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1/2007 ▶ A Deep Look into the Aachen Underworld ▶ Great Benefits from the Smallest Particles ▶ The Double Life of a Fungus ▶ The Amazing Diversity of Dialects ▶ Communication in the Network

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In this issue

Tracking Down the Changes in Language

More than 130 years ago, the linguist Georg Wenker started a comprehensive study of the German language in its spoken form. The "Linguistic Atlas of the German Reich" is a comprehensive and precise documentation of the German dialects of the 19th century. Thanks to an acquisition and digitalisation project, these language maps are now available to scientists around the world. **Page 4**

Messages From the Underworld

Using cores and geophysical measurements, scientists have been able to find out new information on the geological foundations under the city of Aachen, enabling them to gain new insights into hidden processes going on under the ground as well as a better understanding of the complex interplay between tension in the earth's crust and circulating bodies of water. **Page 14**

En Route to New Applications

Ferrofluids, stable suspensions of ultrafine magnetic particles in carrier fluids, are microscopic in size and represent a great opportunity for science. Using magnetic fields, it is possible to apply a force to them, which can be very useful in biomedical research, for example, in novel forms of therapy used to fight cancer. **Page 18**

Insights into the Earth's Interior

Spotlights are used at the drilling site of the Aachen project "RWTH-1". Geologists take an in-depth look at the cores – with revealing results. (Page 14) Cover: Béatrice Oesterreich

Impressum

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Prof. Dr. Jürgen Schölmerich

Is Medicine at German Universities as Bad as it is Painted?

Clinical research should receive more respect for the dedication shown by young researchers, more long-term career opportunities and more transparency of funding allocation

There is general discontent at German university hospitals, as the DFG hears repeatedly in letters from young medical researchers. In these letters, they justify their motivation for leaving the country, or not wanting to return to Germany. For instance, one young neuroscientist accepted a four-year position in England, which allows him 80 percent of his time for research, provides a grant for consumables and, on top of that, gives him independence (see quote 1). This implies what we evidently lack here in Germany:

- Long-term appointments leading to tenure track, in other words an alternative to the W3 professorships at university hospitals.
- A limit on the clinical workload for talented young medical researchers.
- Recognition of time spent doing research to obtain further qualifications.
- Secure core support and funding for research.
- Early independence for researchers, including when it comes to third-party funding.

A recently compiled study of doctors' working hours at university hospitals for internal medicine showed that, with an average of 10 hours per day being spent doing clinical work, most of the research is done at weekends, as is emphasised by the second quote. Medical researchers are evidently a "threatened species," most commonly sighted at weekends.

The third quote concludes by highlighting what is probably the most serious problem: The lack of recognition of the immense workload, the motivation and the scientific curiosity displayed by young medical researchers that frequently exists among managers and the consequences of an excessively hierarchical structure. Medicine as a science and as an art needs a hierarchy of experience, but this does not necessarily apply to research and the commitment of young people ought to be respected. It is precisely those with experience who should invest time in the training, supervision and support of their young colleagues as well as their students. The attempts by politicians to discriminate between young doctors at university hospitals depending upon whether they are currently involved in research or caring for the sick, to the disadvantage of those conducting research, is further clear evidence of a lack of appreciation for these researchers.

But are these anecdotes representative? Of course not. There are a lot of university hospitals where the young staff receive a great deal of support, are released to do research as a matter of course, and where research can therefore be conducted successfully. Yet even at these hospitals, the opportunity to provide long-term career prospects, to limit the clinical workload to a level comparable with that in other countries, and to implement performance related in-house funding, is inadequate. The latter, in other words, the dedicated use of the funding provided by the federal states for teaching and research as distinct from the revenue generated by medical care provision, has been pointed out time and again by the DFG's Senate Commission on Clinical Research. It is pleasing to see that this concept is being put into practice at some university hospitals, but even where this is happening, appropriate structures are not in place to enable the full range of

clinical research. Basic research and disease-related research are much more successful. There are particular problems when it comes to patient-related and outcome research, since clinical research methods and methods of performing epidemiological studies are rarely taught and hence such studies are seldom carried out correctly.

What can be done about this? Any improvement needs to be based on a clear and transparent, performance-related allocation of funding. Of course, any university hospital or medical faculty is obliged to offer the whole spectrum of medical teaching. To enable this, funds need to be made available to each institution from the state contributions, according to teaching load, in addition to the funding for provision of medical care. There have to be focused areas of research – which implies that there also have to be areas with less activity. This, in turn, needs to be reflected in an appropriate distribution of funding provided for research from the state contributions. This funding also needs to actually reach the individual researchers, which means that the funding allocation needs to be individually performance related. If the DFG's move to full overhead funding of research projects is successful, then a significant simplification of the funding situation for clinical researchers is to be anticipated.

Only on the basis of a clear separation of funds given for research or received for patient care is it possible to differentiate between the time doctors spend doing research and the time spent providing medical care, and to secure the former. This also makes it possible to provide longer-term career prospects for young researchers by creating the necessary tenure track posts for those with particular promise. At the same time, it is essential to ensure that doctors conducting research do not end up worse off than those who are solely involved in providing medical care. This is where the ministers of education in the federal states are called upon, to make this clear to the wage negotiators.

Both the hospitals and the research funding bodies need to invest in training for patient-oriented research. Instruments such as an academy of excellence, based on the example of the DFG's Working Group on Medical Technology, are conceivable and would probably be helpful. At the same time, the faculties need to realise that, when evaluating this kind of clinical research, a distinction needs to be drawn between basic research and disease-related research. Of course, performance can also be measured in terms of publications and possibly also on the basis of third party funding. But the processes here are generally longer and more drawn-out. Studies which do not receive funding from industry are particularly cumbersome for the researchers involved and generally also yield fewer publications in any given time period. In this respect, it is important to ensure that this is understood and does not have a negative impact on decisions that affect researchers' careers.

The most important thing, however, will be to ensure that the motivation and curiosity which young medical researchers have are not suppressed through a lack of recognition (including in financial terms) or through treatment that may be interpreted as disrespect, as is evident in the third quote. The age of the dinosaurs has inhibited the development of the mammals for a long time and it is doubtlessly pleasant to be a medical dinosaur. Now seems to be the time to allow the next generation to develop unhindered, however, and if this is allowed to take place, then there is cause for optimism for the future of university hospitals and clinical research in Germany.

Prof. Dr. Jürgen Schölmerich

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Excerpts from letters to the DFG

1. "... I'm also looking forward to returning to Europe next year. It hasn't been easy to decide on the next step to take, but I have now accepted a four-year post as a Clinical Research Fellow in Manchester, with very few clinical obligations (one day a week), no teaching duties, funding for consumables and a great deal of independence (with personal third party funding etc.)."

2. "... There is practically no research done, or it is only done by biologists, research scientists and assistant medical technicians employed especially to do research. That's probably a good thing too, as being granted time to conduct a research project would be illusory in any case, and the weekends are already spent dictating medical reports. ... I consider myself above such a system, which is so perverted that any cartoonist would refuse to caricature it because it is simply too grotesque. I could have reached this professional, social and personal low point with far less trouble. Neither my first class degree, nor my fellowship from the Studienstiftung (German National Merit Foundation), nor my PhD, which I defended with "magna cum laude", nor my research visits abroad, nor the fact that I also passed all of the American State Examinations would have been necessary. ... I will therefore be accepting a second three-year contract in the USA to continue my work."

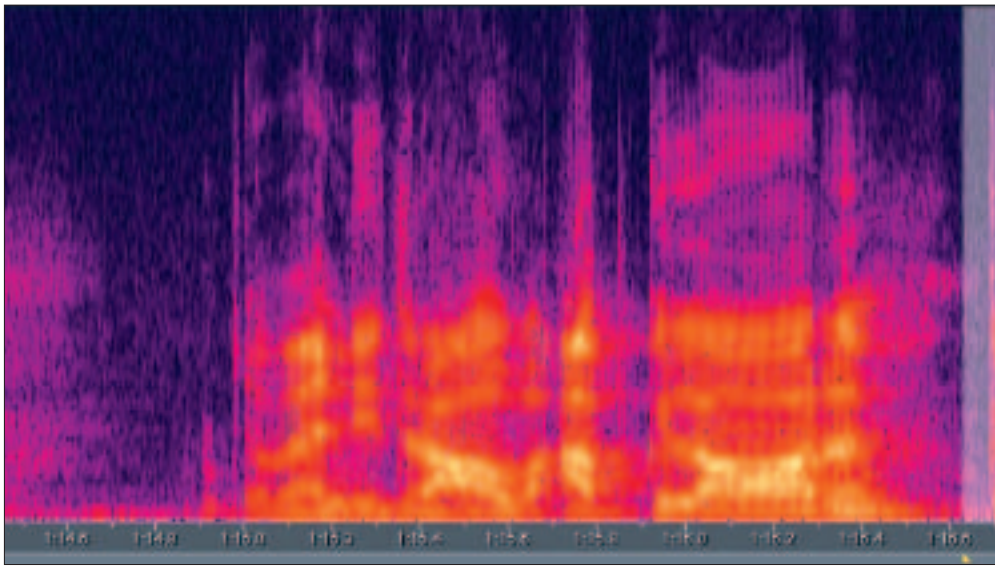
3. "There are just three days a year provided for job-related training. For every additional day spent on further training, we have to draw from our annual leave. For the three-day course on ultrasound, which was held here in our own hospital by our own senior physician, the hospital charges its interns almost €500. It goes without saying, that these three days are deducted from our leave."

The Amazing Diversity of Dialects in Germany

The "Linguistic Atlas of the German Empire" is an exhaustive and precise documentation of the German dialects of the 19th century. The complete digitalisation of the linguistic map opens up new possibilities for international research

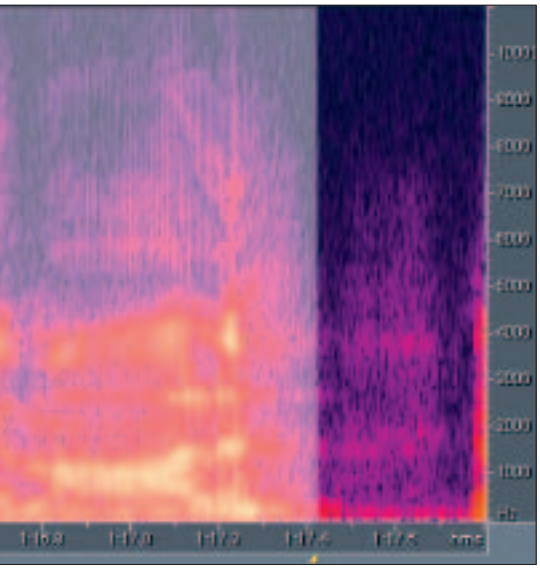
Anyone visiting German-speaking countries and regions is reminded at every turn that official German – as it is spoken – is not uniform; rather, it is a polymorphic entity characterised by regional variations. German dialects contribute to the colour and character of the German language – and this is no recent phenomenon.

Scientific interest in German dialects and their regional distribution began in the 19th century. More precisely, it was a linguist from Marburg, Georg Wenker, who started the trend in 1876 with an exhaustive survey of German dialects. He created an atlas that became known as the "Linguistic Atlas of the German Empire", which is still considered to be the world's most comprehensive documentation of the dialects of an individual language. Wenker's method was simple and effective: he composed a questionnaire containing sentences in High German, which he then sent to every school in the German Empire with a request for translation into the local dialect. The initial survey carried out by Wenker targeted the region around Düsseldorf. When this was successfully completed, he turned next to Westphalia and later extended the collection of data to cover northern and central Germany and, finally, southern Germany. In this way, the dialects of almost 45,000 locations (villages, cities and city precincts) were documented over the course of eleven years, amounting to a complete survey of German dialects. This material represents the only linguistic documentation in the history of most of these places. As linguistic material was also collected from the former Prussian territories, some dialects, which have since been lost or are disappearing, have been partially preserved. Wenker and his colleagues transferred the collected data onto linguistic maps, revealing the linguistic differences between the German dialects. By the time work was discontinued in 1923, the atlas consisted of 1643 hand-drawn linguistic maps. The maps' combined format of 140 cm x 140 cm and the 22 colours in which they are drawn made a complete publication of the work as a printed atlas infeasible from the outset. Since the maps and questionnaires are very valuable as sources, dialect researchers from around the world have been compelled to travel time



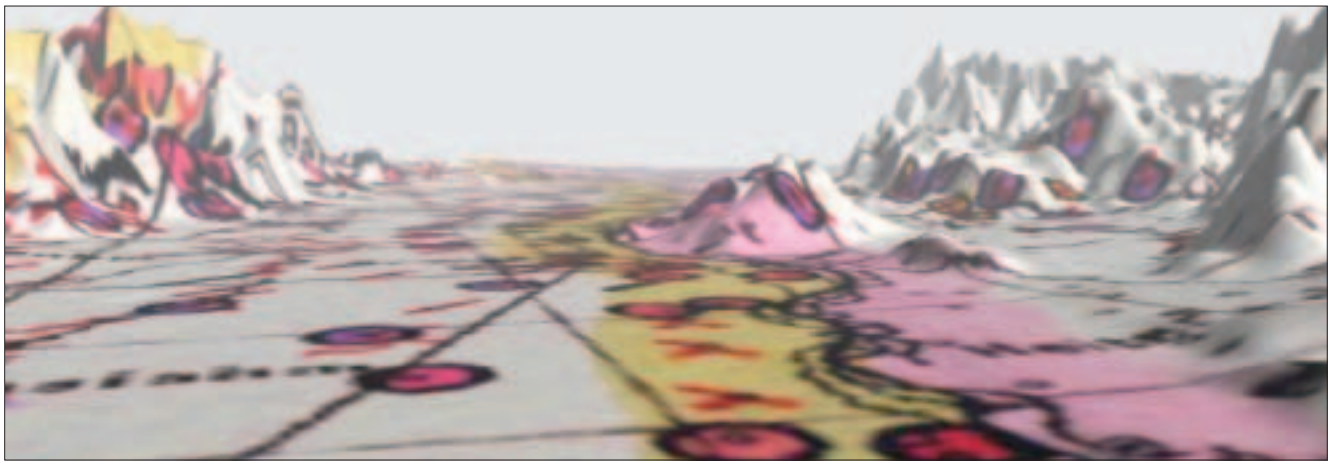
and again to the "Research Institute for German Language – Deutscher Sprachatlas" in Marburg, where the material is archived. In addition, the passing of well over 100 years and heavy use have led to conservation problems. The colours have partially faded and, despite its high quality, the paper is now aging. It is at this point that a project supported by the Deutsche Forschungsgemeinschaft (German Research Foundation, DFG) and known in specialist circles as the Digital Wenker Atlas began. At heart, this involved an archival operation with the complete digitalisation and filming of all the material between 2001 and 2003. But digitalisation also enabled the publication of all of the material on the Internet. Further, it furnished the basis for further scientific analysis of the material. Over time, an information system for linguistic geography, with which the dynamics and transformations of the German language can be examined, has grown out of the published cartographic materials.

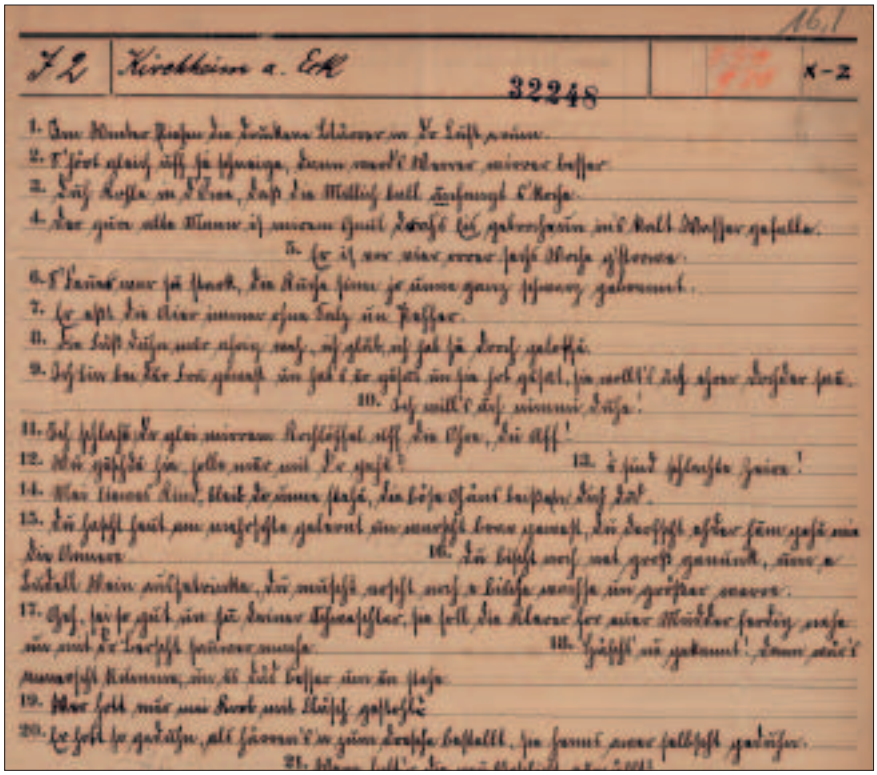
What makes 19th-century dialect data so interesting? The answer is that these data represent a "linguistic stage" that had not changed much since the formation of the early-modern territories. It is only as a result of the technical, political and social changes of the 20th century that the dialects have been brought into competition with standard High German in a new way. The massive migratory movements connected with industrialisation and the consequences of war, and the dissemination of High German as a spoken language with the advent of broadcasting in the 1920s played an important role here. The data collected by Wenker therefore represent, with geographic accuracy, the linguistic starting point of an ongoing development. Wenker's data offer an historical reference point for the current linguistic situation of all local dialects. But it is also possible to draw conclusions regarding historical developments leading up to the 19th century from the linguistic maps. In this regard, the material provides a unique source for the understanding of linguistic change and its mechanisms.



Researchers make the shifting energy concentration in the human voice visible with aid of a "spectrograph". The sentence "There the grapes are unloaded and crushed" is being spoken here in a Rhine-Franconian dialect. Below: Section of a linguistic map. It gives a detailed illustration of the regional and local forms of the word "brother".

The publication of the historical cartography on the Internet presents a formidable technical challenge. Graphic files with a size of up to two gigabytes can be transferred over the Internet and virtually combined in accordance with the researcher's interests; that is, different linguistic maps can be interactively superimposed and analysed. This is achieved using methods developed for the processing of satellite images. In a process that takes several hours, a special cartographic programme converts all pixel coordinates into geographical coordinates. The result of this process, known as "georeferencing", is a map-image that furnishes the exact geographical coordinates for every pixel. This allows geographical information to be related to linguistic topics. For example, it becomes possible to combine the linguistic maps with a three dimensional elevation model or a map of historical territorial borders, in order to visualise spatial dependencies. The high geographical accuracy enables precise analyses of linguistic transformations. Since the 1970s, numerous regional linguistic atlases of the German-speaking territory have been created, which record the linguistic status of the dialects during and after the transformations of the 20th century. This information can be integrated with the system, and the 19th-century maps combined with those from the 20th. The linguistic transformations of the





In the three-dimensional model: In the Rhine rift area, a language border runs right through the Kaiserstuhl. Below: Handwritten questionnaires from the palatine town of Kirchheim am Eck. In 1876, the linguist Georg Wenker began distributing questionnaires containing sentences in High German and requesting that these be translated into the local dialect.

last 100 years thereby become immediately visible. The results of such comparisons are highly informative. They show that the linguistic system of many of these dialects has not changed greatly. The principal change is in the number of speakers: individuals who have acquired their local dialect as native speakers are less common, while their contemporary dialect remains very similar to that of the 19th century. In some regions, however, there have been distinct changes. The transformation is then mostly in the direction of High German. But it is those rare cases in which the dialects develop away from the standard language that are especially revealing. These are of great import for the analysis of linguistic transformation. In its guise as an information system for linguistic geography, the Digital Wenker Atlas integrates a substantial amount of additional material aside from historical and contemporary linguistic maps, such as survey questionnaires, sound recordings and bibliographical entries that can be called up with a click of the mouse. While the survey questionnaires present all of the historical data from a particular place in its original context, the sound recordings provide a basis for the scientific analysis of the spoken language. Even though the sound recordings were taken a few decades after Wenker, this material makes a tangible experience of the character of a dialect possible for the layperson in a way that written surveys cannot match. The online bibliography is another special feature. In the next few years, all published and unpublished studies of German dialects, and studies from related scientific disciplines, are to be recorded in this bibliography. The Digital Wenker Atlas thereby sets a standard which goes beyond linguistics and offers an interdisciplinary information system for linguistic geography that is available on the Internet for free to anyone who is interested.

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▶ www.diwa.info

Communication in the Information Network

How can knowledge exchange in computer networks be meaningfully supported? Studies offer insight into the possibilities and risks associated with network-based group communication, the success of which does not depend on the medium alone

The old proverb says that to know what you don't know is the first step to knowledge. The second step is to find someone who does know. Computer based media, like the Internet, open a multitude of ways to contact experts or to get in touch with people who have similar problems. The ways in which the exchange of information can be shaped by the use of computers, is a highly instructive question for psychologists, educationalists and computer scientists involved in a project called "Net-based Knowledge Communication in Groups". How well the medium is suited to the transfer of knowledge, is not merely a question of technology. The possibilities and the problems of computer-mediated communication vary according to the users and the goals they pursue.

Advice hotlines on the Internet, for example, bring people with widely divergent knowledge levels into contact with each other via email. The medium therefore presents a challenge to expert advisors: in the case of written communication, the advisor must estimate the addressee's level of knowledge. Otherwise, there is a risk that the message will not be understood, because here, unlike in personal discussions, the wrinkled brow or questioning look, which indicate that something has not been understood, cannot be seen. To adapt the formulation of one's message to particular recipients is no easy task, as the recipient is usually not well known. Perhaps the only clue to the previous knowledge of the person seeking advice is the text of the question itself – and that can be quite misleading. It has been shown in experiments that experts, when presented with questions that include technical terms, tend to answer in technical jargon. Moreover, they give fewer explanations of important connections and fewer general tips. But, when giving advice, one cannot assume, based solely on the use of technical terms, that the addressee has a deep understanding of the subject. Not everyone that complains of a migraine knows exactly what that is – and therefore cannot even be certain that they actually have a migraine.

Cooperation via computer networks: Information exchange in groups, for example, in collective problem solving, can often be compared to a puzzle in which every part is essential. A structured approach is often the key to success. This can be achieved by means of "scripts", which work like stage directions on the screen.

In these circumstances, it is possible that email communication between experts and lay persons can miss its target: what was meant as a helpful tip may be incomprehensible to the addressee, or, what's worse, be completely misunderstood. At the same time, communication over the Internet opens up means and methods of tackling the problem. Internet forms, which ask the enquirer to estimate their level of knowledge, enable the expert to adapt the answer to their requirements. In experiments, even simple

multiple choice questionnaires, which ask the enquirer about their general level of knowledge and their understanding of a relevant term, produced better adapted advice. As a result, the average number of subsequent clarification questions dropped by a half.

This query tool, which is as simple as it is effective, is not the only example of a meaningful structuring of net-based communication processes. The advantages to be gained when the medium uses the means available to it can also be seen in the use of scripts, with which the entire interaction process can be pre-structured as in a screen play. Scripts work like stage directions. At particular points in a communication, suggestions for concrete activities are shown; sometimes the activities are allocated to specific participants. The concrete suggestions might offer references to a useful distribution of tasks or propose that certain contents be examined.

If, for example, a group of pupils attempt to solve a homework task together over the net, a script could help them to establish when information should be processed individually and when it should be exchanged for evaluation by the group. It is precisely in net-based group communication, that scripts can help to reduce the time spent on detailed arrangements and orientation processes. They thereby provide effective support for cooperative work on the net. Along with these cooperation-related scripts, there are also scripts that relate to particular subject matters. It is possible, for example, to adopt the role of the "enquirer" or to offer learners a schema for structuring different subjects. If scripts like these are combined, it is evident that they can be used for more than just reducing the additional work associated with the medium: experiments showed that there were exceedingly positive effects on the knowledge acquisition of participants. The effective use of new media therefore leads not only to communication that is temporally and spatially more flexible, but also to outstanding results. The researchers are not only concerned with the meaningful structuring of net-based communication, but also with the question of how the communication partners and subject matters can be suitably visualised. One possibility for shaping the contents of the information exchange is represented by collective "virtual workspaces." In many cases, long-winded descriptions are no longer necessary for explaining your plans to your communication partner; you can show them directly on the electronic workspace. A double advantage is therefore associated with the use of the computer as medium: on the one hand, due to its enormous storage space the PC enables the storage of the "developmental history" of the collective product, which simplifies later analyses. On the other hand, the computer, in contrast to paper or a writing board, is able to perform calculations: the right software – something that is being developed for certain fields of application – can turn a sketch into a simulation. That means that the work team can plan a collective solution, and also implement and test the functioning of, for example, a jointly designed electronic circuit.

With computer-aided communication, it is even possible for communication partners to be visible to each other in a new way, for example, in the form of avatars. Avatars are computer generated characters, who can act as virtual representa-

High technology in computer screen communication. Special recording systems allow the transmission of gestures and facial expressions to a representative. The virtual characters have no life of their own; they are controlled by the people "behind" them. Right: A further example of net-based knowledge communication: A three-person study group "meets" via video conference.

tives. They have no life of their own, but are controlled by the people "behind" them. In this way, gestures and facial expressions are also conveyed to the communication partner. However, unlike video conference, this medium offers the advantage of anonymity. Users of this type of communication are free to choose the character that represents them. In any case, the avatar indicates presence: in a communication situation, in which the participants do not see each other face to face, the avatar indicates that someone is "there" and taking part. In net-based communication, this type of information can have considerable consequences. This can be observed, for example, in the behaviour of knowledge databases users. Users are mostly willing to share their own knowledge with other users, if they know that the others are also cooperative or when they are aware of how important their knowledge is to the others. If people do not share information with others, it is not always caused by a lack of good will. Without intending it, there is a tendency for group members who are exchanging information not to tell the others everything that they know. Often, exclusive knowledge, that no other group members possess, is not passed on, while information that many or even all members possess is frequently expressed and reinforced. This leads to a distorted representation of the subject matter and can obstruct collective decision making. So the exchange of information in a group via the Internet can have advantages and disadvantages. In other words, whether the properties of the medium are beneficial or obstructive depends on the collectively tackled problem.

There is a variety of ways in which computer networks can be used for communication, each of which can extend or restrict the ability to share information. Depending on the situation, either of these may be required.

On the whole, computer-aided information exchange proves to be a complex interaction of technical possibilities, human behaviour and different medial requirements and processes. There has only been rudimentary research up to now on the effects of this interaction. Nevertheless, one thing is already clear: computer-based communication is, in every case, more than a makeshift solution that is only used because people cannot be in the same place at the same time.

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Combating Thunder and Lightning with Lasers

Ultra-short pulses of light from a high-power laser allow long plasma channels to be generated in the air. This technology is not only useful for atmospheric research, it could also lead to significantly improved protection against thunderstorms

When a state-of-the-art, high-power, ultra-short pulsed laser was put into operation in Jena in 1996, new and previously undreamt possibilities became a reality for researchers. This high-power laser does not emit light continuously, but rather, it generates very short bursts of light referred to as pulses every tenth of a second. Each pulse lasts for a mere 100 femtoseconds, which is only 0.000 000 000 000 1 seconds and corresponds to the length of time it takes for light to travel the breadth of a human hair. However, in this very short period of time, these laser pulses posses a peak power of four terawatts, which is more than the total power output of all of the power stations in Europe combined. By irradiating matter with these laser pulses, it is possible – even in air – to break up a medium into its electrical constituents if the light is sufficiently concentrated. This in turn results in a bright flash of light referred to as a plasma focus.

When the laser in Jena was launched, researchers hoped that it would be possible to generate a plasma focus several kilometres long in the atmosphere and, in doing so, make an age-old dream come true: to create an artificial star, a guidable source of white light in mid-air. This would not only enable astronomical telescopes to be calibrated more precisely, but also allow fundamentally new remote sensing methods for atmospheric research. This is a particularly important challenge in view of the alarming climatic developments such as global warming, ozone depletion at high altitudes and increased ozone pollution at low altitudes.

Left: A spectacle of nature – jagged lightning cuts through the sky. Above: An artificial bolt of lightning in the evening sky: High-power pulses of laser light generate a long, white ray of light (a plasma focus) shining in the sky. This picture was taken from the courtyard of the Department of Physics at the University of Jena.

The Jena laser was directed vertically into the sky using a slightly convex lens to bundle the beam of laser light. Its pulse structure was designed in such a way that the blue component of the emitted light, which travels more slowly in air, was emitted ahead of the faster red component. This allowed for the different spectral constituents in the beams to converge after travelling for a certain distance in the air. Since the infrared light emitted by the laser should barely be visible to the naked eye, the spectral and temporal behaviour of the back-scattered light was observed using a telescope, a spectroscope and suitable optical sensors similar to an optical radar, which gives this technique the respective name of LIDAR (Light Detecting and Ranging).

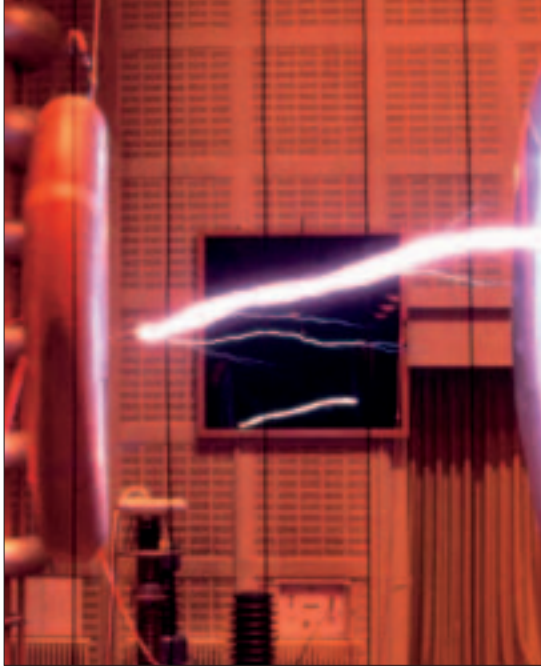
The results were astonishing from the very start. Instead of a dim plasma focus in the distance, a long channel of white light stretching out into the sky was clearly visible.

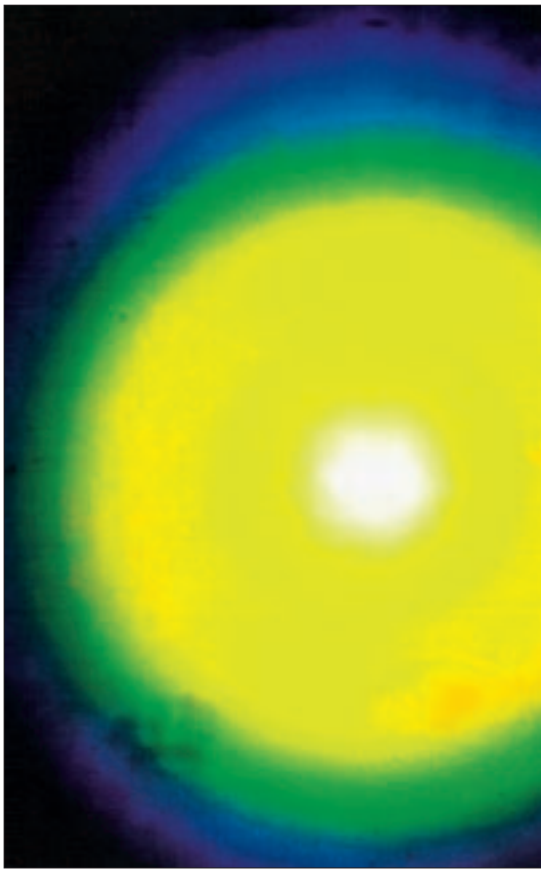
Spectral analysis of this ray of light revealed that it spanned the spectrum from the ultraviolet to the infrared. By measuring the time of flight for returning to the source, it could be determined that the white light had been emitted from altitudes of up to 12 kilometres. Similar light channels generated in the laboratory were found to be electrically conductive, meaning that they constitute plasma channels. This effect was of such great interest to scientists and promised such a wide range of applications that the Deutsche Forschungsgemeinschaft (German Research Foundation, DFG) and the Centre Nationale de la Recherche Scientifique (CNRS) decided to establish a Franco-German research project called Teramobile. The first stage of the project involved the development of a mobile femtosecond LIDAR system that could be used collaboratively to study the various aspects of the plasma channels observed in different locations. The experimental realisation of the Teramobile system is identical to the first system used in Jena, except that an extremely compact construction was chosen in order to allow all of the apparatus, including the laser and the receiver, to be housed in a mobile air-conditioned freight container. The apparatus has now been used to conduct measurements in Palaiseau, Berlin, Lyon, Jena, Toulouse and New Mexico.

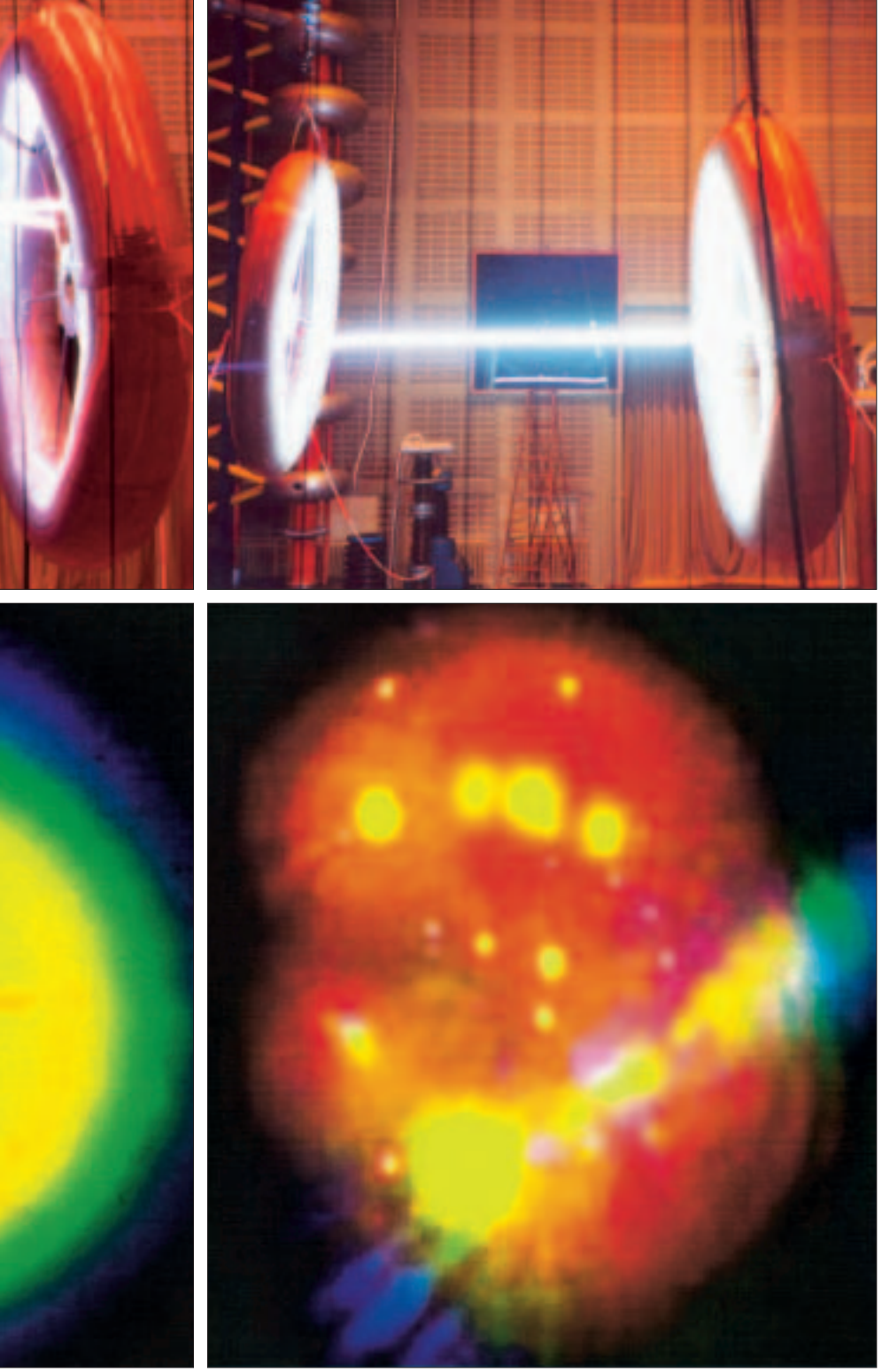
The physical phenomena that lead to the formation of a plasma channel – an effect that had previously been observed in the laboratory – are easily explained: the speed of light in air is ever so slightly reduced when it is exposed to light of such high field strengths, which in turn increases the refractive index in the air. The bell-shaped intensity distribution of the laser pulse makes this effect act as a lens that causes bundling of the laser beam, an effect generally referred to as self-focusing. This culminated, high-intensity light is capable of striping electrons from the air the beam passes through, causing ionisation of the air molecules. These electrically charged particles bring about a reduction in the air's refractive index. This in turn causes a divergence in relation to the bell-shaped intensity distribution of the laser pulse, leading to diffusion or defocusing of the laser beam. The combination of effects that result in focusing and defocusing allows the laser beam to propagate along thin, intense filaments, with the femtosecond temporal structure of the pulse being retained. At higher intensities, the single filament breaks up to form a bundle of filaments, a process referred to as multi-filamentation. This type of self-guiding filament has been observed to propagate over several kilometres in the atmosphere. The effect is just one example of a novel optical phenomenon termed optical turbulence. The broad spectral content of the white light generated in the propagation through the filament is due to the self-phase modulation of the high-intensity laser pulse in the atmosphere, where the term phase-modulation refers to the creation of new wavelengths or colours of light within the spectrum of the laser pulse as a result of the varying refractive index. Of particular interest is the spectral content of the white light measured after passing through an atmospheric absorption path. In this context, a large number of spectral lines have been observed that could be assigned to individual constituents of air. Careful scrutiny of the spectral content thus makes it possible to determine the composition and general properties of the atmosphere. So far, it has been possible to obtain information on ozone concentration, temperature and relative humidity at heights of up to four kilometres using this method. The unexpectedly high signal strength of the spectra that have been obtained indicates that the white light emitted by the plasma channels is predominantly backscattered, meaning that it travels back to the transmitter. This makes a very precise observation of the atmosphere and measurement of atmospheric pollutants possible.

The obtained spectra not only contain the "signatures" or "finger prints" of gases, but also reveal im-

The Teramobile project uses a compact LIDAR system that can be used in different locations







portant information about aerosols, very fine suspensions of solid or liquid particles in the atmosphere. For instance, an analysis of the light signal allows for the aerosols' characteristics such as abundance, size and state of aggregation to be determined. This gives a justified cause for the hope that in the future, remote detection will be used not only to detect airborne water, dust and soot particles, but even pollen, spores or bacteria.

Top left: Spontaneous high-voltage discharge between two electrodes three meters apart. Top right: Directing a laser beam at the discharge transforms it into a controlled discharge that follows a straight path. Bottom left: In the air, the laser beam is transformed into a plasma channel that emits a variety of colours. Bottom right: Increasing the power of the beam causes multiple plasma channels to form.

The intensity of the light within the filament is even sufficient to generate bright plasma sparks from solids, with a clear spectral signature that reveals the composition of the material being irradiated. Using this method, it was possible to identify the copper in the roof of a church at a distance of 100 meters. This offers a great potential for applications in the remote analysis of inaccessible locations such as fires, chemical reactors or contaminated rooms, where a quick and safe examination from a distance is easily possible.

The fact that these plasma channels are electrically conductive also raises the possibility of performing electrical discharges in a controlled manner over large distances. So far, this has only been demonstrated by an electrical discharge three meters long in air. The voltage was set so that no discharge took place without the laser. However, when a plasma channel was emitted, the discharge was released and followed a straight path through the air along the filament bundle. This experiment clearly demonstrates the potential such filaments have for use as lightning conductors. To date, lightning in thunderstorms has only been discharged successfully on a straight, controlled pathway using metal wires that were fired into storm clouds from the ground with rockets. Yet, it is only a logical step to replace these wires with plasma channels in order to be capable of safely discharging storm clouds in a controlled fashion, before lightning strikes. This is an especially important application in aviation – particularly for take-off and landing – as aircraft remain vulnerable to lightning strikes despite the numerous safety precautions that are already taken.

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▶ www.teramobile.org

Natural Sciences

A Deep Look into the Aachen Underworld

With the aid of cores and geophysical measurements, geologists have studied the complex interactions between stresses in the earth's crust and circulating bodies of water. Through these studies, it is possible to gather important insight into hidden processes occurring deep below a city

The objective of a hole drilled in the Aachen urban area was to supply a student service centre with geothermal energy. At the same time, this gave geoscientists a chance to gather insight into Aachen's geologic basement and, thus, a unique opportunity to undertake a research programme with focus on subterranean processes. The Aachen study area is known for its hot springs, mining and periodic earthquakes. Water is a main thread in Aachen's history, from the Roman military bath "Aquae granni" dating from the 1st century to the Bad Aachen spa and sanatorium with hot springs ranging from 45 °C to 75 °C. Just as old is the history of ore mining in the Stolberg mining district and of coal mining in the Alsdorf district. The Lower Rhine Basin north of Aachen is, in addition to the Upper Rhine Graben, Vogtland and the Swabian Jura, among the most seismically active areas in Central Europe. The most recent earth-

A messy business: Drilling fluid spills over onto the platform. Centre: Geologists examine the core samples at a central repository. Top: The drilling site of the "RWTH-1" project is located in the centre of Aachen.

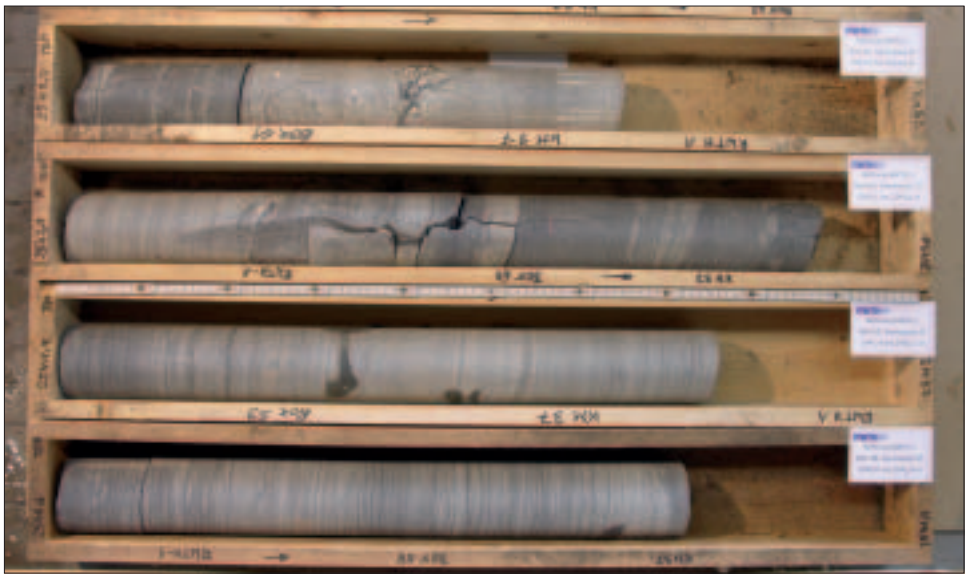
quakes, in 1992 with epicentre in Roermond and a magnitude of 5.9 on the Richter scale and in 2002 northeast of Aachen (Alsdorf, magnitude 4.8), are still fresh in memory. The interaction between stresses in the earth's crust and circulating bodies of water, which have their own water-rock interactions, has been occurring in the regional geology for hundreds of millions of years and is noteworthy, even on an international level. It is the focus of the extensive, multifaceted research programme which is coupled to the geothermal drilling project.

During the drilling work, the geoscientists were able to employ an extensive geophysical measurement programme and to collect cores as well as continuously sample the cuttings, thereby ensuring ample research material for years to come. The term "cuttings" refers to the rock which is ground by the drilling tool and which is constantly flushed to the earth's surface from great depths by the drilling fluids. The cuttings were washed directly on site, dried, a brief analysis performed and archived in more than 2500 containers, each of which contained several kilogrammes of material. For more than 94 percent of the hole, cuttings represent the only direct evidence of the rock which had been drilled through.

The cores, which provide a much more exact representation of the geologic structure, were primarily collected using a special wireline core process which allowed the core to be pulled to the earth's surface by means of a steel cable located within the drill string in a time- and cost-efficient manner. Nearly 150 metres of core were collected at three different depths. The onsite geologists demonstrated excellent intuition with the choice of core samples: Cores were collected at the most interesting sections of the hole.

In addition to directly sampling the cuttings and the cores, the open borehole was also geophysically examined using highly advanced borehole probes. In addition to parameters which were necessary for the drilling process, such as the path and geometry of the borehole, a number of physical rock properties collected solely for the purpose of scientific interpretation were also measured. Acoustic and electrical parameters were measured as well as the spectrum of the natural gamma radiation of the elements uranium, thorium and potassium present in the rock. Moreover, an image tool measured high-resolution micro-resistance and ultrasonic parameters to physically map the borehole wall.

Great advances have been made in our understanding of the stresses in the earth's crust over the past 20 years. Contributing to this have been the analysis of earthquakes, commercial and research-oriented boreholes as well as field studies. As a result, the principle patterns for stess distribution are known today. The mechanisms for the build-up and discharge of stresses which can lead to catastrophic effects, such as the tsunami in Southeast Asia, are, however, greatly unknown and cannot, therefore, be predicted. At the same time, subterranean fractures form the primary mode of transport for water. The inflow of water which is under high pressure can, under certain stress conditions, trigger earthquakes. This mechanism characterises large fault zones at non-stationary plate edges, such as in California. The research work will examine whether this mechanism can also occur in "stationary" fault zones within a continent. Aachen's complex tectonic history is recorded in the rocks macroscopically and microscopically in the form of fractures. As with the physical images of the borehole wall, evidence of various tectonic events, such as earthquakes, can also be seen in the cores. The types of movements and the role of hydrothermal, i.e. deep and hot, waters in the reactivation of the faults are being studied. The rocks collected from the borehole show that these hydrothermal waters circulated in open fractures in the geologic past, reacted with the surrounding rock and caused deformation, allowing new minerals to form which eventually reclosed these flow paths. Relicts of this paleowater may have survived as fluid inclusions in the rock-forming minerals or fracture minerals. Ideally, the contents of these inclusions preserved the physico-chemical conditions present during mineral formation as well as the composition of the water. Examination of such fluid inclusions collected in the "RWTH-1"



borehole showed that very hot waters from deeper crustal levels rose and led to the sealing of the flow paths.

The fracture minerals themselves are being examined with respect to their stable and radioactive isotope composition. This provides information on the origin and possible paths of the hydrothermal waters. In addition, this allows for the determination of absolute age data, thereby facilitating creation of a timeline which describes development of the hydrothermal processes in the Aachen underground as well as the associated formation of ores. New mineral formations can also form as a result of chemical changes in the fissure- and pore waters caused by natural microbial activities. Analyses of the Aachen-Burtscheid thermal waters show signs of sulfate-reducing processes caused by thermophilic and hyperthermophilic microorganisms which may also play a significant role in the genesis of mineral deposits.

Because the temperature of the earth increases with depth, thermal warming can be used directly as thermal energy or converted to electric power depending on the local conditions and the depth of the borehole. In the "RWTH-1" geothermal borehole, a temperature of over 80 °C was measured six months after completion of the drilling work at a depth of 2500 metres. The current concept for the utilisation of geothermal energy with this borehole includes simultaneously providing building heating and driving an absorption heat pump. During the research work, a computational programme for constructing geothermal probes was further developed with which the effects of topography, probe dimensions and operating parameters on the performance and efficiency of a deep geothermal probe can be calculated. These simulations reveal a use conflict between building heating and driving an absorption heat pump: For heating, high flow rates and, thus, high thermal power are desirable. This, however, has a negative impact on the production temperature, which must not fall below a minimum value in order to drive an absorption heat pump. In the case of borehole "RWTH-1", thermal power of up to 150 kW at temperatures between 50 and 70 °C can be expected depending on the circulation rate.

As an important basis for the planning, design and optimisation of future projects for the utilisation of geothermal energy in the Aachen region, the rock-dependent heat-flow for a 40 x 40 kilometre area with a depth of five kilometres will be numerically simulated. With operational data which is to be continuously recorded in the coming years with the Aachen geothermal probe, it will be possible for the first time to examine the numeric calculations for dimensioning deeper geothermal probes which were based on temperature measurements collected in the borehole, particularly with regards to the heat extraction which can be achieved over the long term.

In addition to the research results for utilising geothermal heat as an energy source, geologic, hydrochemical and mechanical processes are being examined in space and time at the Aachen location, producing results which can be applied elsewhere with regards to the formation of thermal springs, deposits and earthquakes. It is already necessary to update existing models on the basis of the data collected below the city.

Upper left: The cores are carefully archived in crates. Below: The borehole is explored with a geophysical measurement probe. After use, it is freed of the drilling fluids. Lower left: A measurement probe is mounted for examining the borehole. Top: The drilling tower with the city of Aachen in the background. Below: Geologists take a close look at the new core.

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▶ www.rwth-aachen.de/geow/Ww/rwth1geo/index.html

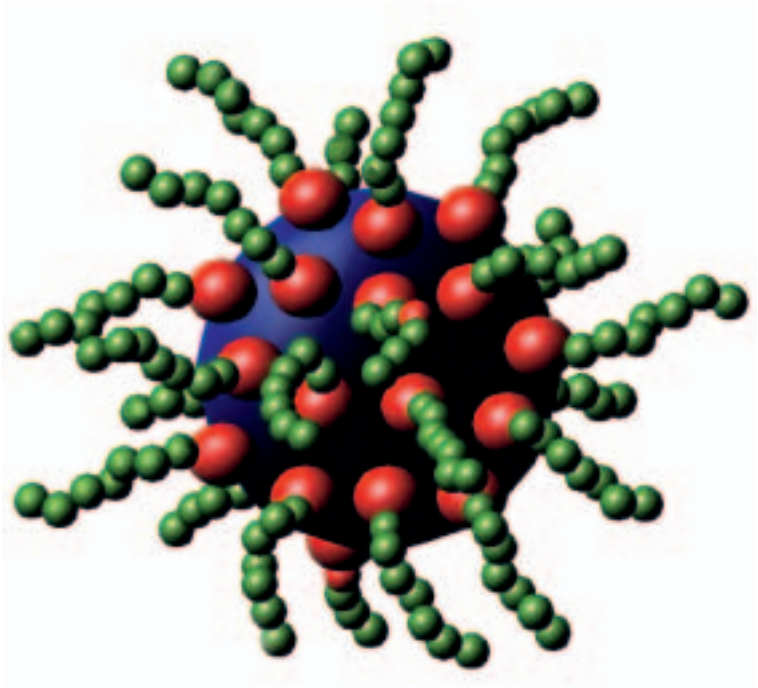
Great Benefits from the Smallest Particles

Magnetic fields can be used to apply forces to ferrofluids, a practice currently being used advantageously in biomedical research. For example, it is implemented in novel forms of therapy used to combat cancer

They are microscopically small and have a huge potential for science: ferrofluids – suspensions of extremely fine magnetic particles in a carrier fluid. In recent years, they have become increasingly important not only in basic research, but also in various fields of application. These fluids contain magnetic particles with a diameter of only ten nanometres. These nanoparticles are coated with long-chain molecules that prevent agglomeration so that the particles in such fluids retain their homogeneous distribution for many years. These fluids have a remarkable characteristic: magnetic fields, which can be easily generated with standard laboratory electromagnets, can be used to apply forces to the particles thus allowing the flow or the properties of such a ferrofluid to be altered. This possibility opens a wide field for fundamental research and has led to the development of numerous applications, some of which, for example cooling of high-performance loudspeakers, are now used in everyday life.

A current focal point of ferrofluid research is the use of suspensions in biomedical applications. "Biocompatible", i.e. physiologically compatible ferrofluids are required for this purpose, which has led to the development of ferrofluids consisting of water as the carrier fluid and iron oxide particles coated with starch molecules, for example, as the magnetic component. One of the most important goals of biomedical research using ferrofluids is the development of novel forms of therapy for cancer patients. Two approaches are used for this: in so-called magnetic "drug targeting", a chemotherapeutic agent is coupled to the surface coating of the particles. After the suspension prepared in this way has been injected into the artery supplying the tumour, the force applied by magnetic fields causes these particles to accumulate in the tumour. With this technique, only small amounts of a chemotherapeutic agent are required to achieve a high concentration of the active substance in the tumour, and at the same time, it ensures that only a small amount, if any, of the drug reaches other parts of the body. Stressful adverse effects can thus be suppressed and the effects of the therapy improved. Animal experiments have shown that this technique can significantly improve a chemotherapeutic treatment.

The second therapeutic strategy is based on heating the tumour tissue. The elevated temperature damages the tissue thus making it more susceptible to other forms of therapy. In order to do this locally, that is, limited to the tumour, magnetic particles are localised in the tumour tissue. Alternating magnetic fields then continuously remagnetise the particles and the associated release of energy heats the tissue being treated. This technique is known as magnetic hyperthermy. In contrast to clinical studies in which the magnetic suspension is injected directly into the tumour, current research aims to incorporate specific



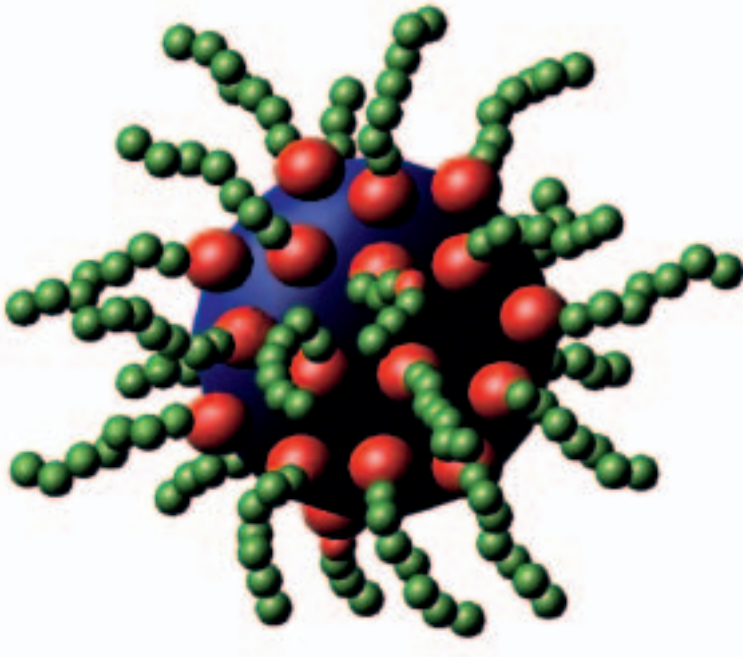
Ferrofluids contain minute magnetic particles that have a diameter of only ten nanometres. These nanoparticles can be coated with long-chain molecules (shown here in green). The surface coating is not shown to scale in the modelled particle for reasons of clarity.

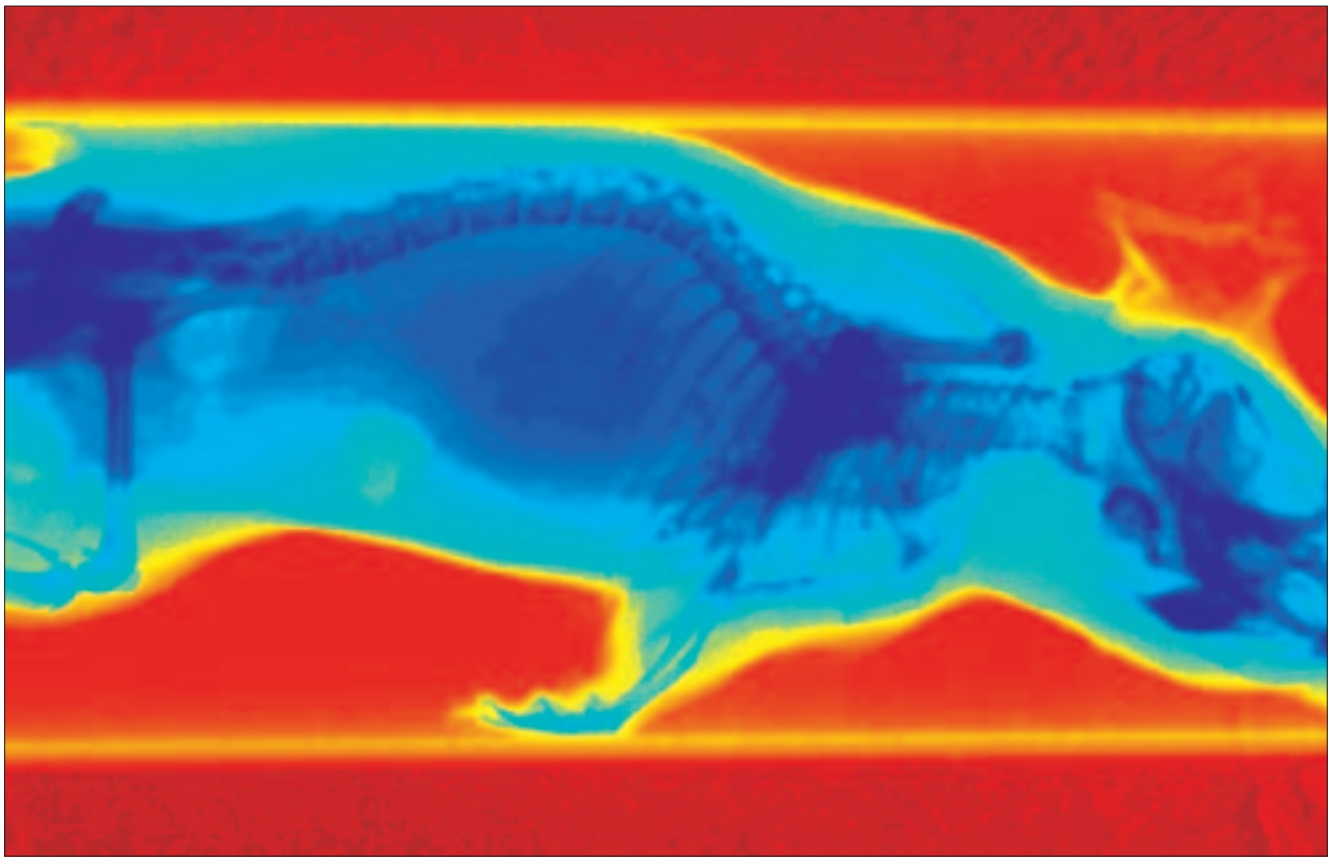
markers on the particles that can then dock onto the tumour tissue. This allows tumours to be reached that cannot be injected directly. In addition, it also avoids damaging the tumour, which could lead to the release of cancerous cells.

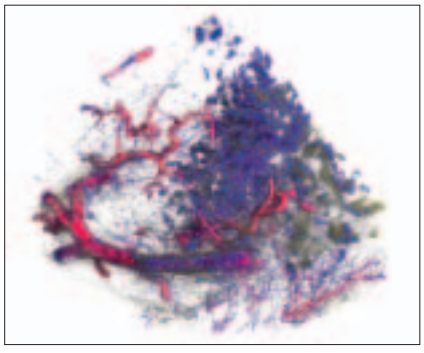
In contrast to direct injection, which leads to a specific localisation of the particles within the region of the tumour, new magnetic and chemical drug targeting techniques are used to study the efficiency of particle storage in the tumour tissue and how the particles are distributed within the tumour. The classic technique used in medical applications to detect the particles in the tissue is a histological section: very thin tissue samples are prepared and then the iron oxide particles are visualised by means of a Prussian blue staining. This technique allows the iron content in the investigated tissue sample to be determined with a high spatial resolution. However, it is obvious that this method provides only very local information on the particle content in the tumour tissue. Considering the amount of work involved in preparing these histological sections, it is obvious that this is not a practicable method to obtain comprehensive information on the three-dimensional distribution of the particles in the tumour or in a laboratory animal. As part of the Priority Programme "Colloidal Magnetic Fluids" of the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), medical aspects of this technique are also being studied. The objective is to study the particle distribution with the assistance of X-ray microtomography. Because X-rays are absorbed to differing degrees by matter, depending on its density, radiography of an object provides a two-dimensional "projection" of its inner structure. Such radiographic studies became a standard medical procedure shortly after Conrad Röntgen discovered X-radiation. Whereas radiography can only provide a two-dimensional projection of the density distribution, tomography gives information on the three-dimensional distribution of the material. This is achieved by recording radiographic images from different viewing angles. These images are combined mathematically, and the three-dimensional information is back-calculated. Tomographic techniques are also standard medical procedures nowadays. However, the spatial resolution of the instruments used for this is limited to a few millimetres because they were designed for the examination of humans.

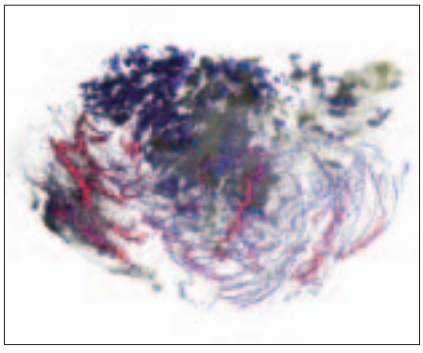
X-ray tomography has also become a standard tool in materials research. It is used, for example, to study porous structures such as metal foams and ceramics. However, owing to the small size of the objects being studied, equipment has been developed with an improved spatial resolution. Modern

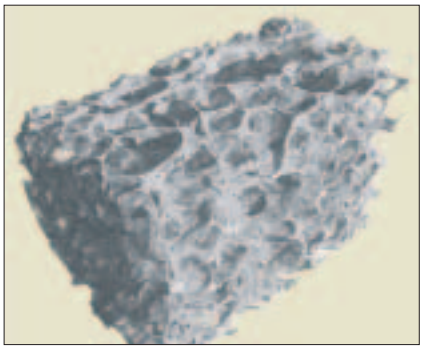
A ferrofluid influenced by a magnetic field. The combined effects of magnetic force, gravity and surface tension lead to the formation of the characteristic spiked structure. Nowadays, ferrofluids are used not only in fundamental research, but also in numerous fields of application – from engineering to medicine.











Above: Made visible: X-ray image of a mouse in an animal experiment – the skeleton can be easily seen. Left and centre: After X-ray microtomography: The distribution of the magnetic particles in a treated tumour is shown three-dimensionally. Right: The method has also proven successful in materials research. The structure of an aluminium foam used in vehicle construction.

tomography cameras, which use synchrotron radiation as a source, produce three-dimensional datasets with a spatial resolution of a few microns. In the meantime, simple laboratory instruments are able to study objects having a diameter of several centimetres with a spatial accuracy of approx. 50 microns. Thus, X-ray microtomography is an ideal method to localise magnetic particles not only in treated tumours, but also in small laboratory animals such as mice. The first results have shown that techniques of enriching magnetic particles in tumour tissue have been successful in animal experiments. The information on the spatial distribution of the particles provides information on the efficiency of the process. And it can help in optimising the application engineering, the magnetic field geometries as well as the type of magnetic particles and their coating. A new synchrotron tomography camera is currently being developed that will allow three-dimensional investigations with a high temporal and spatial resolution. This camera will be used in future projects to study the time-dependent particle distribution in test animals after dosing and will significantly reduce the number of experiments required.

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The Double Life of a Fungus

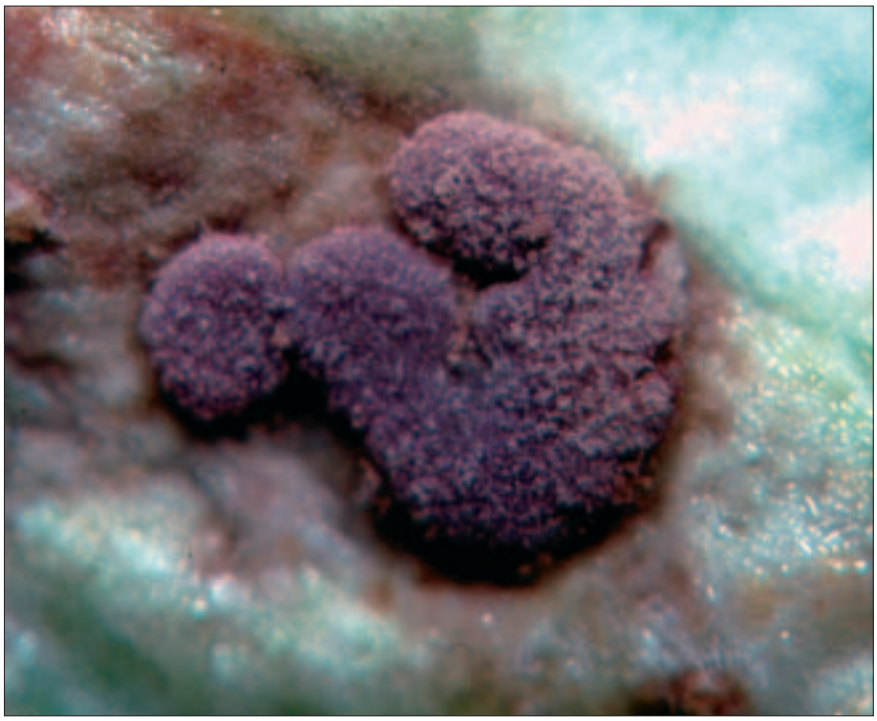
Suspected Sexual Infidelity: The transformation of sexuality to parasitism prompted the evolution of a unique fungal survival strategy – Tuberculina is both a fungi parasite and a plant parasite

Unlike chlorophyllic plants, fungi are unable to use sunlight as their primary source of energy and therefore need to compete with animals to extract nutrients from other organisms. The apparent advantage that animals have due to their bodies, which they use to digest their food as well as to move, is compensated for by the fungi by means of an amazingly simple strategy; they grow very rapidly using filaments called hyphae. Using this growth mechanism a mature fungus is able to produce hyphae several kilometres in length each day. This allows fungi to spread very efficiently and colonise almost any substrate – no crack is too small for them. Many fungi acquire their energy purely by living off dead organic matter. However, with their hyphae they are also capable of growing on and living off other living organisms too. This involves cooperation between several different fungi that exist in symbiosis and tap into the energy of their hosts, be they plants or animals, whom they in turn supply with substances that they need to survive. Others, on the other hand, simply exploit their host organism parasiti-

Violet root rot on a pear tree. It was remarkable to discover that there are fungi that are simultaneously plant parasites and fungi parasites. These Helicobasidium-Tuberculina fungi spend part of their life cycle as violet root rot living off root tissue, but during another stage of their life cycle rust fungi act as their hosts.

cally. It was the evolution of parasites, in particular, which gave rise to the most complex life cycles of all living beings, as shown here taking the rust fungi, which are plant parasites, as an example.

Juniper-pear rust, a fungus which attacks the leaves of pear trees, infects the leaves in late spring, initially forming orange pustules that contain its venereal spores on the upper leaf surface. If fertilization takes place, sporangia appear on the underside of the leaves in summer, releasing spores into the atmosphere, which enable the fungus to perpetuate its life cycle by moving to juniper as its new host plant. There the rust spreads through the branches, initially inconspicuously as swellings on the stems, only becoming apparent the next spring, when it produces two more types of sporangia, which in turn enable to recolonise and reinfect the pear trees. Strictly speaking, this cycle involves alternation of two genetically distinct stages of the rust fungus. On the pear tree the fungus has only one nucleus per cell, which is either male or female, and is in reproductive mode. On the juniper, on the other hand, each cell contains a male and a female nucleus. With these two apparently very different stages to its life cycle, juniper-pear rust is just one of many fungi that truly lead a double life.

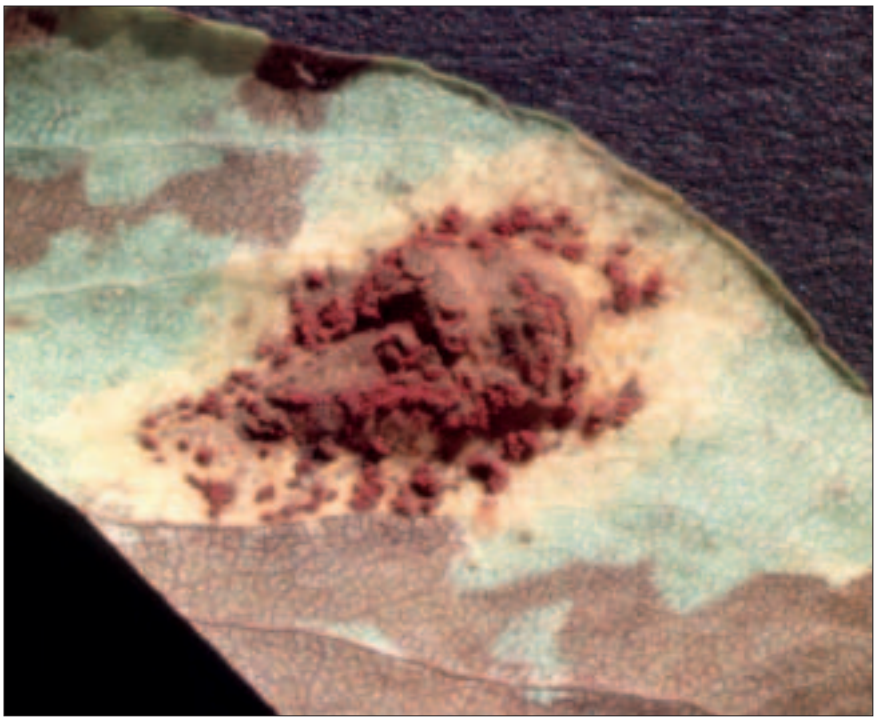


But this does not mean that rust fungi can relax and lead a peaceful existence. The fungus Tuberculina has specialised in feeding parasitically on rust fungi. Its hyphae grow through the rust and tap into its energy resources. Whilst genetic analyses have been able to demonstrate that Tuberculina and the rust fungal hosts with which it is intimately intertwined are very closely related, but that they are indeed two different fungi, the analyses produced a surprise from another point of view. It was found that Tuberculina also has a second, entirely different stage in its life cycle, Helicobasidium, a fungus which leads to violet root rot. Helicobasidium is a plant parasite that covers its host's roots in a dense mat of hyphae, which then penetrate and subsequently destroy the root tissue. The idea that Tuberculina and Helicobasidium are in fact two forms of one and the same fungus seems incredible at first, as it reveals a unique developmental pathway. This group of fungi is the only one that needs to switch between hosts from the kingdoms of fungi and plants in order to be able to complete its life cycle.

Recent studies have surprisingly shown that Tuberculina also has a second stage in its observed life cycle.

In order to be able to fully understand the developmental path that connects the two distinct stages, experiments were conducted to test infection by the two forms. Only for a brief period in the spring does Helicobasidium appear above ground and release spores. These spores are carried away on the wind and, with a little luck, come to rest on a leaf that has already been infected by a rust fungus. There the spores

can quickly germinate and grow towards the rust, where they then use the point of entry created by the rust to enter the leaf. What is more, Tuberculina is capable of forming spores again within just three days of making contact with the rust. These spores ooze out of the leaf and are carried off by the wind to infect more rust fungi elsewhere. The life cycle is completed by the formation of little balls of swollen hyphae, which hang from the underside of the leaves and fall to the ground when the leaves fall in the



An amazing life: Tuberculina looks like a purple sponge when growing on rust fungi. Below: The parasitic juniper-pear rust grows as orange pustules on pear leaves. The pustules then release the fungi's spores. Above: If juniper-pear rust is infected by Tuberculina it becomes unable to produce spores, and is thus no longer able to propagate.

autumn. Having fallen to the ground, they are then able to infect the roots. The question is: how does a fungus end up with such a remarkable life cycle? How can an organism develop the ability to be a parasite of two hosts that are so entirely different? Rust fungi are plant parasites. Why, then, are the closely related Tuberculina and Helicobasidium species not solely plant parasites, but also fungi parasites?

The first thing that stands out is that the rust fungi are only infected by Tuberculina during their sexually active phase. Juniper-pear rust is only attacked while on the pear, for instance, not while on the juniper. Taking a look at the parasite, we see the same phenomenon. Tuberculina-Helicobasidium fungi are only able to infect rust fungi during their sexually active Tuberculina stage. This is, thus, a liaison between two sexually active organisms. But how does Tuberculina recognise when the rust is in the right stage of its life cycle? The answer to this question may be that the Tuberculina-rust parasitism developed from a sexual reaction between their common ancestors. This sexual reaction would thus have been transformed into a "parasitic interaction" through the developmental separation of the two groups over the passage of time. The next question to be asked then is, is the method of interaction between Tuberculina and the rust fungi hosts actually a sexual reaction? At points of contact the cell walls of both fungi dissolve over a large area and the cytoplasm start to mix. Then cell nuclei from the parasite invade the cells of the rust fungus. This apparently takes place without any perceptible defence mechanism on the part of the rust that has been infected. Interestingly, the interaction between the plant parasite in the Helicobasidium stage and the plant's root cells is entirely different. Helicobasidium grows through its host's cells, in a fairly conventional way, taking up nutrients through the cell wall. Additionally, recent experiments indicate that the parasitic behaviour is even gender-specific. In other words, only a female Tuberculina strain can infect the male part of the rust, and vice versa. There are, therefore, arguments in favour of the hypothesis that the infection process is indeed a reinterpreted form of sexual function. Tuberculina evidently approaches the rust fungus and masquerades as a sexual partner. The act of "sexual intercourse" begins and Tuberculina and the rust merge. But the rust is fooled and the Tuberculina that it saw as a sexual partner is suddenly a parasite, smuggling its cell nuclei into the rust's cells and feeding on them. The Tuberculina-rust parasitism is a research model of general interest for studying types of parasitism and the way they evolve. The revelation of the life cycle described above also has practical applications. For instance, in the past attempts were made to use Tuberculina as a biological means of counteracting the damage done by rust fungi, for example in forestry. The discovery of this interaction between Tuberculina and rusts gives us the new insight that Tuberculina can only be used to infect the rust fungus during one specific stage of its life cycle, meaning that its use as a means of combating rust is only likely to be successful if its use is very carefully timed. Far more important, however, is the realisation that the apparent savour, Tuberculina, can itself potentially develop into a serious plant parasite during its Helicobasidium stage. This makes it clearly evident just how important it is to fully understand the biology of any organisms which are to be used commercially.

How does Tuberculina recognise the stage in the rust fungi's life cycle during which it is susceptible to exploitation?

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PD Dr. Robert Bauer
Prof. Dr. Franz Oberwinkler
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The Deutsche Forschungsgemeinschaft

The DFG (German Research Foundation) is the central self-governing organisation responsible for promoting research in Germany. According to its statutes, the DFG serves all branches of science and the humanities. The DFG supports and coordinates research projects in all scientific disciplines, in particular in the areas of basic and applied research. Particular attention is paid to promoting young researchers. Researchers who work at a university or research institution in Germany are eligible to apply for DFG funding. Proposals will be peer reviewed. The final assessment will be carried out by review boards, the members of which are elected by researchers in Germany in their individual subject areas every four years.

The DFG distinguishes between the following programmes for research funding: In the *Individual Grants Programme,* any researcher can apply for financial assistance for an individual research project. *Priority Programmes* allow researchers from various research institutions and laboratories to cooperate within the framework of a set topic or project for a defined period of time, each working at his/her respective research institution. A *Research Unit* is a longer-term collaboration between several researchers who generally work together on a research topic at a single location. In *Central Research Facilities* there is a particular concentration of personnel and equipment that is required to provide scientific and technical services.

Collaborative Research Centres are long-term university research centres in which scientists and academics pursue ambitious joint interdisciplinary research undertakings. They are generally established for a period of 12 years. In addition to the classic Collaborative Research Centres, which are concentrated at one location and open to all subject areas, the DFG also offers several programme variations. Transregional Collaborative Research Centres allow various locations to cooperate on one topical focus. Cultural Studies Research Centres are designed to support the transition in the humanities to an integrated cultural studies paradigm. Transfer Units serve to transfer the findings of basic research produced by Collaborative Research Centres into the realm of practical application by promoting cooperation between research institutes and users.

DFG Research Centres are an important strategic funding instrument. They concentrate scientific research competence in particularly innovative fields and create temporary, internationally visible research priorities at research universities.

Research Training Groups are university training programmes established for a specific time period to support young researchers by actively involving them in research work. This focuses on a coherent, topically defined, research and study programme. Research Training Groups are designed to promote the early independence of doctoral students and intensify international exchange. They are open to international participants. In International Research Training Groups, a jointly structured doctoral programme is offered by German and foreign universities. Other funding opportunities for qualified young researchers are offered by the *Heisenberg Programme* and the *Emmy Noether Programme.*

The Excellence Initiative aims to promote top-level research and improve the quality of German universities and research institutions in the long term. Funding is provided for graduate schools, clusters of excellence and institutional strategies.

The DFG also funds and initiates measures to promote scientific libraries, equips computer centres with computing hardware, provides instrumentation for research purposes and conducts peer reviews on proposals for scientific instrumentation. On an international level, the DFG has assumed the role of Scientific Representative to international organisations, coordinates and funds the German contribution towards large-scale international research programmes, and supports international scientific relations.

Another important role of the DFG is to provide policy advice to parliaments and public authorities on scientific issues. A large number of expert commissions and committees provide the scientific background for the passing of new legislation, primarily in the areas of environmental protection and health care.

The legal status of the DFG is that of a private association. Its member organisations include research universities, the Academies of Sciences and Humanities, the Max Planck Society, the Fraunhofer Society, the Leibniz Association, the Helmholtz Association of National Research Centres, research organisations of general importance, and a number of scientific associations. In order to meet its responsibilities, the DFG receives funding from the German federal government and the federal states, as well as an annual contribution from the Donors' Association for the Promotion of Sciences and Humanities in Germany.

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Illustrations

Oesterreich (cover); Querbach (p. 2); Forschungsinstitut für deutsche Sprache/Deutscher Sprachatlas (pp. 4-6); Armbruster (p. 7); Will (pp. 8/9); Ertl (p. 9 b.); Superbild (p. 10); Wöste (pp. 11-13); Winandy (pp. 14,15, 16 c. and b.); Trautwein-Bruns (p. 16 a); Oesterreich (p. 17); DFG-Schwerpunktprogramm 1104 (pp. 18-20); Lutz (pp. 21-23); Lichtenscheidt (back).

Layout of pictures: l.: left; r.: right; a.: above; c.: centre; b.: below

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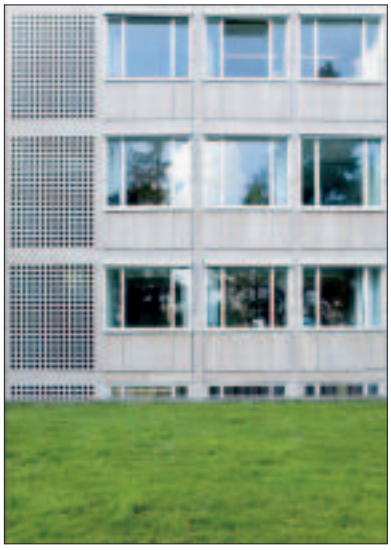

The architecture of the DFG Head Office in Bonn, designed in 1954 by Sep Ruf, is characterised by its clear structures. After undergoing several additions, the office now accommodates over 700 employees working in the field of research promotion.