/Denmark. After earning his PhD in Scandinavian and German philology in 1999, he worked in succession as research assistant, junior professor, and, from 2004 to 2006, as director of the Department of Scandinavian Studies in Göttingen. He has served as professor of North Germanic philology (modern literature and culture) and director of the Department of Scandinavian Studies of the University of Freiburg since 2008. His research interests include Scandinavian literatures from the 17th century to the present, literary practices and the performativity of literature, Søren Kierkegaard, nature poetry and literary discourses of nature, and Scandinavian-German cultural relations.*

*Photo: private*

***Dr. Thomas Mohnike***

*studied art history, theater, and religious studies in the USA in 1993/94 and Scandinavian and Germanic linguistics, literature, and culture in Kiel, Uppsala/Sweden, and Berlin from 1994 to 2001. In 2006 he earned his PhD at the University of Freiburg. From 2003 to 2010 he coordinated the Scandinavian studies network of the European Confederation of Universities on the Upper Rhine (Eucor). Since 2009 he has served as director of the Department of Scandinavian Studies at the University of Strasbourg. His research interests include imaginary geographies – constructions of identity and alterity in Northern Europe, the transnational history of Scandinavian studies, and the reception of Norse mythology since the Middle Ages.*

*Photo: Hanspeter Trefzer*

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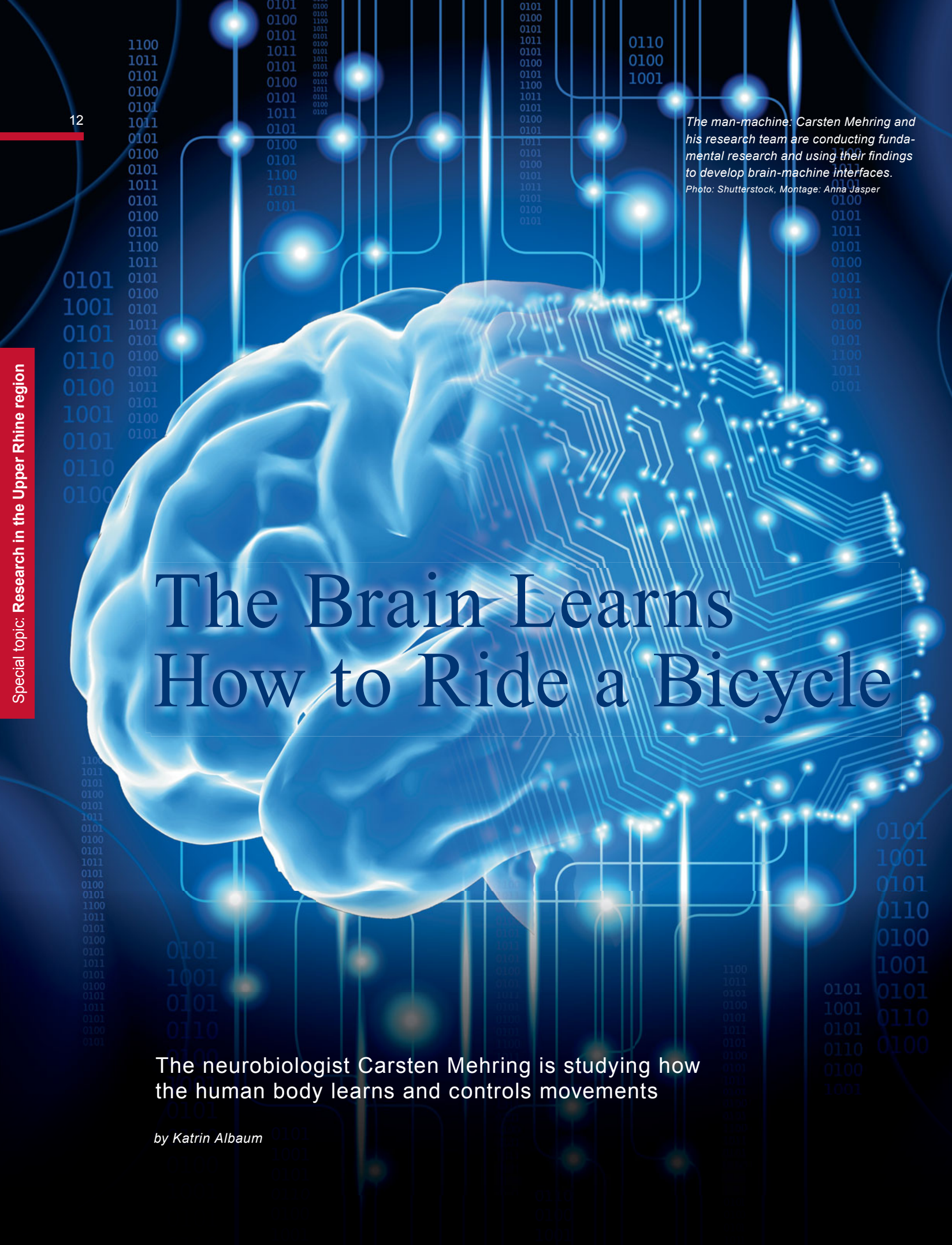


*The man-machine: Carsten Mehring and his research team are conducting fundamental research and using their findings to develop brain-machine interfaces.*
*Photo: Shutterstock, Montage: Anna Jasper*

# The Brain Learns How to Ride a Bicycle

The neurobiologist Carsten Mehring is studying how the human body learns and controls movements

*by Katrin Albaum*

"When it comes to flexible movements, even a child can beat the best robots."

A young man sits in a black leather armchair. His hand rests on a keypad. On his head he wears a hood with an array of electrodes attached to it. He is participating in a neuroscience experiment as a test subject. His task is easy: All he has to do is move his finger at irregular intervals and push one of the buttons. No one tells him when to do it. He is free to decide when to move his hand – or so he thinks. In reality the electrodes on his head are not just measuring the activity in his brain: They are charged with a weak electric current the test subject is not consciously aware of. "This allows us to activate particular areas of the brain," explains the Freiburg neurobiologist Prof. Dr. Carsten Mehring. "Different stimulation patterns raise or lower the probability that the test subject will move his finger. We can thus influence his decision." The purpose of the experiment is to determine how the activity of particular nerve cell networks is connected with movement and behavior.

**The Complexity of Lifting a Coffee Cup**

Mehring's team of brain researchers is studying what happens in the human brain when a person moves his or her hands or rides a bike. The researchers want to understand how the brain controls movements and learns new movement patterns. They are conducting behavioral experiments and applying methods like electroencephalography, in which electrodes measure electrical activity along the scalp. In addition, the scientists are using the findings from their fundamental research to develop brain-machine interfaces, for example to enable paralyzed persons to control a prosthetic arm via an implant in their brain.

An ordinary everyday movement like lifting a coffee cup seems simple: One decides consciously to do it, and the rest happens automatically. However, it also involves a multitude of unconscious processes. "Movement control is a difficult problem for brain research," says Mehring. "The human body has more than 600 muscles. We do not know precisely how our brain controls them." This is why scientists have not yet succeeded in programming robots to move as skillfully as humans. "We can train a robot to pick up a particular chess piece, but the machine is limited in its capacity to generalize and transfer knowledge it has acquired to a new task," explains Mehring. A chess computer can beat the best players, but "when it comes to flexible movements, even a child can beat the best robots."

**Structural Learning**

The outer layer of neural tissue in the human brain is called the cerebral cortex. It can be divided into areas that serve different functions. Numerous neural networks are involved in controlling a movement. The motor area is responsible for deliberate movements: It passes signals on to the spinal cord, from where they reach the muscles. When the surroundings change, the motor system needs to adapt the movement commands. The visual area helps by processing visual impressions, and the auditory area supplies the necessary acoustic information. The somatosensory area provides information on the current state of the muscles, enabling the brain to correct a movement and make it as precise as possible. "These areas and the neural networks inside them work together to improve a movement pattern."

In cooperation with other scientists, Mehring developed a concept that explains how humans learn a new movement pattern and why they can generalize it. "If you've learned how to ride a bicycle you can generally ride any model, whether it's a racing bike, a mountain bike, or a city bike – even though you need to activate different muscles for each of them." Mehring's team approached the problem of generalization from a mathematical perspective: A certain muscle activation pattern, such as that necessary to ride a mountain bike,

*What's going on inside my head?: In the method of electroencephalography, electrodes measure the neural activity on the brain's surface.* Photo: Thomas Kunz

corresponds to a point in a parameter space. The muscle activation pattern for riding a racing bike, which is of a different size and shape, corresponds to another point, because the brain needs to control the muscles of the cyclist differently. "If I can ride the one bicycle and want to ride the other, that means I know the one point and want to find the other one."

"When it comes to flexible movements, even a child can beat the best robots."

But how does the cyclist learn how to ride the new bicycle? How does he find the right parameter point? It cannot be that he has to try out all possible muscle activation patterns until he has found the right one: "Then it wouldn't be possible to learn a new movement task within a plausible amount of time. That's what the mathematical analysis shows." The solution to the problem is Mehring's concept of structural learning: The brain doesn't just learn the right muscle activation pattern for riding the mountain bike – it also learns what movement patterns that are important for riding any type of bicycle have in common. In the mathematical representation, all the movement patterns one needs to learn how to ride bicycles lie on a so-called manifold. A manifold may be thought of as being analogous to a plane or a curve in a three-dimensional space, but in reality these processes occur in a high-dimensional space. In order to switch from a mountain bike to a racing bike, a cyclist does not – mathematically speaking – need to search everywhere for the right movement pattern but only within the space or along the curve. "We and other research teams have found evidence to support this concept in a number of experiments."

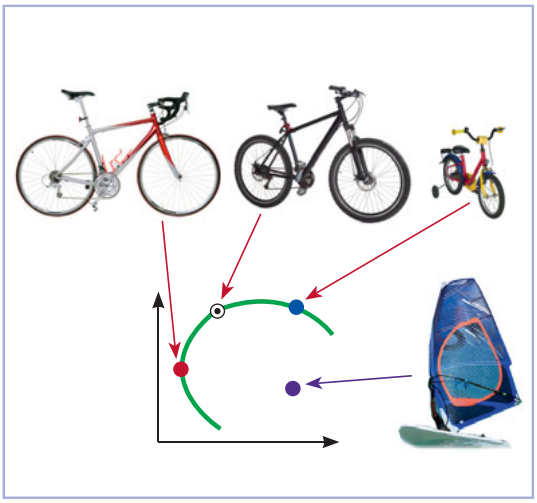
## Exchange in a Network

Mehring receives crucial input for his research from other scientists in "Neurex," the trinational neurosciences research network on the Upper Rhine. The network includes around 100 labs at the Universities of Freiburg, Basel, and Strasbourg. "Neurex brings together brain researchers from various backgrounds and areas of specialization. In addition, the specialties of the neurosciences research groups at the universities in Freiburg, Basel, and Strasbourg complement each other very well. Mehring is a member of the external advisory board of the Erasmus Mundus doctoral program "Neurotime," which includes the three previously mentioned institutions as well as the Universities of Amsterdam/Netherlands, Bangalore/India, and Jerusalem/Israel.

In a new study, Mehring and his team demonstrate how people improve movements and plan them in advance. The test subjects held a robot arm with their hands and moved it to control a mouse pointer. The task involved tracing a path on a monitor with the mouse pointer. The researchers tested how long it took the participants to trace the path. The longer the test subjects had practiced beforehand, the faster they finished the task. In a second test, most of the path was hidden: The only visible section was the first few centimeters in front of the mouse pointer. "The test subjects who had practiced beforehand made more efficient use of the information provided to them. Those who had learned the movement could include information on the future course of the path and thus adapt their movement early on."

At the moment, Mehring is working on a new technique for modifying the activity of particular neural networks. "We are developing a closed-loop simulation system that continually measures brain activity and adapts the electrical stimulation to it in real time." The researchers hope it will help them find causal relationships between neural activity and behavior. Despite these advancements in brain research, however, it will still be quite some time before robots learn how to ride bicycles like humans.

www.neuro.uni-freiburg.de



*Generalization, from a mathematical perspective: The brain doesn't just learn which muscles it needs to activate to ride a particular kind of bicycle (points on the curve) – it also learns what movement patterns for riding any type of bicycle have in common (curves). This is why anyone who has ever ridden a bicycle can generally ride any model – whereas other movement patterns, such as those that are important for surfing (point next to the curve), require a new learning process.*

*Photo: PRILL Mediendesign, apops, steamroller, joël BEHR (all Fotolia), Montage: Kathrin Jachmann*

***Prof. Dr. Carsten Mehring** has served as head of the neurobiology and neurotechnology working group at the Bernstein Center Freiburg and the Institute of Biology III of the University of Freiburg since 2013. He earned his doctorate in Freiburg in 2003 and then worked in Freiburg and at the University College and the Imperial College in London/England. From 2002 to 2007 he was a member of the Junior Academy of the Heidelberg Academy of Science and Humanities. He is part of the University of Freiburg's Cluster of Excellence BrainLinks–BrainTools.*

*Photo: Thomas Kunz*

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*Illustration: Svenja Kirsch*

# "Hey, you want to come along cafeteria?"

Vanessa Siegel is studying which words from standard German are left out in teenage slang


*by Claudia Füßler*

"Kiez" German, Turk slang, ghetto language – the object of Vanessa Siegel's research goes by many names. But what the research assistant for German linguistics at the University of Freiburg is actually interested in only becomes clear when she says things like "Ich bin Jugendhaus" ("I'm youth center") or "Ich geh Schule" ("I go school"). This reduced language, which sound in the ears of native German speakers as if someone had missed a few grammar lessons in school, is what the doctoral candidate is focusing on in her research.

Siegel wants to create a profile of this speech style in her dissertation. "Almost nothing at all has been done on it yet. Everyone knows this way of speaking, but there are no extensive empirical studies on it," says the linguist. That's astounding when one considers that it is by no means new. "Historically speaking, the phenomenon does have to do with migration. It presumably originated with Turkish youths in large cities." There is evidence that teenagers in Frankfurt were already speaking like this 20 years ago. "Like this" means syntactically reduced. Words that would normally be there in standard German are dropped, especially words with a grammatical function – like articles, as in "Komm, du bist doch aus kurdische Krieg gekommen" ("Come on, you came from Kurdish War"), prepositions, as in "Wir waren halt so Campingplatz und so" ("We were like campground"), or pronouns, as in "Wenn der ein paar Sachen nicht aussprechen kann, sagt der dann einfach auf Türkisch" ("When he can't pronounce things, he just says in Turkish").

**An Expression of Identity**

Although these syntactic structures have long distinguished the speaking style of certain youths, they have only entered the public consciousness in the past ten years – through comedy stars like Bülent Ceylan. As a result, more and more people have begun speaking this way as a joke. "Even here my colleagues sometimes say things like 'Ey, kommst du mit Mensa?' ('Hey, you want to come along cafeteria?')," says Siegel. However, most people aren't aware that this language is not spoken by people who "can't yet speak German quite right" but by people who learned German as their mother tongue, mainly teenagers in neighborhoods with a high immigrant population. "What many don't know is that teenagers are fully

capable of using prepositions and articles correctly; they just don't do it all the time," says Siegel. This has nothing to do with a lack of language skills but is an expression of their identity, similar to clothes. "It's a style they can use to position themselves with."

The title of Vanessa Siegel's dissertation is *Morphosyntaktische Reduktion in multiethnolektaler Jugendsprache* ("Morphosyntactic Reduction in Multiethnolectal Youth Language"). She is writing it at the Hermann Paul School of Linguistics (HPSL). Interdisciplinary research and a broad international network are the trademarks of this joint graduate school of the Universities of Freiburg and Basel, which is dedicated to training PhD students in linguistics and neighboring disciplines – a total of 95 at the moment – and preparing them for the job market. Doctoral candidates, postdoctoral scholars, and professors form an inspiring collective at the school, building bridges between topics, methods, and research traditions.

"This form of speech makes the youths' language creative and rich."

*Comedy stars like Bülent Ceylan brought the reduced language to the public consciousness.*
*Photo: Ralph Larmann*

Siegel is working with empirical language data on teenagers from Stuttgart for her study. Most of the 14- to 18-year-olds speak the language of their parents in addition to German. The linguist aims to glean various information from the interviews she conducted with the youths. First she compiles statistics on the frequency with which the youths leave out articles, pronouns, or prepositions in their speech. Then she determines the grammatical and semantic contexts in which this happens. She wants to demonstrate that these omissions are not simply arbitrary but systematic. In addition, she is studying whether perhaps the youths' second native language also plays a role, and if so, how.

Siegel says that she has grown very fond of the speakers she recorded anonymously for her study, and above all, her own perception of youth language has changed. "At the beginning I was not entirely free of the associations aroused in many when they hear this language: People think of the ghetto, aggressive machismo, a propensity for violence," says Siegel. She has long stopped making such associations. On the contrary: "This form of speech makes the youths' language creative and rich. It's an additional form of expression that even girls like to make use of."

**Multi-Layered and Always in Flux**

Vanessa Siegel has been fascinated by language all her life. Reading has always been one of her favorite hobbies. While completing her studies in German and linguistics, however, she realized that she found spoken language even more fascinating. "Since everyone can speak, no one is interested in exactly how it works. We think of it as something that just happens," says Siegel. "But our language is an incredibly creative and dynamic system. It is always in flux and at the same time so multi-layered and complex."

Grappling so intensely with language day in and day out has made Siegel into an especially attentive listener. She detects subtleties in conversations that no one else notices: Does a speaker use a lot of antiquated words? Does a speaker realize he can't finish a sentence as intended and then change it in mid-sentence although he knows the grammar doesn't quite fit anymore? Is a fine, barely perceptible intonational nuance the sign of a particular accent? "I register certain things, but I don't analyze," says Siegel.

*Urban origin: Youths in Frankfurt were already using the speech style Vanessa Siegel is studying 20 years ago.*
*Photo: Frank Wagner/Fotolia*

***Vanessa Siegel***

*is a research assistant at the Department of German of the University of Freiburg and a doctoral candidate at the Hermann Paul School of Linguistics in Basel and Freiburg. Before beginning her studies in linguistics and German literature in Freiburg and Stuttgart, she completed training as an IT specialist at the Freiburg University Library. She has been studying "Turkish slang" – or, more precisely, syntactically reduced youth language – for more than four years.*
*Photo: Thomas Kunz*

"But it is indeed interesting that you can learn things about the person you are speaking to without them having to say them outright, such as where he comes from, his educational level, if he's used to speaking a lot, and what kind of people he usually speaks with."

**Only Unimportant Words Are Dropped**

Vanessa Siegel's second passion is something one wouldn't expect: numbers and computers. The linguist completed training as an IT specialist before beginning her studies. "Not a bad combination," says Siegel, who also takes care of computer-related tasks at her department. After all, linguists work with language databases and software that is still far from perfect from a technological standpoint. "A particularly interesting field is natural language processing," says Siegel. "The machines often can't cope with things like dialect or even indistinct speech, no matter how much the researchers have programmed them and fed them with speech material beforehand." She could see herself working on new solutions to these problems in the future.

But for now she is completely wrapped up in analyzing her own collection of speech data. She finds it striking that there are no adults who speak like the youths she is studying – outside of the odd joke. It appears to be a passing phenomenon, a habit that young people grow out of. However, this again is a sign that the youths have a good command of language – as is a further finding from which Siegel derived the underlying hypothesis of her study: She noticed that the words and linguistic elements youths leave out are always ones that aren't absolutely necessary to understand the content of the sentence. "This suggests that the speaker knows without thinking about it that these words have no important function."

*http://paul.igl.uni-freiburg.de/siegel*

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# Searching for Clues in Grave 33

## Archaeologists and natural scientists are collaborating to explain pivotal cultural changes in the fifth century

*by Annette Kollefrath-Persch*

*Burial offerings provide important information about the social status of the person they were buried with and help scientists to determine the time of the burial.* Photo: Jean-Jacques Bigot/INRAP

At the end of the 5th century, a woman with a lot of jewelry was laid to rest next to other deceased persons in a burial ground at the site of the modern-day Alsatian village of Niedernai. What kind of food did she eat? Did she spend her entire life in this region? Was her family buried beside her? These are the questions the archaeologist Dr. Susanne Brather-Walter is grappling with at the University of Freiburg. Together with scientists from Germany and France, she is investigating whether the archaeological sources from the time after the fall of the Western Roman Empire, from the mid fifth to the early sixth century, need to be fundamentally reassessed and, if this is the case, newly interpreted.

The finds were excavated, restored, and brought to the Archaeological Museum in Strasbourg. The grave of the unknown woman and her jewelry were put on display there. Three years ago the museum asked Brather-Walter whether she would like to study the burial ground. That was the beginning of a German-French research project funded jointly by the German Research Foundation and the French National Agency for Research. Brather-Walter is co-head of the project along with Prof. Dr. Eckhard Wirbelauer, professor of ancient history at the University of Strasbourg. As soon as the results of the scientific analyses and the archaeological interpretations are available, Wirbelauer will place them in the context of contemporary text sources.

## “Niedernai has been a stroke of luck for us.”

In contrast to older studies, which attempted to find answers to these questions solely on the basis of selected archaeological finds, Brather-Walter’s research team is analyzing the entire range of finds from Niedernai and using a wide variety of scientific methods: The analysis of ancient DNA, radiocarbon dating, isotope analysis, and semi-precious stone analysis offer the possibility to test whether traditional patterns of interpretation are correct. “The natural sciences alone cannot answer the questions,” says Prof. Dr. Sebastian Brather, an archaeologist participating in the project, “but they give us data and points of departure for new horizons of interpretation.”

### Complete and Undamaged

The grave of the woman from the fifth century, referred to by the researchers as grave 33, was discovered in 1995: Officials ordered for an area of 1000 square meters under a planned expressway to be systematically searched with excavators, as is common practice before large-scale construction projects in France. The workers hit upon a cemetery with 32 graves and 33 bodies. The remains were buried deep in the ground and were thus undamaged. Brather-Walter sees this find as a stroke of luck: “The cemetery in Niedernai is the only complete and largely undamaged necropolis from the second half of the fifth century to be excavated in modern times – not only in Alsace but in the entire broader region.”

A significant change took place in the second half of the fifth century: the transition from antiquity to the Middle Ages. The transformation of the Western Roman Empire led to various early medieval successor states. The cause was not migration, although this time was indeed characterized by great mobility. It is therefore of great interest who was buried in Niedernai, which was under Roman rule at the time: Was it a cemetery for Germanic immigrants, for the local Roman population, or for members of the Roman military, regardless of their ethnic affiliation? The main question the research team is attempting to answer is whether the fundamental cultural changes identifiable in the archaeological material were caused by immigration from eastern territories or whether they can also be explained by a cultural reorientation of the previously Roman population.

### Genetic Information, Bones, and Teeth

In the search for answers to this question, says Brather-Walter, the work of her colleagues from the life sciences is essential: The first thing to clarify is whether the people buried in the cemetery were biologically related. Since the burial ground was used for around 70 years, it might be possible to reveal parent-child relationships. The previous analyses of ancient DNA, referred to as aDNA for short, provided no indications that the people were closely related in the sense that they came from an extended

family. The final results should be available by the end of 2015. Then the archaeologists will be able to begin their interpretational work.

In order to find out when the graves were dug, the researchers begin by analyzing the objects found in the graves. This allows a stylistic dating. To include graves without burial offerings in the analysis, they determine the time of burial by conducting radiocarbon dating on the bones. This method also has an important control function, says Brather-Walter: The dating doesn't just reveal the time at which the graves were dug but also whether their assumption is correct that the burial offerings date from the time around 500.

Studies of isotopes, such as oxygen, nitrogen, and carbon analysis, provide answers to the key question of where the people buried in the cemetery came from. They allow inferences about their diet and thus indirectly about their social position. In addition, the isotopes can reveal whether a person's diet changed in the course of their life. The analyses involve taking bone and tooth samples. Much like the growth rings of a tree trunk, teeth grow in layers. With samples from ten layers per tooth, the scientists can compile a personal nutritional profile for each of the people – a task they have just begun to tackle. If the profiles show changes, they could stem either from a change of diet or indicate that the person moved to Niedernai from a region with other soil conditions. "A Roman soldier who grew up on the Mediterranean coast can be identified by childhood tooth rings with isotope conditions pointing to a diet of seafood," explains Brather-Walter. However, it is not easy to interpret the results of the analyses: If Niedernai received grain shipments from other regions, the isotopes will correspond to those of a person who lived elsewhere.

"The Rhine was not a border around the year 500."

*Skeleton of a child aged approximately seven years with an axe: This grave is one of 32 found at the cemetery of Niedernai.*
*Photo: Marianne Zehnacker*

### A Folding Chair Indicates Social Status

It is nearly impossible to determine where the woman from grave 33 was born and what regions she lived in before dying in Niedernai. Thanks to the numerous burial offerings in the grave, however, it is clear that she enjoyed an elevated social status: They include hairpins set with red semiprecious stones, a ring and chain, two brooch pairs to close her gown, a quartz amulet, a bangle with an amber pendant, and a knife with a decorated leather sheath. Also buried in the grave was a folding chair – very unusual, explains Brather-Walter: "In Rome, the consuls had folding chairs as an insignia of their office. The objects found in this grave thus underscore the status of the woman buried in it, as contemporaries were conscious of the social significance of sitting." The semiprecious stones on the jewelry likely come from India; they will soon be analyzed at the Louvre Museum in Paris. The textile analysis will be another focus of the project in 2015. "Grave 33 is symbolic of the upheaval and representative of the beginning of the sixth century," says the archaeologist. "In addition, we can visualize the fashions of the times not only with regard to diet but also clothing thanks to the textile analyses."

The results of the project have already led to two important findings. First, "the Rhine was not a border around the year 500," stresses Brather-Walter. Rather, the High and Upper Rhine formed a culturally related region together with the Alsace. Second, the cooperation between the archaeologists, historians, and natural scientists works great. "It makes the research so much more interesting for all of us," confirms Brather: "Niedernai has been a stroke of luck for us."

*www.pr.uni-freiburg.de/go/niedernai*

***Dr. Susanne Brather-Walter*** *studied prehistory and early history, ancient history, and archaeology of the Roman provinces in Munich and Kiel. In 2005 she earned her PhD at the Ludwig-Maximilian University of Munich with a dissertation on the early medieval necropolis of Mengen in the Breisgau-Hochschwarzwald district. She then completed a research traineeship at the State Office for the Preservation of Historical Monuments in Esslingen and headed a German Research Foundation pilot project on the documentation and analysis of early medieval grave finds in Lauchheim with the help of 3D computed tomography. Since 2009 she has conducted research at the Institute of Archaeological Sciences of the University of Freiburg.*

*Photos: Thomas Kunz*

***Prof. Dr. Sebastian Brather*** *studied prehistory and early history, history, and anthropology at the Humboldt University of Berlin. After earning his PhD in 1995 and completing a travel fellowship from the German Archaeological Institute, he served as a research assistant at the University of Freiburg, where he completed his habilitation in 2002 with a thesis on ethnic interpretations in early historical archaeology, and at the Goethe University Frankfurt. He then returned to Freiburg as the holder of a Heisenberg Fellowship from the German Research Foundation. Since 2006 he has served as professor of early historical archaeology and medieval archaeology at the University of Freiburg.*

***Prof. Dr. Eckhard Wirbelauer*** *earned his PhD at the University of Freiburg in 1992 after studying ancient history, Latin, and medieval Latin philology. In 1998 he completed his habilitation thesis, a historical-geographical and source-critical study of the Ionian islands Cephalonia and Ithaca. He subsequently worked as a lecturer in Freiburg. In 2004 he was appointed to a chair at the University of Strasbourg, first as professor of Greek history and since 2006 as professor of Roman history. He is a member of "UMR 7044: Archaeology and Ancient History in the Mediterranean Area (ArchHiMedE)," a joint research unit in Strasbourg and Mulhouse sponsored by national research institutes.*

*Photo: private*

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# Competition of Perception

Photo: Rawpixel/Fotolia

# The psychologist Karl Christoph Klauer wants to identify the patterns behind prejudices

*by Rimma Gerenstein*

Work, work, build a house: The Swabians are thrifty and hardworking. Homeless people, on the other hand, are lazy bums. The Italians, cheerful by nature, enjoy la dolce vita at bunga bunga parties. Africans have rhythm in their blood but aren't very good at fidelity. And women, those emotional, high-strung creatures, fail miserably as managers. Welcome to the deep quagmire of rash judgments and unquestioned beliefs. A depressing place, to be sure. Not for nothing did Marcus Aurelius give the wise advice: "Free yourself from your prejudices and you will be saved."

What the Roman emperor fails to mention in his aphorism, however, is that nobody can avoid prejudices. "They are a big part of our socialization," says Karl Christoph Klauer, professor of social psychology at the University of Freiburg. "We take in prejudices from our parents, teachers, or friends from an early age, whether we like it or not." Thus, whether it is a matter of believing that foreigners are criminals, men are better at driving cars, or vegans are overprivileged health fanatics, prejudices are deeply ingrained in our collective memory. "But that doesn't mean that we are entirely at their mercy and can do nothing to change our knowledge and behavior."

## Thinking in Stereotypes Prevents Information Overload

The psychologist and his team have been studying prejudices for many years, such as those concerning age, gender, or ethnicity – the three most important and frequent social categorizations of human perception. What Klauer is interested in, however, is not the content of particular prejudices but the patterns behind them. We all reveal a glut of information about ourselves every moment of our lives – how old we are, what country we are from, how high our social status is likely to be, whether we might be an interesting person to talk to. "But what determines what enters our consciousness when we see a person? What factors govern the categories in which we think?"

Although prejudices – or rather the people who act in accordance with them – might evoke the image of burly rednecks, researchers know how valuable preconceived thought patterns are for routine information processing. They are

*White against red: In one experiment, the test subjects saw a discussion between two basketball teams with white and black players. The participants didn't base their decisions on the players' skin color but rather on the team they played for.* Photo: Patrick Seeger

*People are often susceptible to prejudice when under pressure. If we chance upon a dangerous-looking figure, most of us cross the street – without reflecting on whether the person might really be dangerous.* Photo: Baschi Bender

indispensible even in seemingly harmless situations: "Imagine you are waiting at the airport or going shopping," says Klauer. "If you had to run through every possible social categorization for every person you came across, it would be too much for you." To avoid breaking down like an overloaded computer, our brains fall back on stereotypes, general assumptions that have proved useful in the past. This economical approach enables us to make quick decisions, identify threats, and fight our way through all the information. "Especially in situations in which we are under pressure, we often fall back on stereotypes without examining them any further." If we chance upon a dangerous-looking figure in disheveled clothes at night, most of us instinctively cross the street. "In situations like this we have no time to examine whether individual details indicate that it could be a nice person."

**Who Says What**

Thus, individuality is what people ignore when they avail themselves of preconceived opinions: Is a man in disheveled clothes necessarily homeless and dangerous, or would gender perhaps play no role at all in another situation? In order to determine what influences our perception, Klauer uses so-called unobtrusive methods. His test subjects initially are not aware that the are participating in a study about prejudices. They see a discussion on a screen, for instance between men and women. Each speaker makes a statement: "The university library's opening hours are very convenient for me." "The administrative burden of studying is enormous." "I'm unhappy with the course offerings." Is this a study on prejudices about running a university?

Actually the topic of the discussion has nothing to do with the experiment. Klauer uses the "who says what" paradigm to test what the test subjects pay attention to. Following the discussion, the team presents the participants several of the statements and asks them to assign them to the person who said them. Not everyone has a photographic memory – and that is what Klauer is counting on. When the test subjects make a false match, they usually still choose someone from the right category, in this case "man" or "woman." In other words, we evidently take into account a person's gender when processing a statement, even if the topic of the discussion is not gender differences but the opening hours of a library.

The "who says what" paradigm also shows how memory works, explains the researcher. Occasionally his team gives the test subjects statements that weren't included in the experiment. These statements have no match, but the participants of the study still have to assign a speaker to them. "In these instances another function of prejudices comes into effect, namely the reconstructive filling of memory gaps. When people can't remember something, they fall back

> "When people can't remember something, they fall back on stereotypical expectations."

***Prof. Dr. Karl Christoph Klauer***
*studied mathematics and psychology at RWTH Aachen University. In 1988 he submitted his dissertation on attitudes to the University of Hamburg. Five years later he completed his habilitation thesis on problem solving at the Free University of Berlin. Following stints in Heidelberg and Bonn, he accepted an appointment to the chair of social psychology and methodology in Freiburg in 2004. His research interests include social cognition, mathematic modeling, and cognitive psychology.*
*Photo: Patrick Seeger*

on stereotypical expectations. They rely on general knowledge about their culture and society." In a discussion on gender roles, the participants tended to assign feminist statements ("I approve of women who start work again quickly after having a child.") to women and more conservative statements ("Married men shouldn't iron their shirts themselves.") to men.

**Basketball Players and Enemy Gangs**

Klauer's experiments suggest that the prevailing circumstances play an important role in directing our attention. When social categorizations are at odds with what a person perceives, it is crucial how well a categorization fits a particular situation, explains the psychologist. He succeeded in demonstrating that even a monumental category like ethnicity does not inevitably have to be a decisive factor. "And yet we think of this categorization as being as present as one's own first name." In this experiment the team again used the "who says what" paradigm: The test subjects saw a discussion between two basketball teams with white and black players. The participants didn't assign the statements to players on the basis of their skin color but rather the team they played for.

At first glance, the results seem to correspond to a common theory from evolutionary psychology according to which ethnicity is only a crutch. When test subjects are offered alliances and coalitions as a social categorization, aspects like skin color are relegated to the background. Klauer conducted an experiment to test this theory and expand on it: He presented his test subjects with a discussion between white and black inmates of two prisons. All of the inmates were familiar with the conditions in both of the institutions and exchanged opinions on them. "But alliances were out of the question. We told the test subjects that all of the inmates were enemies of one another."

The results of this study were clear as well: The test subjects did not take into account skin color but the prison the inmate was incarcerated at. The team used the same method to test the category of gender. "We therefore suspect that this structure could be a general law," explains Klauer. "When we combine a strong and a weak category, the strong one suffers if the context highlights the weak one. This applies even with unfamiliar categories like what prison an inmate is kept at."

In situations like examinations, job interviews, police interrogations, or court verdicts, prejudiced decision makers can cause a lot of damage. However, "when one knows how prejudices work and when to look out for them, they are easier to prevent," says Klauer. This conviction makes him optimistic about the results of the studies. After all, many proven methods for fighting racism or sexism proceed according to the same principle: When people in a group are working on a project together, their common task becomes the main focus of attention – differences in skin color and gender become less important.

*www.psychologie.uni-freiburg.de/Members/klauer*

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# One Fungus, Two Uses

Sabine Sané wants to use the tree parasite *Trametes versicolor* to break down pollutants in waste water – and to produce electricity at the same time

*by Thomas Goebel*

*The fungus* Tramates versicolor *produces an enzyme that breaks down wood. This property could be useful in waste water treatment plants.* Photo: mdennah/Fotolia

*Like mold on fruit juice: The fungus can be cultivated on a liquid culture medium.*

*Photo: IMTEK*

"There are currently two challenges to purifying waste water: the great amount of energy involved and micropollutants," says Sabine Sané. The doctoral candidate at the Department of Microsystems Engineering (IMTEK) of the University of Freiburg has thus come up with a method for breaking down waste water pollutants that could previously only be removed with great difficulty and could potentially alter the ecosystem – and at the same time her method can be used to generate energy.

The astounding thing about Sané's idea is that she wants to achieve both of these goals with the help of the same bracket fungus, *Trametes versicolor*. It produces a versatile enzyme that is capable of breaking down micropollutants. At the same time, it can help a so-called biofuel cell to produce electricity in the waste water. "It actually seems too good to be true," finds the biologist. "The project is still in its infancy – but I think it really will be possible to make the idea work." As one of four researchers to win the international "Future Water" prize in July 2014, Sané has now received the opportunity to implement her idea. Awarded by the Huber Technology Foundation, the prize is worth a total of 10,000 euros.

So-called micropollutants are characterized by the fact that they only appear in very small dosages. "But that doesn't mean they're harmless," warns Sané. When they are not broken down in water and manage to spread through the environment, they can damage animals and plants that live in the water – and thus pose a threat to the aquatic ecosystem.

"Up until fairly recently we didn't know exactly what substances are present in waste water," reports Sané. Thanks to better detection techniques, however, it is now possible to detect pollutants even in very low concentrations. In the future, this will probably lead to stricter regulations for this area. The hazardous substances can even make their way into tap water, says Sané, although she doesn't yet see any acute danger for humans.

"The project is still in its infancy – but I think it really will be possible to make the idea work."

Estrogen from birth control pills, for instance, which is excreted in urine, thus making its way into our waste water, can cause gender changes or infertility in fish. Other harmful substances excreted in urine include antibiotics, substances from painkillers, and contrast media for medical imaging. Ointments for soothing pulled muscles or bruises enter into our waste water when we

shower, and waste water even contains residue from pesticides.

The bacteria used to clean up waste water at conventional treatment plants are often unable to remove these pollutants: “They are persistent against bacteria and are still present in more or less the same amounts when the water leaves the plant.” The plants thus try to remove the pollutants from the water using activated carbon, which has the disadvantage of being difficult to dispose of, or they destroy them with the help of ozone, although the danger posed by the degradation products created with this method is not yet clear. “These two methods are not very environmentally friendly, have not yet been perfected, and are not particularly cost-effective either.”

> “At one point it struck me that this was an opportunity to kill two birds with one stone.”

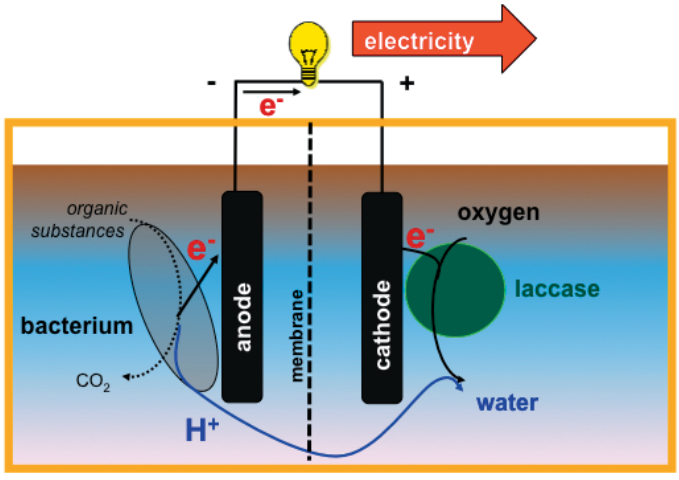
**Helpful Parasite**

This is where *Trametes versicolor* comes in. The fungus is very common in European forests and grows primarily on European beech trees. It produces a constant supply of laccase. “This enzyme actually degrades wood,” says Sané – especially the wood component lignin. In this way, the fungus sustains itself as a tree parasite. The enzyme is adapted perfectly to the complex structure of wood: The fungus can oxidize many substances and break them down into their constituent parts. It can also break down micropollutants.

Sané came up with the idea of exploiting this ability to purify waste water in treatment plants while working on her doctoral dissertation under Prof. Dr. Roland Zengerle at the Laboratory for MEMS Applications. In the “Bioelectrochemical Systems” research group, led by Dr. Sven Kerzenmacher, she initially set her sights on an entirely different potential area of application for *Trametes versicolor* and its enzyme: improving biofuel cells that can be powered in waste water and produce energy for water treatment plants.

In order for electricity to be produced, electrons need to travel from one pole, the anode, to the other, the cathode (see illustration below). In the case of a biofuel cell in waste water, bacteria already living there build up at the anode: “They form a really thick layer.” While breaking down organic matter found in the water, the bacteria use the anode instead of oxygen to “breathe” – meaning that there is no need to expend any energy oxygenating them and that they can transfer their electrons to the anode. The electrons then migrate to the cathode, where the laccase works as a catalyst, conveying the electrons to the oxygen as they arrive. “The enzymes are so catalytic that there is no need to use precious metals like platinum.”

**Biofuel Cell**




***How a biofuel cell works***

*Bacteria build up at the negative pole, the anode. They break down organic substances and form carbon dioxide ($CO^2$). In the process, electrons ($e^-$) and protons ($H^+$) are emitted. The positively charged protons pass through a membrane directly to the cathode, the positive pole. The negatively charged electrons migrate there too over an external circuit, thus producing electricity. At the cathode they reduce oxygen, which then fuses with the proteins to create water. The enzyme laccase, which is produced by* Trametes versicolor, *supports this reaction as a catalyst.*

*Grafik: Sabine Sané*

*Waste water plants need a lot of energy, and conventional methods for removing micropollutants from waste water are expensive, not very environmentally friendly, and not fully developed.*
*Photo: Thomas Leiss/Fotolia*

In the course of her work, Sané came to the conclusion that it is unnecessary to go through the difficult process of isolating the enzymes before they are passed on to the cathode. It is enough to cultivate the fungus on a liquid culture medium – like waste water. The fungus forms a layer over the water, similar to mold on fruit juice, and supplies the liquid continually with new laccase and further enzymes. The enriched liquid can then be passed on directly to the cathode.

**Biofuel Cell and Waste Water Treatment Plant**

"At one point it struck me that this was an opportunity to kill two birds with one stone," says Sané: Why shouldn't it be possible to use the enzymes the fungus was producing anyway to break down micropollutants? The reason why she was immediately fascinated by this thought, Sané suspects, is perhaps because its scientific roots do not lie in one of the technical fields but in biology, or more precisely ecology.

Together with her research group leader, she came up with the idea of combining the biofuel cell and the degradation of micropollutants in waste water as a follow-up project after completing her dissertation. Sané plans to complete her dissertation in spring 2015. She already has the results. At the moment she is applying for external funding for the project – and hoping that the prize she won for the idea will be helpful in this endeavor.

"The first thing to do will be to conduct fundamental research in the lab," says Sané, for example to determine the best place and time in the various processes involved in a combined waste water treatment and biofuel cell plant to cultivate the fungus, the precise enzyme mix it gives off, and the effects this mix produces. "We haven't yet put the components together." Another important question to answer is what happens when the enzymes of the tree fungus break down micropollutants: Are the resulting degradation products indeed less hazardous? And can bacteria perhaps simply break down the substances created in this process further?

Sabine Sané hopes that at some point her idea really will be implemented in technically polished and energy-efficient waste water treatment plants. She is open to cooperation with industrial partners – even though there is quite a lot to do before that point is reached: "A project partner will of course need to see a lot more data than is currently available to decide whether such an idea can indeed be put into practice."

*www.pr.uni-freiburg.de/go/sabine-sane*

***Sabine Sané***
*studied biology in Freiburg. For her diplom thesis in 2007, she cooperated with the German Primate Center (DPZ) in Göttingen. The thesis dealt with group coordination in baboons in South Africa. She then worked for the DPZ in Senegal, among other places, and at the Max Planck Institute of Immunobiology and Epigenetics in Freiburg. In January 2010 she began research for her doctoral dissertation in the "Bioelectrochemical Systems" research group at the Department of Microsystems Engineering (IMTEK) of the University of Freiburg. Her research interests include new concepts for extending the life of enzymatic biofuel cells.*
*Photo: Johannes Erben*

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# Research with Consequences

Silja Vöneky is studying how ethical standards are written into law and whether they are permissible, particularly with regard to biosecurity concerns

*by Mathilde Bessert-Nettelbeck*

*Life-saving vaccine or highly contagious virus? For some research projects in the life sciences, the risks are just as high as the potential benefits.*
*Photo: stockasso/Fotolia*

*Leave it to parliament: The German Ethics Council has recommended allowing lawmakers to determine which research should be regarded as especially dangerous and to appoint an expert commission to assess experiments with biosecurity risks.*

*Photo: German Parliament/Thomas Trutschel/photothek.net*

Researchers are working to develop a vaccine against the Ebola virus, which has recently claimed more than 7000 lives in West Africa. They modify the pathogen, giving it the ability to enter into the human body over the air. Shortly afterwards a terrorist organization breaks into the lab, steals the modified virus, and makes it into a weapon of mass destruction. This might be a fictitious scenario, but it demonstrates a very real risk of conducting free research in a globalized, connected world. However, free research can also lead to great scientific advancements, such as the development of vaccines that save human lives. But who is responsible for deciding, before a potentially dangerous experiment is published or even conducted, whether the possible benefit to science is worth the risk? Who answers the question: "Should this be allowed?"

"Allowed" can mean legal, but it can also be understood in the sense of morally grounded or ethically justified. There's no clear-cut dividing line, says Prof. Dr. Silja Vöneky. The University of Freiburg law professor is using the example of biosecurity to study the role of ethical standards in law. Biosecurity is defined by moral philosophers and legal experts as the risk that research findings from the life sciences become subject to misuse for criminal purposes. The related area of biosafety has to do with laboratory safety.

However, it is not the courts but rather research funding organizations, scientific organizations, and scientists that decide whether potentially dangerous research receives funding and is actually conducted. "They develop non-legislative regulations in the form of ethical standards and are applying them increasingly to promote self-regulation in research involving potential biosecurity risks. This tendency might be described as an ethicalization of law," explains Vöneky.

**Ethics, Law, and Morals**

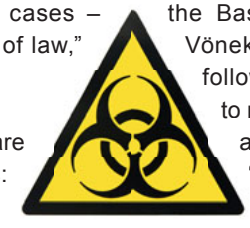
From a legal perspective, the Ebola researcher would consider whether he were committing a criminal offense by conducting his experiments. "The Biological Weapons Convention of 1972 prohibits the production or storage of biological weapons. Research on viruses for non-peaceful purposes is prohibited," says Vöneky. However, she adds, "the agreement does not regulate the risk of misuse of research for peaceful scientific purposes, such as the production of vaccines." Other regulations, including the German Law on Genetic Engineering, only cover questions of biosafety. At a high-security lab, research on the Ebola virus is legal.

Nevertheless, researchers are responsible for their own experiments and will ask themselves whether their actions contradict their morals or ethical principles. The moral perspective, for example, can be formulated like this: Would my fellow citizens or my own friends approve of or condemn this action? Moral philosophers, on the other hand, test moral principles and consider carefully which norms should be applied in the case of conflict: For example, research on the Ebola virus could endanger human lives but would still be ethically justified if it were the only way to develop a vaccine capable of overcoming the disease and thus save many lives.

Vöneky endeavors to determine where ethical standards work together with law. She tests

whether and to what extent practices are permissible under German and European law as well as international law. In civil law, criminal law, and public law, moral and ethical standards come into play by way of flexibility clauses, where they refer to customs and morality. Legal provisions also contain references to ethical guidelines drawn up by specific professional groups – for instance in international law or in bylaws. “In the case of experiments on humans or stem-cell research, ethics commissions have also been constituted on a legal basis to rule on ethical issues in concrete individual cases – another example of the ethicalization of law,” Vöneky explains.

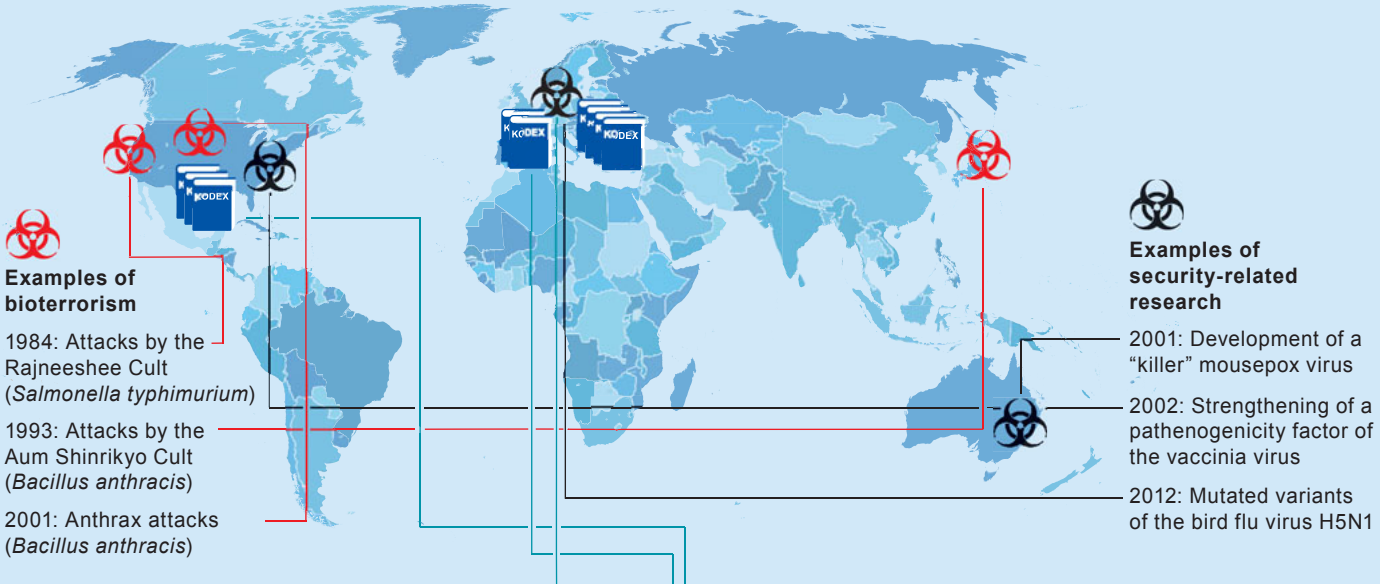
Increasingly, new ethical guidelines are also being established for researchers: The Max Planck Society – and in 2014 also the German Research Foundation and the German National Academy of Sciences – has set down codes of practice for responsible risk management in research. “Although these codes are not legally binding, they can become legally relevant in decisions on awarding research funding and in questions of liability. The key factor is how they are implemented,” explains Vöneky, who helped draft the code for Max Planck.



The governing bodies and codes encroach on the freedom of research – a right guaranteed in the Basic Law, Germany’s constitution. For Vöneky, the key question is therefore the following: At what point do lawmakers need to rule on what research should be allowed and whether it should be approved? “The Federal Constitutional Court resolved that the legislative branch of

## Biosecurity Worldwide

*Illustration: Kathrin Jachman, Mathilde Bessert-Nettelbeck; Map: Ekler/Fotolia*




**Examples of bioterrorism**

1984: Attacks by the Rajneeshee Cult (*Salmonella typhimurium*)

1993: Attacks by the Aum Shinrikyo Cult (*Bacillus anthracis*)

2001: Anthrax attacks (*Bacillus anthracis*)

**Examples of security-related research**

2001: Development of a “killer” mousepox virus

2002: Strengthening of a pathenogenicity factor of the vaccinia virus

2012: Mutated variants of the bird flu virus H5N1

**Examples of guidelines and rules on biosecurity**

KODEX

***Germany***
*2008/2014: German Research Foundation*
*2008: BIO Deutschland*
*2010: Max Planck Society*
*2012: Leibniz Association*
*2013: Robert Koch Institute*
*2014: German Ethics Council*

*2010: World Health Organization*
*2009: International Gene Synthesis Consortium*
*2007: National Science Advisory Board for Biosecurity*
*2012: United States Government Policies*
*2007: Royal Netherlands Academy of Arts and Sciences*

*Source: German Ethics Council (2014) (Ed.): Biosecurity – Freedom and Responsibility of Research; University of Freiburg, Institute of Public Law, Department 2 (International Law and Comparative Law).*

the government should regulate the most important issues concerning basic rights. This means that scientists cannot decide alone when to refrain from conducting research on a particular topic in order to protect public health." Vöneky argues that internal codes can be used to sensitize scientists to the potential for misuse of research. These standards can also be put in place faster than a law. The governing bodies of science organizations and universities can implement these codes. In Freiburg scientists ask the ethics commission of the University Medical Center when they need approval for research funding proposals. "But in particular cases of high-risk research, only a legally constituted national or European commission can ensure with its votes that the risk–benefit analysis is democratically legitimate and that the decision is reached on the basis of uniform criteria."

> "The Federal Constitutional Court resolved that the legislative branch of the government should regulate the most important issues concerning basic rights."

**Commissions Prevent Rejections**

By asking a commission of this kind to examine research with a high potential for misuse beforehand and evaluate the findings, says Vöneky, researchers can avoid situations in which their research is rejected, as after the H5N1 experiments in 2012. Two research groups from the USA and the Netherlands had modified H5N1 viruses, the cause of the so-called bird flu, in the lab in order to learn more in advance about the natural mutations. The modified virus turned out to allow airborne transmission between mammals. The scientists argued that their research had been justified since the benefit outweighed the risks. However, their findings led to a moratorium on experiments of this kind and to demands for a ban on funding and publication of findings. Such measures are still being considered for similar cases today. A legally constituted national commission could ensure that only high-risk research whose findings can be published is eligible to receive public funding.

In summer 2012 the German Parliament commissioned the German Ethics Council to prepare a statement on biosecurity and freedom of research. A working group headed by Vöneky recommended combining the two regulation models: A biosecurity code will minimize the biosecurity risks of research in the scientific community, while a nationwide interdisciplinary expert commission will assess experiments with particular relevance for security. Lawmakers will determine which research should be regarded as especially dangerous and who will sit on the commission. "Since everyone would be affected if a dangerous virus fell into the wrong hands, not just the researchers, the democratically elected representatives in parliament should make all fundamental decisions on how to minimize the security risks of this research."

*www.jura.uni-freiburg.de/institute/ioeffr2/silja-voeneky*

***Prof. Dr. Silja Vöneky*** *has served since 2010 as professor of public law, international law, comparative law, and legal ethics at the University of Freiburg. In 2009 she completed her habilitation at the University of Heidelberg with a thesis on the foundations and limits of democratic legitimation for ethics commissions. From 2005 to 2011 she headed the research group "Democratic Legitimation of Ethical Decisions – Ethics and Law in Biotechnology and Modern Medicine" at the Max Planck Institute for Comparative Public Law and International Law in Heidelberg. Since 2012 she has served on the board of directors of the Network of Excellence for the Law of Civil Security in Europe (KORSE) at the University of Freiburg. In 2012 the German federal government appointed her to the German Ethics Council.*

*Photo: German Ethics Council*

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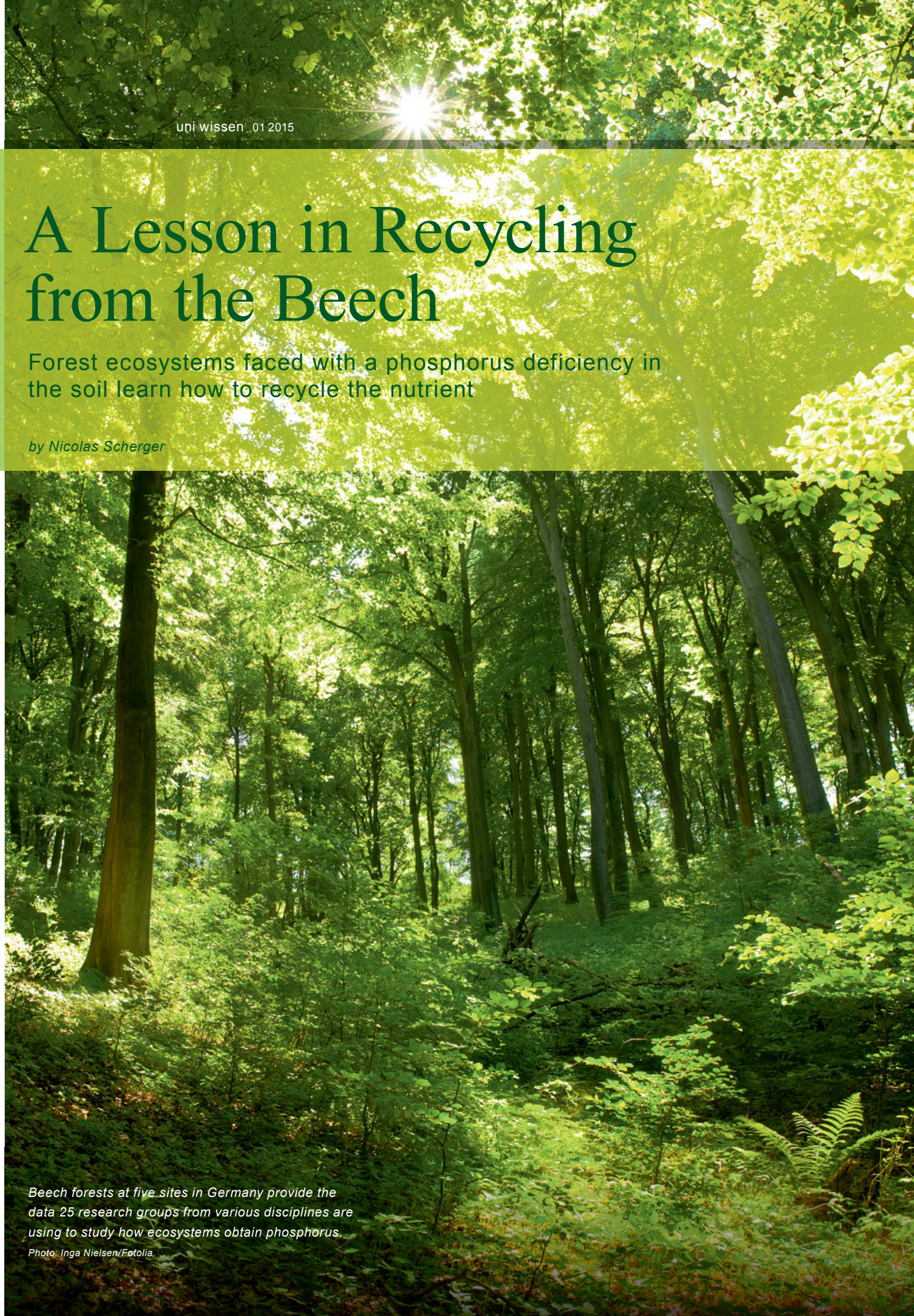
Videos from a symposium on the risk of misuse in the life sciences at the University of Freiburg (2014) (in German): www.pr.uni-freiburg.de/go/symposium-missbrauchsrisiko

Read more about Silja Vöneky's research in "Control over One's Own Genes" on our research portal Surprising Science: www.pr.uni-freiburg.de/go/hoheit-gen

# A Lesson in Recycling from the Beech

## Forest ecosystems faced with a phosphorus deficiency in the soil learn how to recycle the nutrient

*by Nicolas Scherger*



*Beech forests at five sites in Germany provide the data 25 research groups from various disciplines are using to study how ecosystems obtain phosphorus.*
*Photo: Inga Nielsen/Fotolia*

Phosphorus is an essential nutrient for plants. It helps them to produce adenosine triphosphate, ATP for short, during photosynthesis as a source of energy for their cells. They make it available by releasing acids that disintegrate phosphoric rock grate from their roots. But at the same time another process takes place: Phosphorus is washed out of the soil with the rainwater and flows down streams and rivers to the sea. In this way, the supply of phosphorus is depleted in the long run in many continental ecosystems across the world. The plants need to find a way to reuse the nutrient before it is lost. "We are testing the hypothesis that forest ecosystems in phosphorus-poor locations have developed an especially efficient recycling system to compensate for the deficiency," says Prof. Dr. Friederike Lang. The University of Freiburg soil ecologist is director of the German Research Foundation priority program "Ecosystem Nutrition: Forest Strategies for Limited Phosphorus Resources," which began work at the end of 2013.

**Leaves, Detritus, and Dead Plants**

Rock isn't the only source of phosphorus for the ecosystems. The nutrient is also present in leaves, detritus, and dead plants – the layer of humus above the mineral soil. The researchers hypothesize that this organic material becomes more and more important over time as a repository for phosphorus. "Ecosystems in locations with phosphorus-rich soil evidently have the initial strategy of obtaining as much as possible from the mineral reserve. Since there is enough available, they don't need to recycle anything, and the losses are great," explains Lang. If the symbiotic community behaves like this over thousands of years, however, the soil ends up losing nutrients. "Then the plants begin to organize a closed nutrient cycle: They take in phosphorus from the organic material and see to it that as little as possible is washed out."

The scientists are doing research at five sites in Germany at which forest research institutes have been studying nutrient flow for almost 30 years. The sites are similar in many respects: They have the same rocks and the same acidic soil, they are at roughly the same altitude, and the predominant tree species in all of them is the beech. However, the phosphorus content in the mineral soil decreases from site to site. That of the richest and the poorest differ by a factor of 40. "This approach makes the results comparable over a long period of time and allows us to draw inferences on how plants react when more or less phosphorus is available," says Jaane Krüger, the University of Freiburg research assistant coordinating the program.

**Help from Microorganisms and Fungi**

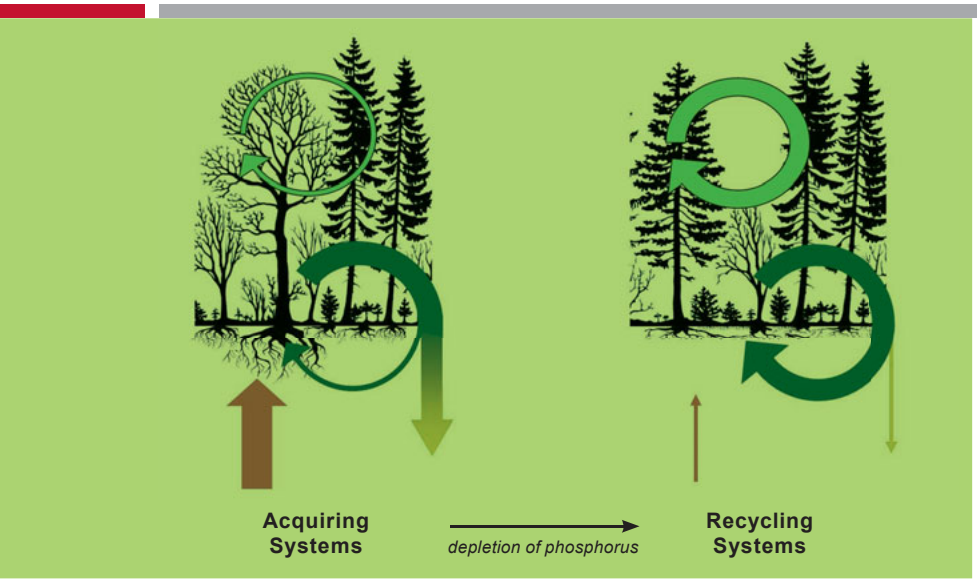
What is clear is that the trees succeed in obtaining enough phosphorus, even at the sites where less is available: The amount in leaves and needles is the same everywhere thanks to microorganisms and so-called mycorrhizal fungi. They decompose dead organic material, thus making the phosphorus available to the plants. The microorganisms release the nutrient into the soil, where it can be absorbed by roots. Mycorrhizal fungi, on the other hand, cover the tips of the roots with a thick network of filaments, supply the plants directly with phosphorus, and receive sugar from them in return.

So is the hypothesis on the different behaviors of forest ecosystems correct, and what precisely

*Roots, humus, rocks, and particles of various sizes: Friederike Lang's team is providing all research groups participating in the program with soil samples.*
*Photo: Thomas Kunz*

*The main hypothesis of the research program: As long as the soil contains a lot of phosphorus, forest ecosystems obtain most their supply from this mineral reserve. Most of the phosphorus from leaves, detritus, and dead plants is not reused and is therefore lost (left). In the long term, the supply of the nutrient in the soil is depleted. Then ecosystems change their strategy and recycle phosphorus from dead organic material. This leads to a closed cycle.* Illustration: Department of Soil Ecology






stimulates them to change their strategy? A total of 25 groups from soil science, forest science, microbiology, plant science, hydrology, and earth sciences are working together in the program to find out – six of them at the Faculty of Environment and Natural Resources of the University of Freiburg. Lang's team is studying the soil structure: Particles in the soil accumulate to form aggregates. Roots play a major role in this process. How this benefits the plant is not yet clear. "We believe it is important how phosphorus is distributed in these aggregates," says Lang. If the nutrient is on the surface the roots have an easier time absorbing it, but if it is inside it is better protected from being washed away.

"We want to determine which components and interactions of an ecosystem enable a closed phosphorus cycle."

The team is planning on studying the distribution of phosphorus in the aggregates later on. Up to now they have concentrated their efforts on measuring the size of the balls of particles at the five sites. It has become evident that the aggregates at the phosphorus-poor sites are smaller and more stable. A possible explanation for this is that nutrients from the humus layer released by microorganisms seep through pores that form between the aggregates. If fine roots enclose an aggregate, the plant can easily access the nutrients. "The flow of nutrients is greater in some of the pores, lower in others – just like expressways have more traffic than country roads," says Krüger. Thus, it is possible that the plants direct the flow of nutrients to their own advantage. "But these are new ideas that will have to be proven."

The team is also responsible for preparing the soil samples for the 25 research groups and collecting data that is important for everyone involved in the project. This includes the soil's pH, the amount and distribution of the roots, the proportion of rocks and soil per square meter, and the thickness of the humus layer. "Everyone receives comparable samples that are representative of the individual sites," Krüger stresses. The team will write an interim report after three years and the final report after six – that is also part of their project coordination duties. This will involve filtering the most important findings out of all of the experiments conducted by the groups and combining them into a coherent whole.

**Insight for Forestry and Agriculture**

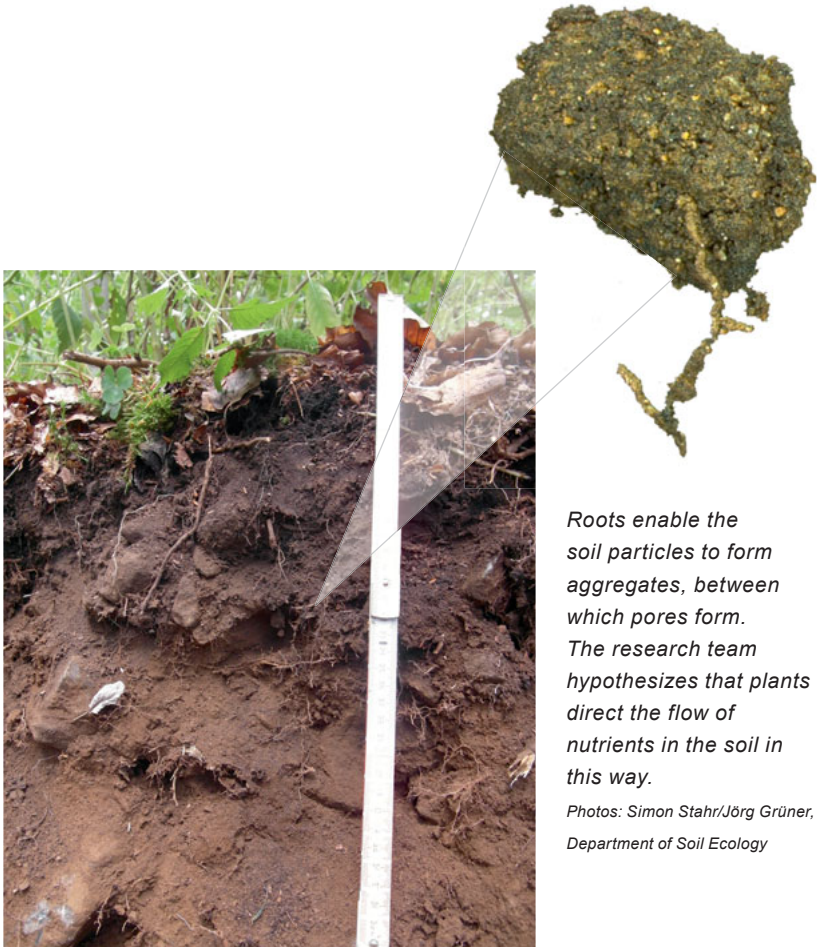
According to the Freiburg scientists, most of the findings from the first year of the project support the central hypothesis. One finding they consider important is that the organic material plays a key role at the sites with a low supply of phosphorus: The less phosphorus the mineral soil of a site contains, the stronger is the humus cover and the thicker the upper layer of roots in the soil below it. "A thick tangle of roots allows the plants to quickly reabsorb the phosphorus released from the humus before any of it is lost," says Krüger. Another finding from the microbiology subprojects took them by surprise: "The researchers found completely different compositions of species of microorganisms at the rich and poor sites," reports Lang. "Now they want to investigate what function the individual species have for the ecosystem."

In the end, the program could lead to new insight for forestry management – for instance with regard to the question of how much biomass can be removed from the forest. "It used to be that only trunks and large branches were interesting, while a large part of the treetop, which contains a lot of phosphorus, was allowed to rot in the forest," says Krüger. Today, by contrast, it has become common – for hauling reasons and to obtain more burnable biomass – to take entire trees, a practice that robs the forest of a lot of phosphorus. Scattering the ashes of the biomass

in the forest after burning is only of limited utility, particularly against the background of nutrient recycling: The phosphorus is then mineral-bound and difficult to access, especially for plants on poor sites that would otherwise obtain it from organic material. In addition, the ecosystem cannot take in large amounts fast enough and some of the nutrients are washed away again. Biomass allowed to rot in the forest, on the other hand, decomposes slowly – the nutrients are released and absorbed simultaneously. It thus seems questionable whether the full-tree harvest method is sustainable and ecologically prudent.

The team also hopes the findings of the project will prove useful for agriculture: "We want to determine which components and interactions of an ecosystem enable a closed phosphorus cycle," says Lang. "If it were possible to transfer recycling strategies to agricultural land, we could save a lot of phosphorus fertilizer in the future – and at the same time we could avoid an environmentally harmful loss of phosphorus on agricultural land."

www.ecosystem-nutrition.uni-freiburg.de



*Roots enable the soil particles to form aggregates, between which pores form. The research team hypothesizes that plants direct the flow of nutrients in the soil in this way.*

*Photos: Simon Stahr/Jörg Grüner, Department of Soil Ecology*

***Prof. Dr. Friederike Lang*** *studied earth ecology at the University of Bayreuth, earned her PhD in Hohenheim, and completed her habilitation at the Technical University of Berlin in 2009. She then conducted research there on a Heisenberg Fellowship, before being appointed to the chair of soil ecology in Freiburg. Her research group studies forest nutrition, gas exchange in forest soil, the ecology of soil structure, mineral-organic interactions in soil, soil conservation, and mechanized forestry management – with an emphasis on the sustainable use of soils and forests. She is director of the priority program "Ecosystem Nutrition: Forest Strategies for Limited Phosphorus Resources," vice president of the German Soil Science Society, and a member of the German government's scientific advisory board on forest policy.*

***Jaane Krüger*** *studied technical environmental protection at the Technical University of Berlin. After completing her degree in 2007, she stayed on in Berlin as a research assistant in soil science. Since 2012 she has served as a research assistant at the Department of Soil Ecology of the University of Freiburg. Her research interests include the binding and mobility of nutrients and pollutants in soil. She coordinates the priority program "Ecosystem Nutrition: Forest Strategies for Limited Phosphorus Resources" and is writing a dissertation on organic pollutants and microaggregates in soil.*

*Photos: Thomas Kunz*

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*Secure area, trained staff: In the lab at the Freiburg Materials Research Center, scientists can conduct experiments with fluorine concentrations of up to 100 percent.*
*Photo: Sandra Meyndt*

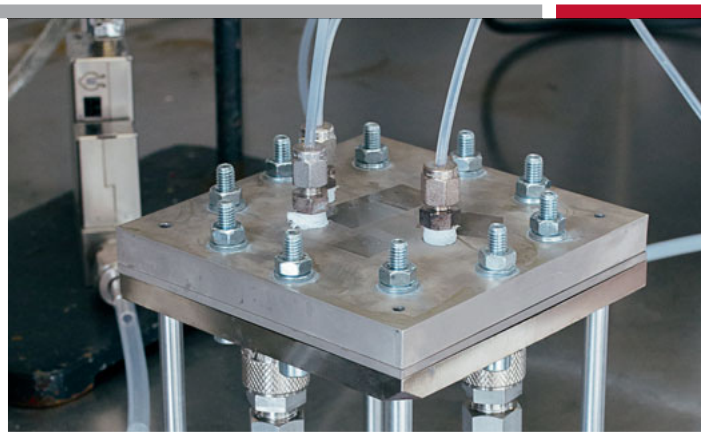
# Element with a Hot Temper

## Fluorine reacts with nearly every other substance – and gives many of them useful new properties

*by Jürgen Schickinger*

All most people think of when they hear the word fluorine are toothpaste, propellants, and air conditioners. For Prof. Dr. Ingo Krossing, on the other hand, director of the Institute of Inorganic and Analytical Chemistry of the University of Freiburg, fluorine is very interesting: “When we introduce the element to chemical systems, we can dramatically change and control its properties.” Fluorine is also found in batteries, non-stick coatings, fuel cells, dyes, liquid crystals, blood substitutes, and in every second agent approved for use in medicine. Krossing wants to develop new fluorine compounds to enhance the performance of batteries. Other fluorine-containing substances he is working on could potentially improve industrial production processes and make them more environmentally friendly.

All the same, Krossing sees himself as a fundamental researcher. A board member of the Fluorochemical Working Group at the German Chemical Society, he aims to determine causes,



*This new minireactor makes it possible for scientists to introduce fluorine to organic compounds. The next step in miniaturization will be the microreactor – a chip currently under development in Freiburg.*

analyze the mechanisms behind chemical reactions, and break new ground in chemistry. “But it’s not enough to just publish such findings. We need to see to it that they are used.” He has been particularly successful finding a balance between fundamental research and industrial application in his research on weakly coordinating anions. His “outstanding achievements in synthesis and application” earned him the Otto Klung–Weberbank Award. Krossing’s findings on anions are on the one hand so fundamental that they now have a place in chemistry textbooks, while on the other hand they have the potential to greatly improve the concrete inner workings of batteries for hybrid vehicles, mobile phones, and table computers. “We are working on developing even better conductive salts and additives,” says Krossing, who has established a battery laboratory for this purpose in cooperation with the chemical company BASF.

**Coating Anions with Teflon**

Salts are composed of ions. This is what chemists call electrically charged atoms or molecules. Anions are always negatively charged: They have more electrons, which carry a negative charge. Cations, on the other hand, have a positive charge, because they are missing electrons. Both types of ion are released when salt crystals break up. Conventional salts like table salt need a solvent – in most cases water – and often energy for this to happen: The salt withdraws heat from the water as it dissolves. But modern salts do not need a solvent, and they also need less energy. Their crystal lattice structure often breaks on its own at room temperature. The salts take on a liquid form and are then referred to as ionic liquids. This is what Krossing is focusing on: “In our standard anions, 36 of the 57 atoms are fluorine atoms.”

## “Fluorine is the most reactive element around.”

There is a reason for this. Ionic liquids are electrolytes, which means that they can conduct electricity. When batteries produce electricity, anions on the positive pole give off a charge in the form of electrons. To even out the charge again, one cation needs to migrate to the negative pole each time an electron is released. “This movement slows down the process,” explains Krossing. In the course of their migration through the ionic liquid, the cations constantly encounter anions. The oppositely charged particles are attracted to each other like magnets. The cations keep getting “stuck” and thus take a long time to reach the other pole. “The trick is to keep this interaction to a minimum,” explains Krossing. To this end, he covered anions with a coat of fluorine-rich polytetrafluorethylene, more commonly known as Teflon. This reduces the negative charge. The anions become weakly coordinated and less “sticky” for cations.

**Making Predictions on the Computer**

However, conductive salts need to do more than just conduct electricity. Automotive batteries reach temperatures of up to 80 degrees Celsius when a car is left out in the sun. “Many standard electrolytes can only stand temperatures of 50 to 60 degrees,” says Krossing. When his team of 30 researchers develops new connections, they begin by running a computer simulation to find out what will happen when they add fluorine to a substance. “Computer chemistry enables us to predict which direction the properties will take.” More than 90 percent of the prognoses on viscosity, conductivity, density, melting point, and other parameters are correct. The scientists still need to conduct real experiments to remove any remaining uncertainties in the end, but many less than previously. This reduces the time needed to conduct the research, the cost of chemicals, and the amount of waste, which works to the benefit of the researchers, the budget, and nature in equal measure: One of Krossing’s cooperation partners is the German Environmental Foundation.

Krossing has set up a special fluorine laboratory at his institute to conduct experiments with fluorine concentrations of up to 100 percent. The security area is only accessible to members of his team who have been trained to handle the


*Fluorine is a very versatile element: It is found in batteries, toothpaste, and every second agent approved for use in medicine.*
*Photo: Oleksiy Mark, Dreaming Andy, WoGi, by-studio (all Fotolia)*

versatile yet dangerous element: In its pure form, elementary fluorine gas, it is toxic. The same is true of the highly corrosive compound hydrogen fluoride, known in its aqueous form as hydrofluoric acid. It is created during many reactions involving fluoride compounds. "If you burn a ten-square-centimeter area of your skin with hydrogen fluoride and don't have it treated, you'll be dead within three days," says Krossing. When hydrofluoric acid is used to burn glass, its surface becomes frosted, a method often used on champagne bottles. Other fluorine compounds damage the ozone layer, intensify the greenhouse effect, or release extremely toxic substances as soon as they catch flame. Last but not least, the hot-tempered element is prone to violent reactions. The lab is thus fitted with sensors that set off an optical and acoustic alarm when fluorine or hydrogen fluoride do manage to escape. "We built the fluorine laboratory in accordance with the latest security guidelines," Krossing stresses. Parallel to his work in the lab, he is developing microreactors with Prof. Dr. Peter Woias, professor for the design of microsystems at the University of Freiburg's Department of Microsystems Engineering. Microreactors are two-by-two-centimeter chips with tiny dimples for chemical reactions.

## Industrial Partners

The goal of all the experiments is to create fresh fluorine compounds to increase the life of lithium-ion batteries, better anions and cations, and new initiators and catalysts. The latter initiate or power reactions – in the industrial production of plastics, lubricants, dyes, coatings, and other products. Krossing has improved several such processes and reduced their ecological footprint. His many partners include the chemistry companies Solvay and Merck, the medicine and security technology company Dräger, and IoLiTec, a company founded in the startup laboratory of Freiburg's BioTechPark in 2002 that produces ionic liquids. Krossing is receiving one of the European Research Council's coveted Advanced Grants; the funding will run until 2017. The "protoelectric potential map" he developed with a part of the funding caused a sensation among experts.

In addition, Krossing hopes to discover new fluorination methods – even just for the sake of knowledge. Indeed, his greatest dreams as a researcher are located beyond industrial applications. "I want to transcend chemical boundaries," he says. He envisions entirely new compounds. In a project called "Anti-Salts," which is receiving funding from the German Research Foundation, he plans to coat cations with Teflon for the first time ever. Krossing is eager to achieve what was previously impossible in other areas as well. "Fluorine is the most reactive element around," he says: Nearly all other elements and substances bind with fluorine. The only two that do not are the noble gases helium and neon. Krossing would like to change that. Could this be a Nobel laureate in the making? The prospects are good: Five other winners of the Otto Klung–Weberbank Award ended up receiving the famous phone call from the Nobel Committee.

*http://portal.uni-freiburg.de/molchem/research/f2-lab*

***Prof. Dr. Ingo Krossing***
*has served as director of the Institute of Inorganic and Analytical Chemistry of the University of Freiburg since 2006. Before coming to Freiburg, he conducted research and taught in Canada, Karlsruhe, and Lausanne/Switzerland. He studied chemistry in Munich. He already received scholarships and several awards for his research while completing his doctoral dissertation and habilitation thesis. Krossing is deputy chair of the Wöhler Association for Inorganic Chemistry, has served as scientific director of the Freiburg Academy of Science and Technology (FAST) since 2011, and was a fellow at the Freiburg Institute for Advanced Studies (FRIAS). The main focus of his research is ionic systems including weakly coordinating anions.*
*Photo: Sandra Meyndt*

## Further Reading

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