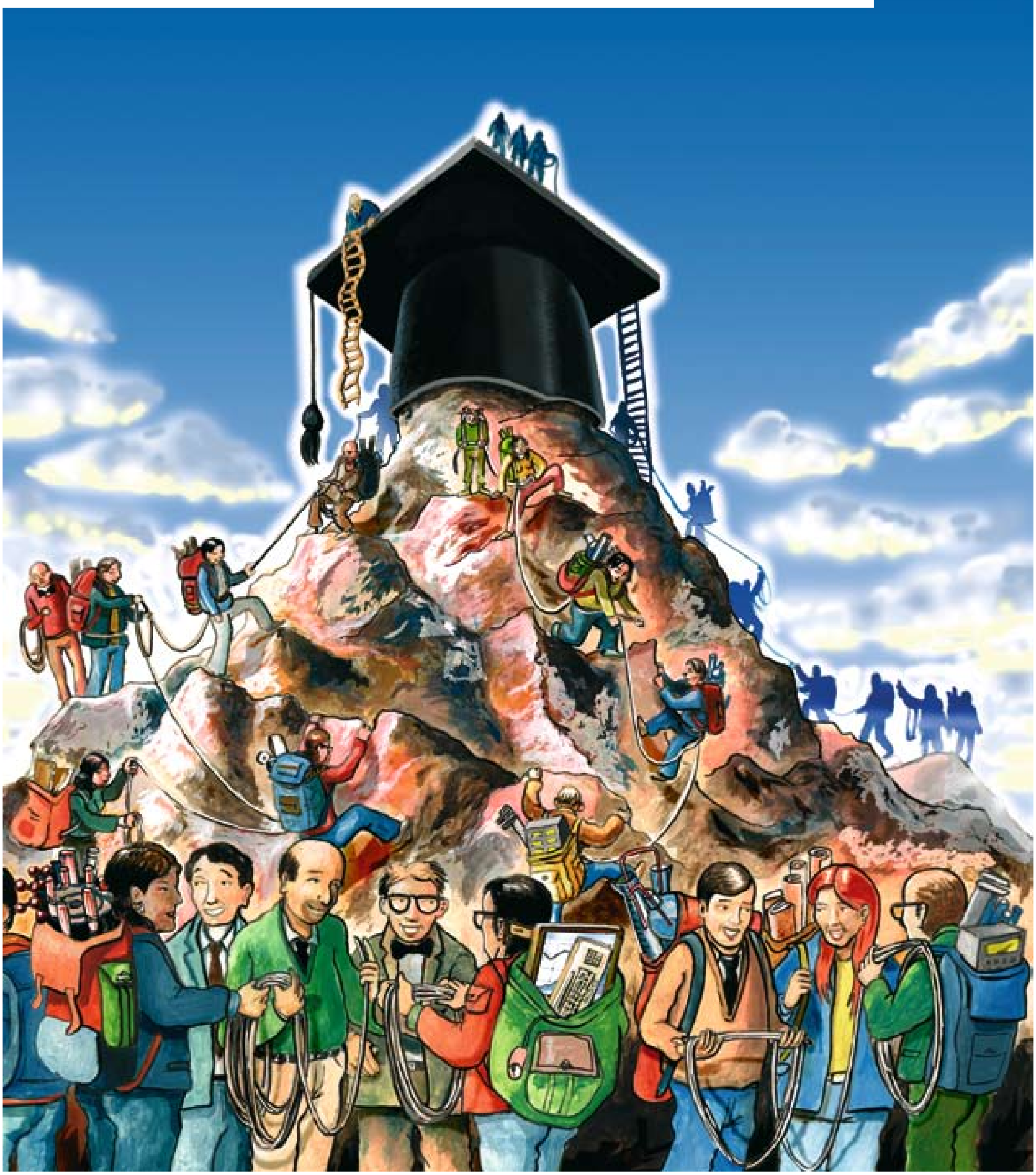
# Research Training Groups

of the Deutsche Forschungsgemeinschaft





DFG

Obtaining a doctorate under ideal conditions in DFG Research Training Groups

# Structured doctoral training programmes

*by Ernst-Ludwig Winnacker*

Obtaining a doctorate is at the same time the last stage of study and the first stage in life as a researcher. In this decisive phase all doctoral candidates need to be given the necessary latitude to carry out independent scientific work, develop their own ideas and earn recognition for their work. They also require a demanding research environment that provides stimuli, makes exchange possible and, where necessary, ensures specialist support. The Research Training Groups (RTGs) funded and promoted by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) have, since their inception 15 years ago, contributed in an exemplary way to creating these conditions for doctoral candidates.

At one time it was typical for doctoral candidates to write their theses alone in "ivory towers" or as "apprentices" to their – mostly male – doctoral supervisors, with varying degrees of assistance and support. However when, in the 1980s, the annual numbers of doctorates increased to five figures and the time taken to obtain a doctorate became increasingly longer, the existing model of individual support and supervision began to reach its limits. Consequently, in 1990, a new funding instrument for structured doctoral training was established and the first RTGs were set up.

A Research Training Group is a university training programme, set up for a maximum of nine years, which enables particularly well-qualified doctoral candidates to obtain a doctorate quickly and under excellent conditions. It is run by a small group of committed and respected scientists and comprises a coordinated research programme, dedicated to focused and topical questions, and a tailor-made programme of studies. This imparts the necessary specialist knowledge in order to develop a doctoral thesis of the highest possible quality within the targeted time limit of three years. Additionally, it ensures a profound introduction to the branch of science in which the work is being carried out and can, depending on the subject, include practical experience in companies, language and presentation courses, technique workshops, etc. The university teachers who apply for RTGs are very flexible in their arrangements – what is important is that the doctoral candidates are provided with both the specialist knowledge and the skills that they will need as they strive for an academic or non-university career after obtaining their doctorate. The doctoral candidates are to direct their gaze beyond the limits of their own subject, design "their" RTG themselves and be able to practise scientific independence at an early stage.

The comprehensive offer is intended to support the doctoral candidates in their work, but not to take up too much time. On the contrary, RTGs and structured doctoral training programmes aim to limit the time to degree and lower the age at which doctoral degrees are conferred. Enabling doctoral candidates to concentrate entirely on the completion of their doctoral theses in the RTG considerably shortens the length of time needed to earn a doctorate. On average, DFG-funded doctoral candidates achieve their doctorate six months faster than their colleagues who are funded elsewhere, and at the conclusion of their doctorate are, on average, two years younger than their counterparts in Germany. However, the target mark of 36 months for earning a doctorate has not yet been achieved by the others, either.

A survey, carried out at the end of 2004 by the "Thesis" doctoral network on the situation of doctoral candidates, showed that one in three doctoral candidates felt that they were poorly supported and supervised. Another factor that is often criticised is the frequent dependence on a supervisor who is at the same time the employer. Deficiencies in the support of doctoral candidates are obviously not restricted to Germany. Indeed the European representation of doctoral candidates, "Eurodoc", in its recommendations on doctoral reform (submitted together with the European University Association in February 2005) called for, among others, transparent supervisory and support structures with clearly defined responsibilities. This is already established practice in the Research Training Groups: here the allocation of each student to one supervisor has in most cases been replaced by a double or multiple supervision and support system, especially in the case of interdisciplinary subjects, and/or by the additional appointment of tutors or mentors.

As the examples in this booklet clearly show, there are RTGs in all research fields. At the moment, the humanities and social sciences, the natural sciences, and the life sciences (i.e. biology and medicine), each have about 30% of the Research Training Groups. The remaining 10% are in the engineering sciences, and this is increasing. Most of the RTGs have an interdisciplinary orientation and that is no accident, since it is becoming increasingly clear that progress in science is made at the interfaces between the disciplines. Interdisciplinary, innovative projects are ideal for creating a good basis for the next generation of researchers and their scientific future.

An outstanding feature of the Research Training Group is its international character. The percentage of international doctoral candidates has increased steadily over the last few years and is approaching the 30% mark (almost three times as high as the German average!). Of the international doctoral candidates, approximately 26% come from Western Europe, 35% from Eastern Europe, 24% from Asia and the remaining 15% from other regions. In addition, the number of applications from abroad has risen sharply. In view of the international competition for the much sought-after new generation of young scientists, this is a gratifying indication of the attractiveness of the RTGs, all of which have intensive contacts with international scientists.

In this day and age scientific progress is impossible without international networking. Therefore it is an important criterion when reviewing proposals for setting up RTGs. The doctoral candidates in RTGs are involved in international cooperation at an early stage, both by means of lectures and visits from international guest scientists, and through participation in congresses and relatively long research stays at foreign host institutes.

There has been a marked increase in the number of International Research Training Groups (IRTGs), in which a group of German university teachers cooperate with a partner group abroad. Currently more than 40 IRTGs exist, most of them with European universities, but also three with the USA, three with China and one, quite recent, with Japan. This variant of the Research Training Groups was introduced in 1997 in order to take into account the international networking of sciences and to permit systematic joint training of doctoral candidates across national borders. In the case of the IRTGs, the same standards of excellence apply to applicants as in the case of the national groups. Both sides must jointly run a high-calibre research and study programme, and the supervision and support necessary for obtaining a doctorate are also provided jointly, as a rule by one supervisor at the home institute and one at the partner institute. For the doctoral candidates in the groups involved, a stay lasting approximately six months with the respective partner is envisaged. Right from the start of their careers as researchers, the candidates in IRTGs become familiar with different science systems "from the inside" and also profit from complementary expertise and different research approaches.

Establishing such IRTGs not only leads to closer networking at the level of the doctoral candidate, but also at the sponsors' level. For example, bilateral agreements have already been reached with a large number of partner organisations and ministries worldwide concerning the joint financing of International Research Training Groups. Particular commitment is shown by the German-French University DFH and the French Ministry of Education, the Graduate University of the Chinese Academy of Sciences and the Chinese Ministry of Education, as well as by the research funding organisations in the Netherlands (NOW), Hungary (OTKA) and Japan (JSPS); more agreements are in the works.

An estimated 6% of all doctoral candidates in Germany conclude their doctorate studies at a DFG Research Training Group. In specific terms, more than 6,000 young scientists write their doctoral theses in the approximately 270 RTGs currently in existence, an average of 22 to 25 doctorates per RTG. Of these, approximately two-thirds receive their fellowships from DFG funds; the others are doctoral candidates financed from other funds, who participate equally in the study programme and can also be granted travel funds. In total, the DFG has financed almost 600 Research Training Groups since the beginning of the programme.

A central aim of the programme is to contribute to the reform and further development of the phase leading up to the award of a doctorate. Research Training Groups give universities the incentive and ability to create and try out new structures for the promotion of the new generation of scientists. In this way, they make models and experience available for more diversified and permanently installed programmes for doctoral candidates. The existing models of structured doctoral training programmes – in addition to the DFG, for example the Max Planck Society and several German states also support similar programmes – have set new standards for guiding doctoral candidates and measuring university teachers. A DFG symposium in the summer of 2003 showed that there are outstanding examples of structured promotion of doctoral candidates throughout Germany, and that meanwhile in various places and in various fields of science, research training centres have arisen or are in the process of being created. It has also become clear that there are subject-specific admission requirements and subsequently different doctoral cultures, and that these should continue to exist. It is an accepted fact that no reform may question the tried and proven elements of the German doctoral courses – above all their scientific profundity. This principle applies in particular to the inclusion of study up to a doctorate as a "third cycle" – after the Bachelor and the Master – in the Bologna Process.

The DFG is not in a position – nor is it obliged – to set up Research Training Groups across the whole country and make it possible for all university graduates to earn a doctorate in one of its structured programmes. In future it would like to concentrate even more on promoting RTGs that set examples and show a model character of innovative forms of supervision and support, for all the various generations of scientists. The established measures must be given support by the universities or the federal government – to paraphrase Benjamin Franklin: "An investment in the young scientific generation always yields the most interest."

*Prof. Dr. Ernst-Ludwig Winnacker is President of the DFG*

# Facts that Einstein did not know

At the Institute of Quantum Optics, part of the University of Hanover, two small glass vacuum tanks are at the heart of an experimental set-up: in them young scientists plan to reveal the quantum nature of matter.

The peculiarity of quantum physics is that in the microscopic world the accustomed distinction between waves and particles becomes blurred. Depending on the way they are considered, light waves are made of photons, quanta of electromagnetic energy, or particles of matter in their state of energy appear as waves. If this sounds like sorcery we need not feel frightened: After all, even the fathers of the quantum theory, Max Planck and Albert Einstein, wrangled with the consequences of their discovery throughout their lives. As bizarre as the theory may seem it has been repeatedly proven correct, right up to the present day.

Thorsten Henninger, studying for a doctorate at the European Research Training Group "Interference and Quantum Applications" in Hanover, would like to take a good look at quantum effects – he wants to cause atoms to lose their individuality and merge in a gaseous state, he wants to collect matter in what is referred to as Bose-Einstein condensate in such a way that he can "photograph" the quantum-mechanical wave functions. As early as 1995, American researchers cooled several thousand rubidium atoms to such an extent that they behaved like one single super atom. Rubidium atoms belong to the boson class, which are atoms that have an altogether even number of protons, neutrons and electrons. Such particles always strive for the same state. It is only because of this herd instinct that they can condense to form a wave packet, provided that Brownian motion due to the temperature is not too strong. However, Thorsten Henninger wants to go one step further – he wants to cool down not only bosons, but also fermions (atoms that do not have an even number of protons, neutrons and electrons), to close to absolute zero,

> *"Interference is the link that holds the Research Training Group's topics together."*

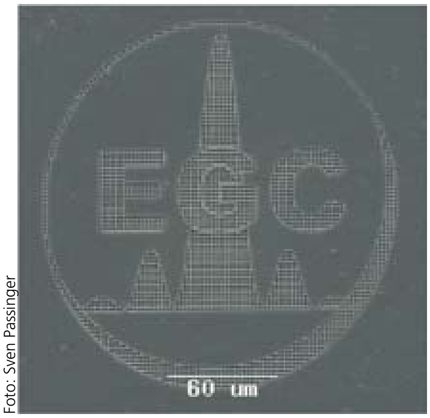
which is about -273 degrees Centigrade. Such atoms behave in an opposite way to bosons: they repel each other, which means they are at different locations, move at different velocities or are distinguished from each other in some other way.

In the experiment, bosonic rubidium (isotope 87) and fermionic potassium (isotope 40) are in a vacuum system. The physicist bombards the atoms from six directions with laser beams of a particular wavelength, cooling them down. A magnetic field draws the cold atoms into the middle. Once in the magnetic trap they are cooled further by evaporation. The rubidium atoms now form a condensate; at the same time the potassium, since it is a fermion that cannot be condensed, forms a cloud. If the rubidium and potassium atoms are illuminated with two different colours, the compact condensate in the diffuse cloud of potassium can be photo-

Foto: MPI für Gravitationsphysik

*The working environment for the gravitational wave detector GEO600, showing the vacuum tanks and pipes in the clean room.*

Foto: Sven Passinger




*The logo of the European Graduate College, EGC, traced here in nano-dimensions with a laser beam by Sven Passinger.*

graphed. By selecting an appropriate magnetic field, the rubidium and potassium are then artificially linked to form a molecule. "We want to show, for the first time, how fermionic potassium/rubidium molecules are physically produced," says Thorsten Henninger.

How the "pointlike particles", the atoms, in a Bose-Einstein condensate can be aware of each other can only be accounted for by their wave nature. Particle waves form an interference pattern just as light does. Such a pattern may, for example, reveal itself in the iridescence of a soap bubble. Even if two condensates are superimposed they form typical interference stripes. "Interference is the link that holds our Research Training Group together," explains Professor Eberhard Tiemann, spokesman for the RTG. In Hanover scientists are not only investigating the interference of matter waves, in order to understand fundamental phenomena such as Bose-Einstein condensates, but also using light and its interference possibilities, in order to tackle quite different problems.

The Quantum Theory was one of the 20th century's great revolutions in physics, and Einstein's General Theory of Relativity was the other. In this theory, gravitation is no longer described as a force of attraction as in Isaac Newton's work, but rather as a warping of space-time – large masses bend the geometry like a heavy ball on an elastic membrane, and as the forces change this warping must follow. The wavelike structures arising from this lead to very slight variations of the distances between all objects in space. In Ruthe, near Hanover, scientists are now waiting for a star in the Milky Way (or not too far away from our galaxy) to explode as a supernova, or for two black holes to collide, as that would give them an opportunity to measure the gravitational waves that are transmitted as a result – similar to the waves in water when you throw a stone into it.

Michaela Malec is also eagerly awaiting such an event. "The gravitational waves are so weak that the distance between the Earth and the sun would change only by the diameter of an atom in the event of the explosion of a star in our galaxy. Therefore we require extremely precise measuring instruments to discover changes in distances." GEO600 is such an instrument, and it functions in accordance with the principle of a Michelson interferometer. It measures changes in distances with the help of light running times between mirrors. Some mirror arrangements, which is what is special about these detectors, intensify the circulating light power up to 1,000 times and hence permit the desired, highly precise measurements. GEO600 is one of six gravitational wave detectors in existence worldwide. Some years from now – in cooperation with ESA and NASA – LISA will also go into service. LISA is a gigantic interferometer, consisting of three satellites, intended to detect gravitational waves in outer space. "LISA will be concentrating on different frequency ranges of gravitational waves than the ones the terrestrial detectors listen for," says Michaela Malec. "But the latter are not in competition with one another, either. On the contrary, if one detector measures something, another one must acknowledge the signal in order to be certain that these are not disturbance signals from other sources, such as seismic vibrations or fluctuations of the laser intensity or frequency."

The physicist is investigating sub-systems on the computer, with a "virtual detector", in order to separate out such disturbances in simulations. "In that way we can identify the problem and, if it is of a technical nature, systematically eradicate it," Malec explains. In the autumn she will complete her doctorate, jointly supervised at Hanover and Glasgow universities. GEO600 is a joint British-German project in which the Albert Einstein Institute of the Max Planck Society is participating. Michaela Malec did six months of research work at the Scottish university, a partner in the European Research Training Group. "That was immensely valuable to me," she says enthusiastically.

There is also cooperation between the Research Training Group and the University of South Paris in Orsay. The students in the Research Training Group from Hanover, Orsay and Glasgow will gain experience through the international exchange of ideas and knowledge and organised workshops, and joint doctorates are also an important aim. "As the procedures for obtaining a doctorate vary widely across the European countries, we draw up a separate contract for each candidate," explains Eberhard Tiemann. Additionally, Hanover itself provides a stimulating environment for doctoral candidates. For example the DFG Collaborative Research Centre "Quantum-limited Measuring Processes with Atoms, Molecules and Photons" is located here, and close cooperation with the Albert Einstein Institute and the Hanover Laser Centre also exists. The students of the RTG like this very much. "We don't want to be one-track specialists," says Thorsten Henninger.

*"The time I spent at the British partner university was immensely valuable to me."*

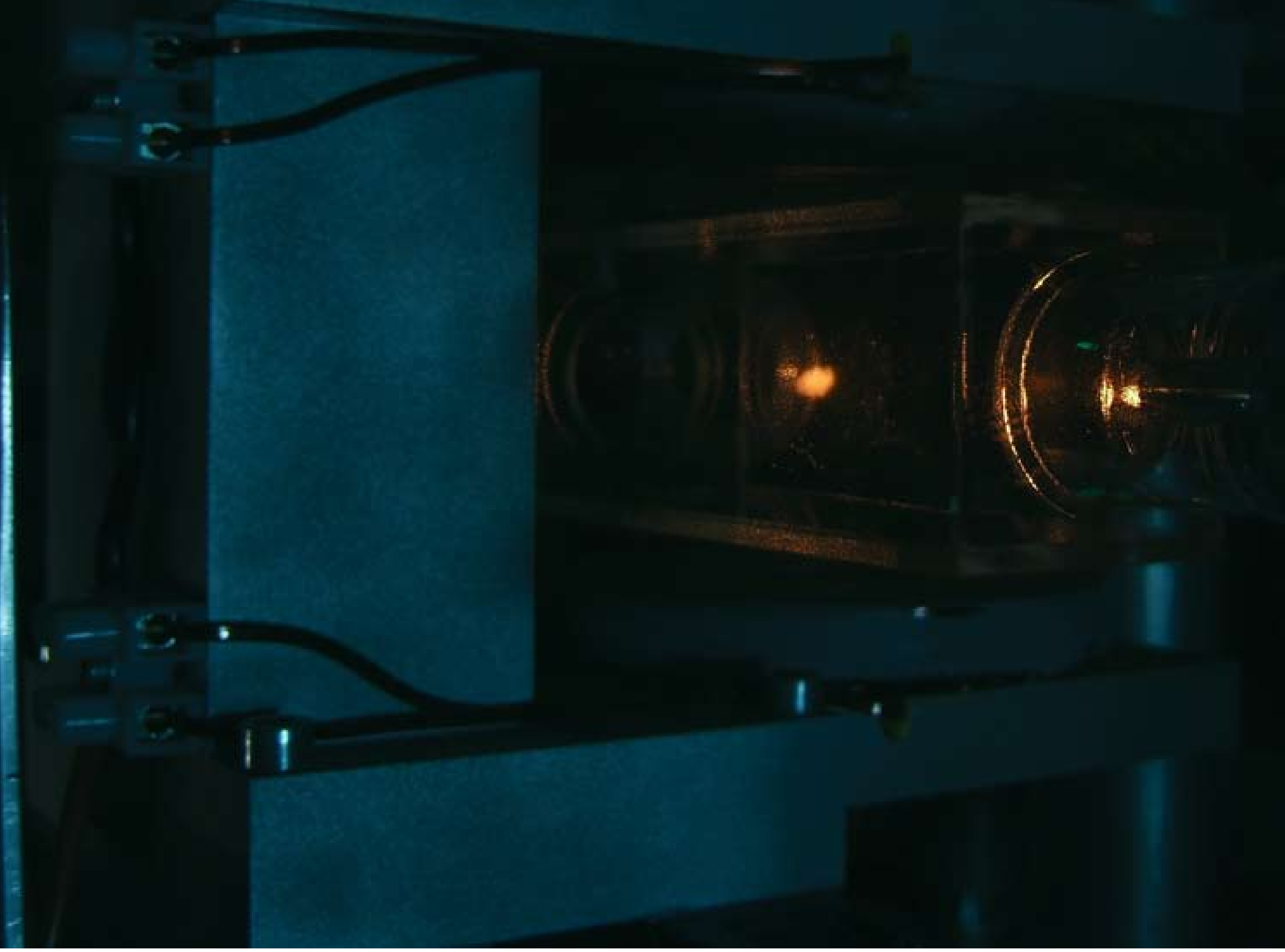


Foto: Thorsten Henninger

*A red rubidium cloud near absolute zero, approximately -273 degrees Centigrade – Thorsten Henninger renders the wave nature of matter visible.*

The laser centre is Sven Passinger's workplace. The doctoral candidate is working on a rather practical side of interference and quantum effects: nanotechnology. "The enormous progress in this field makes it possible for us to produce new photonic materials, such as photonic crystals," he reports. In photonic crystals the refractive index on the scale of the wavelength of light is periodically modulated; the light no longer disperses and so none is lost. In future semiconductor materials with photons could replace the semiconductor materials with electron transport that we use today, for example in computer chips or general information processing circuits. Because photons are much faster, telecommunications and computer technology could be accelerated.

The process with which Sven Passinger produces such new structures is called two-photon polymerisation. He focuses a femtosecond laser beam into a resin that is actually transparent for light of the wavelength used but is light-sensitive with half the wavelength, and the resin then polymerises at the points bombarded by light and so hardens. This is successfully achieved through the two-photon absorption. In this case, use is made of the fact that two photons from the laser beam have the same energy as a photon of half the wavelength. As the photon density is only high enough when in focus, polymerisation only takes place when it is also in focus. In this way Sven Passinger can write three-dimensional structures into the material with the help of the laser beam and then chemically remove the areas not bombarded. In the process he achieves a resolution of up to 100 nanometres (millionth of a millimetre). He can supplement this method if he superimposes four laser beams spatially and temporally so precisely that a periodic interference pattern is obtained. The advantage in this case is that large volume structures, up to several cubic millimetres, can be produced with a resolution in the nanometre range. He describes his vision as follows: "The main attraction of photonic crystals would be if one could succeed in using a material with a high index of refraction so that the light can, so to speak, be steered around the corner. The glass fibres used today for data transmission run in quite large curves and a 90 degree bend would revolutionise telecommunications."

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*"We appreciate the close contact to various institutes."*

# School as a laboratory

In recent years the international comparative school achievement studies TIMSS and PISA have revealed only poor to mediocre results for German schoolchildren for mathematics, science and reading literature. In particular, applying scientific concepts seems to be difficult for German 15-year-old pupils. As a consequence numerous questions are being asked by a public concerned with the teaching and learning of science at school. "In this context it is important to know what tasks and problems science teachers actually use in lessons," says Paul Jatzwauk, "otherwise we will never be able to find out why German schoolchildren's achievements are so poor". Could they really not solve the problems or exercises in the achievement tests, or were they simply not used to dealing with a certain type of questioning?

*"Why did German schoolchildren achieve such poor results in comparative studies?"*

Paul Jatzwauk, who studied to become a teacher of history and biology in Leipzig, is now writing his doctoral thesis at the University of Duisburg-Essen on the "Use of tasks in biology lessons". Although exercises and problems are of central significance with regard to motivating pupils and helping them learn, and although teachers frequently structure their biology lessons using exercises and problems, there are few empirically underpinned findings on their use worth mentioning, according to Jatzwauk.

His work is part of an extensive research programme at the Research Training Group "Teaching and Learning of Science", which is attached to a Research Unit of the same name in Essen. "In a closely enmeshed way we examine the problems of the teaching of the natural sciences at the level of the schoolchildren, the teachers and the school system as a whole," explains Professor Elke Sumfleth, spokeswoman of the RTG.

Psychologists, researchers in chemistry, physics and biology education and education researchers have gathered together in Essen for closely networked research and are together providing the interdisciplinary dimensions to the "Empirical Education Research" programme of the University of Duisburg-Essen. In particular, cooperation with the psychologists involved is something which Sumfleth, herself a chemistry educator, has come to appreciate. "That is where the methodological competence for our empirical research comes from, something which was perhaps a bit underestimated in the didactics of natural sciences in the past," she says.

*"The doctoral theses are tied closely to the DFG Research Unit."*

What is presumably unique at a German university is the networking between a Research Unit and a Research Training Group, both funded by the DFG. "From the theoretical and the research methodological point of view the the-

Graduiertenkolleg Naturwissenschaftlicher Unterricht

Video recordings are an important instrument for the empirical research in the RTG "Teaching and Learning of Science".

ses of the fellows will be tied closely to the Research Unit, which contains several interdisciplinary projects dealing with the improvement of teaching in the natural sciences," says Elke Sumfleth.

For his doctoral thesis, connected to the project "Tasks and Problems in Teaching Natural Sciences", Paul Jatzwauk has selected a sample of 25 biology lessons at the class level 9 (roughly equates to 16-year-olds or 5th form) at various upper secondary schools in North Rhine-Westphalia. His analytical interest is focused on the features and requirements of exercises and problems used in biology lessons, the way they are used and the difficulties of pupils when dealing with those tasks.

*"Experimenting places high demands on learning."*

To illustrate the process nature of teaching and to analyse interaction and instruction sequences he uses video recordings. For deeper analysis of the videos he has developed a special system of categories. Finally, he would like to answer the question as to how the characteristics of the use of tasks and problems in biology lessons are reflected in schoolchildren's achievements. He hopes that one day he can make a contribution to guides for everyday teaching being developed on the basis of basic research.

The holder of a degree in psychology from Bochum University, Hubertina Thillmann deals, in her doctoral thesis, with the analysis and promotion of learning by experimenting in natural science lessons. Teachers still consider experimenting in these subjects as the method of choice for arousing the interest of the pupils, motivating them to learn, training their ability to cooperate and conveying to them the natural scientific way to acquire knowledge.

From relevant literature and from other research work within the project "Diagnosis and Promotion of Learning and Problem-Solving Processes in Natural Science Teaching", Hubertina Thillmann knows that, contrary to expectations, the learning effectiveness of classroom experiments conducted by schoolchildren themselves is quite low. She wants to find out why the expected learning success is so seldom achieved. One possible reason, she suggests, could be found in the specific regulatory demands of learning through experimenting. Since in this case, unlike conventional learning with texts, the information must not only be absorbed and retained, but must first of all be generated by systematic experimenting.

In order to do research on pupils' regulatory competence required for classroom experiments, Hubertina Thillmann is using a computer-assisted learning environment in which the way the pupils proceed during experimenting is recorded online. She can subsequently analyse, for example, how the child regulates the progress of his/her own learning process. "I initially use the computer-based experimenting environment as a diagnostic instrument. It was developed in the Research Unit, as a diagnostic instrument," she states.

In a further step the results of her doctoral thesis are intended to contribute to one day being able to individually assist schoolchildren so that they are able to learn more successfully, based on the experiments carried out in the natural sciences. Her hope is that teachers are "better able to motivate their pupils for self-regulated learning".

Alexander Kauertz completed a course of study for a teaching post in mathematics and physics in Dortmund. With his doctoral thesis he has set himself the aim of developing an achievement test in physics for schoolchildren at the 10th year level (approximately 16-17-year-olds). His thesis is related to the project "Vertical Linkage and Cumulative Learning in Natural Science Lessons". One of his ideas involves addressing the complexity and inner networking of the facts and relationships for physics teaching in a new way. "The conventional structure of text books and curricula, with headings such as optics, electricity or mechanics, does not support learning," he says, and postulates that learning physics is easier for pupils if they get to know the subject matter through a vertical linkage. His concept contains some basic ideas: "Matter, energy or nature of science make it possible to repeatedly look at certain physical contents – but always from a different point of view."

In practical terms, teaching according to basic ideas means that concepts, once they have been learned at successive year levels, are always increasingly differentiated, broadened and deepened. The content is therefore continued and each aspect becomes more and more strongly interlinked over the course of time. "In this way cumulative learning becomes possible", Kauertz says, "and pupils have a chance to use what they already know for learning new physics concepts."

Following up the concept of basic ideas, Kauertz is constructing tasks for a physics achievement test. There must be at least approximately 150 items to be able to measure and diagnose pupils' physics achievement. "The construction of the physics items is the most sensitive and difficult part of my work," he says. Once they are later established in the school system, Kauertz hopes teachers will want to ensure that their pupils pass the test. "Then things will get exciting. As the items of the achievement test correspond to the concept of the basic ideas, in a backwash effect it will turn out that one day physics teaching in general will function according to this principle."

*"How can physics knowledge already acquired be used for learning new concepts?"*

***db***

# The dream of a hale and hearty Methuselah

At the age of only 27, Tanja Maresch should actually have other things to worry about. But the biochemist studies wrinkles with obvious enthusiasm. It is on the outer shell of our body that it first becomes apparent that youth is ephemeral. In the course of life, damage and defects unavoidably accumulate within the body – in the genes, the proteins or lipids. Typical degenerative changes manifest themselves on the skin, in muscles, in bones, and in our eyesight and hearing. “The population is growing increasingly older,” says Tanja Maresch and means this in a double sense. Although the great successes in medicine have enormously increased our life expectancy, they still cannot stop the process of ageing.

Since time immemorial we have wanted to slow down the ticking of our biological clocks but are only just beginning to understand how ageing is triggered at the molecular level. Tanja Maresch is studying for her doctorate in the Research Training Group “Molecular Targets of Ageing Process and Strategies for the Prevention of Ageing”, based at the Institute for Environmental Medicine at the University of Düsseldorf. “It is known today that oxidative stress is one of the main factors triggering and maintaining ageing processes,” says Professor Jean Krutmann, spokesman of the RTG. This stress is caused by free oxygen radicals or oxidants; but exactly what mechanisms they spark off in the organs in each case is still largely unknown.

Free radicals arise as perfectly normal waste products in the cell metabolism, created by the mitochondria found inside each cell.

*Tobias Jung studies how defective proteins are distributed in nerve cells and how to put an end to them.*


Foto: Tobias Gremmel

Several hundred of these organelles colonise every cell and each one has double-strand DNA rings with 37 genes at their disposal that participate in metabolism. The mitochondria generate energy in the form of adenosine triphosphate (ATP), and at the same time produce free radicals, oxidants that have an unpaired electron and are therefore very reactive. This is the cause of oxidative stress; in order to obtain the missing electron, the free radicals attack cell constituents including the proteins of the respiratory chain and the mitochondrial DNA, which is only slowly repaired. In young cells the free radicals are kept in check by protective mechanisms, the anti-oxidants, but during the ageing process the balance shifts in favour of the aggressive substances.

The concentration of free oxygen radicals increases the speed at which we age. It is determined by the predecessors within the cell but also by external factors, such as ultraviolet radiation or defective nutrition, which stimulate the production of oxidants. "The core area of research here in Düsseldorf is the question of how external factors can trigger and accelerate ageing," explains Jean Krutmann. "The Institute for Environmental Medicine is unique in Germany."

*"Each doctoral candidate has several "complementary" doctoral supervisors."*

One source of premature ageing is solar radiation. "Whoever constantly exposes his or her skin to the sun is punished by light ageing," Tanja Maresch explains. "We already know that light-aged skin shows more mutations in the mitochondrial DNA. At the same time reactive oxygen species also play a role." She would like to find out how the mutations, oxidative stress and ageing-induced cell changes are interrelated, and presumes that the process sets a vicious circle in motion: the UVA radiation penetrates as far as the true skin, the dermis, and produces the reactive oxygen species which then cause, among other things, mutations in the mitochondrial DNA. As a result the proteins are incorrectly coded, the respiratory chain develops defects and even more free radicals are produced. "The effect, according to our thesis, then intensifies itself without further external input." In her work she is concentrating on a specific muta-

*Tanja Maresch examines the damage too much sunbathing causes in the mitochondria of skin cells.*

Foto: Tobias Gremmel

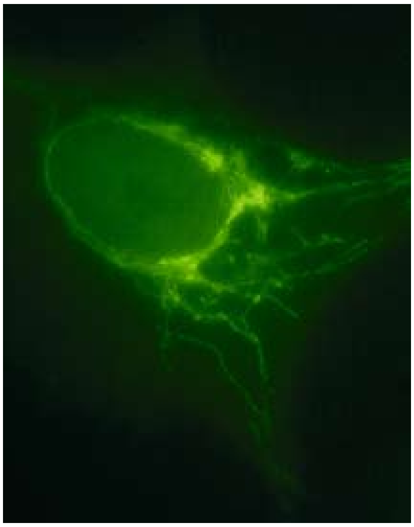


Foto: Ilaria Dalla Rosa

*Ageing processes take place in the mitochondria, the energy suppliers of the cells. The green colouring is due to fluorescent marking.*

tion, referred to as the common deletion, which comprises about one-third of the mitochondrial genome. On a skin equivalent model she wants to exactly measure the damage: primary skin cells mixed with collagen join together in a three-dimensional matrix on which they can sow keratinocytes, cells from the upper layer of the skin; in that way a centimetre-high model is obtained, which exactly reflects the natural structure of the skin. It has enormous advantages, as cell cultures react differently from living skin and as test persons naturally cannot be irradiated indefinitely.

Ilaria Dalla Rosa, who studied biology at Bologna, is also dealing with the effect of UV radiation on the mitochondrial genome. The Italian biologist focuses on topoisomerase II, an enzyme that is not fully understood. "In fact it is vital," she says, "since processes such as cell division cannot function without topoisomerase II". The enzyme manipulates the topology of the cell nucleus DNA by rotating, splitting the molecules or adding additional windings to the double strand; in that way it puts order back in the genes if they have become confused during reading or copying processes. The enzyme also plays a role in the DNA of the mitochondria. "Topoisomerase II becomes active if damage has been caused by UV light," says Ilaria Dalla Rosa, but the enzyme recognises the damage and responds with double-strand ruptures and self-destruction. Scientists presume that this mechanism strengthens small defects so much that degeneration of the whole genome is the consequence. Ilaria Dalla Rosa would like to find out whether the mutation rate is accelerated if the cell produces too much topoisomerase II during UV radiation. And can anti-oxidants perhaps prevent this or topoisomerase II inhibitors retard light ageing?

The research field of this RTG, which has been in existence since the summer of 2004, is quite sharply focused. This provides the advantage of very close cooperation, for example also between the RTG and the DFG Collaborative Research Centre "Molecular and Cellular Mediators of Exogenous Noxae". "The students of the Research Training Group are very intensively supported," says Jean Krutmann. For example, each doctoral candidate must also work in other laboratories and has, in addition to his/her own doctoral supervisor, further "complementary" supervisors who provide feedback appropriately.

"It is good to perceive other parts of the mosaic apart from our own," confirms Tobias Jung. His part of the jigsaw puzzle is a protein complex that acts like a kind of waste disposal service: the proteasome. "If oxidants stress a cell, defective proteins are produced which can no longer perform their task and have to be removed. That is done by the proteasome." At present he is working on neurons which he obtains from the hippocampus of mice and subjects to biochemical stress, for example with hydrogen peroxide, which is transformed into a very unpleasant radical when it encounters iron, copper or zinc in the cell. In that way he can observe how the damaged proteins are distributed and how the proteasome decomposes them.

One of the great problems of our quite elderly society is neurodegenerative illness, which physicians also call dementia. When parts of the brain fail in old age this is thought to be also due to oxidative stress and to the fact that the protective mechanisms in the nerve cell are no longer functioning. Alzheimer's disease is the most frequent of all dementia illnesses. Besides the amyloid plaques, deposits appearing at an early stage between the neurons, above all in the hippocampus and in the cerebral cortex, bundles of tau protein are a characteristic identifying feature in the case of Alzheimer's syndrome. At a later phase of the illness these tau proteins clot in the nerve cells themselves and block neural transmissions. Their density is directly related to mental decline. The proteasome obviously does not recognise this defective protein. "There are already medicines in existence that influence the activity of the proteasome," says Tobias Jung. But because they are still in their infancy there is still a lot to be done by scientists like him.

*"It is good to also perceive other pieces of the mosaic within the RTG."*

Also in the case of dementia illnesses it is likely that risk factors from the environment, such as nutrition or fine dust, are in play. We would all like to live for a long time without growing old, whether this involves such serious old-age phenomena as Alzheimer's syndrome or infirmity, or "mere" blemishes, such as the skin losing itselasticity. Industry has already produced various fountains of youth in the form of anti-ageing agents – from skin creams to hormone replacement products and dietary supplements. "But a lot of it is just hot air," judges Jean Krutmann. "Therefore we scientists have a special responsibility to work honestly and on a well-founded scientific basis, on a problem that affects all of us." ***mk***

# Transformations by light

Light is the main source of energy for life on our planet. Plants have evolved to utilise the energy from sunlight, using chlorophyll. Light also serves organisms as a source of information, is the catalyst of many chemical processes, can be converted directly into electricity by means of photovoltaic systems, and is used as a radiation medium for the healing of many illnesses. But the related key words, "photosynthesis", "photo-sensor technology", "photochemistry" and "phototherapy", suggest why our knowledge of the interaction of light and matter is still very incomplete or full of gaps. "In order to arrive at fundamentally new findings," says Professor Bernhard Dick, spokesman of the Research Training Group "Sensory Photoreceptors in Natural and Artificial Systems" at the University of Regensburg, "biologists and physicists, chemists and physicians need to interact on an interdisciplinary basis, and this does not have a very long scientific tradition and often involves a difficult learning process."

Bernhard Dick is a chemist, specialising in spectroscopy. When he joined the teaching staff at the RTG he initially thought all he needed to do was to make his specialist knowledge available to others. However, he quickly discovered that he had let himself in for a scientific adventure that still fascinates him and spurs him on. "During my time at school, biology was still a more descriptive science. Here in the RTG I am suddenly learning an infinitely large number of new things in the field of molecular biology."

The "Sensory Photoreceptors in Natural and Artificial Systems" RTG focuses on understanding the principles of natural photoreceptors and developing conceptions for the simplest possible artificial photo-systems. From the outset it was a challenge for all involved to adjust to the different terminologies of the different disciplines – physics, biology, chemistry and medicine – and to develop a common language. The fourteen fellows in the RTG, with their doctoral theses at the interfaces between medicine, chemistry, physics and biology, are integrated into the front line of internationally orientated basic research, since many details of the mechanisms that organisms use to receive and process light signals are still completely unknown.

"A physicist can say different things than a chemist or biologist about the interaction of matter and light," says Bernhard Dick. Therefore, he and his colleagues rarely miss the weekly interdisciplinary lectures, which, over several semesters, provide all members of the RTG with a tour d'horizon on the actual state of knowledge concerning light absorption.

"In our field of research, new knowledge is obtained almost daily," Berhard Dick reports. Currently six groups of photoreceptors are known: rhodopsins, phytochromes, xanthopsins, cryptochromes, phototropins and what are known as the BLUF proteins. The last four groups are blue light receptors – that is, substances that absorb light at a wavelength of between 400 and 500 nanometres. The last three of these are characterised by flavin-based photochemistry. "That is, however, something that we have known for only a few years, and Regensburg researchers from the RTG were notably involved in the decoding of the reaction mechanisms," says Professor Dick, with pride.

Flavins are naturally occurring yellow dyes; an important substance of this group is riboflavin, which belongs to the vitamin B2 complex. In the Research Training Group, Professor Dick has already discovered some tricky points of interdisciplinary cooperation, since the chemical behaviour of the flavins held a surprise in store. He had based some research work on the assumption, often made by chemists, that the reactions of flavin proteins proceed according to a redox reaction, which means that electrons would be transferred. However, it turned out that something completely different happened. "In the light-driven reaction a real chemical bond is formed between the flavin and an amino acid, which is then broken again after some minutes." For Professor Dick this is an indication of the fact that "supposedly reliable subject knowledge must be considered with care at the discipline boundaries".

> *"Biologists, chemists, physicians and physicists find a common language."*

In his doctoral thesis, Christian Vogl is now examining those proteins that carry a flavogroup. "Best suited to this are proteins which carry modified flavogroups, that is radioactively marked ones, or those that have been changed in the redox potential," he reports. In order to obtain them, it has so far been the practice to develop the protein structure, replace the natural flavogroups with synthetic ones and finally restore the protein to its original configuration. As the yield of modified flavoproteins with this method is relatively low, Vogl would like to set up an expression system on the basis of the soil bacterium Bacillus subtilis. "The bacterium is supposed to receive the information to produce as much as possible of a certain protein and at the same time to take up the artificial flavins supplied from the outside and to build them into the desired proteins." If all goes well he will have "killed two birds with one stone," he will have obtained a "plentiful production" of flavoprotein, in order to be able to study the blue light absorption as well as the subsequent reactions in the protein, and he will also have obtained a variation of artificially modified proteins. There are quite a few stumbling blocks: "First of all what we must do is study the mechanism of the absorption of the artificial riboflavin into the bacterium. Is that really possible? And if so, can I optimise that?"

Wolfgang Bachleitner is in search of a yet unknown photoreceptor that synchronises the internal clock of fruit flies. In order to adjust each day to the 24-hour rhythm of the Earth, many organisms use light as a timer. "In the case of the fruit fly, Drosophila melanogaster, it was proven that several photoreceptors and/or pigments can be used for the synchronisation of this circadian oscillation," Bachleitner reports: "The compound eyes, ocelli, Hofbauer-Buchner eyelets, and the blue light photo pigment cryptochrome." The Research Training Group has discovered, however, that what are known as knockout mutants, fruit flies that completely lack these receptors, nevertheless respond to light, indicating, Bachleitner presumes, that there are more photoreceptors, as yet undiscovered. He suggests, "It could be the gene with the designation Rh7, that is, a seventh rhodopsin, the sequence of which was discovered in the genome of the fruit fly." Bachleitner has now produced a mutant of the fruit fly in which the Rh7 over-expresses, which means that it is highly concentrated, and he would like to compare its behaviour with "knockout" flies that have no Rh7.

"My work here in the RTG involves cell membranes," reports Christian Horn. Each cell is surrounded by a membrane, which contains, for example, receptors for relaying signals or those that viruses dock onto in order to infiltrate the cell. An important group of proteins within the cell membrane is what is known as ion channels. "After countless experiments and constant improvements, in 1976 Erwin Neher and Bert Sakmann were the first to succeed in measuring the flow of ions through individual channels in the cell membrane of a muscle fibre," reports Horn, "and they were awarded the Nobel Prize for that in 1991."

*"We are working on new findings in our field of research almost every day."*

Today's standard techniques of artificially building up cell membranes and testing their function still have their tricky aspects. It is unsatisfactory to mount them in front of a type of aperture diaphragm, since that way they do not last long, or to lay them on a solid substrate, since then it is only possible to take measurements on one side. Horn has now developed a substrate consisting of a nanostructured surface of porous aluminium oxide, which makes it possible to measure the products of diffusion at both sides of the membrane. He has tested it with bacteriorhodopsin, a protein that transports protons through membranes under the influence of light.

Horn's doctoral thesis is almost completed. "I was able to measure the flow over a course of several days," he says. With a conventional measuring arrangement the system would only have functioned for a few hours. Due to its long-term stability his technique is possibly of interest for the development of biosensors. ***db***

Christian Vogl

*Two types of Bacillus subtilis – on the right, a culture that has been genetically modified in such a way that it overproduces riboflavin and releases it into the surrounding culture medium. On the left, the genetically unchanged culture which only produces as much riboflavin as it needs to function. It does not release any into the medium so that here there is no fluorescence to be seen under the ultraviolet light.*

# Pitfalls of perception

Towards the end of 2004, Dutch film maker Theo van Gogh, who was provocative in his views on Islamic tradition, was murdered by a Moroccan immigrant. In the Netherlands, until then so proud of its liberal immigration policy, this triggered an outbreak of xenophobia, which was responsible for numerous mosques and Koran schools going up in flames. What mechanisms are responsible for Moslems no longer being allowed to feel at home in the Netherlands following the murder? How did the feeling of "us" against "them", the Muslims, arise and develop?

"The others – this concept can be interpreted in an extremely flexible way," says Professor Amélie Mummendey, a social psychologist and spokeswoman of the Research Training Group "Conflict and Cooperation between Social Groups" at the University of Jena. At a football match of the German Bundesliga, for example, a fan from Mönchengladbach perceives the opponent footballers from Munich as "the others". On the other hand, at an international game, they belong to "his" national team – even if the opponents come from the Netherlands, which is geographically much closer.

Psychologist Mirjam Dolderer has taken the case of the murder of Theo van Gogh as the starting point for her doctoral thesis. Her main interest is research on stereotypes. "So far what has been mainly studied is whether the perception of a whole group can be positively influenced if a member of an alien group is respected," she reports. However, from the relevant literature it is well known that, as a rule, this is not the case. The positive perception of an individual is not generalised but viewed as an exception, "a process which, in psychology, is known as sub-typing". In her doctoral thesis Dolderer is now examining what happens if, instead, a member of a social community confirms in an extreme way the characteristics or ways of behaving ascribed to his/her group, such as the murderer of van Gogh. Psychologists call this a stereotype. "Does this then reinforce the stereotype?"

In order to address this issue, Dolderer has first of all determined, on the basis of a questionnaire, how the population perceives people of Arab origin. Besides this control group, she also polled a second group, and at the same time she asked them to also state what they could remember of the details of the murder of van Gogh. A third group was asked to remember details of the murder of Rudolph Mooshammer in Munich early this year. The result was that those who were reminded of the murder of Mooshammer judged people of Arab origin considerably more negatively. By contrast that picture was not changed by the memory of the van Gogh murder.

The behaviour of an individual had therefore contributed to a reinforcement of the stereotype. "But not where I would have expected it," says Dolderer. "After being reminded of the Mooshammer murder, individuals found the pic-


dpa-Fotoreport

*The murder of Theo van Gogh, obviously motivated by religious fundamentalist thinking – here persons attending the funeral in Amsterdam – enraged the population of the Netherlands.*

ture of people of Arab origin clearly more negative, although this murder – contrary to the one in the Netherlands – was based not a religious/political conflict, but on greed." Mirjam Dolderer now wants to check different explanation patterns in a follow-up study.

The dynamics and change processes within and between groups are the theme of the research in Jena. "The more global the world becomes, the more associated camp formations become a problem," says Professor Peter Noack, who teaches educational psychology in Jena and is also involved in the RTG. Amélie Mummendey underscores the relevance of the area of research, saying "Look what happens when two companies or two neighbouring schools are to be merged. The long-standing ideas of groups clash and solutions are mostly not obvious."

"The RTG is a fantastic crystallisation point for the promotion of research on intergroup relations," says its spokeswoman. "In addition to the doctoral candidates we have involved postdoctorate staff and our work here radiates out as far as basic studies." From the outset she planned and set up an International Research Training Group in psychology. "Three more universities, in the United Kingdom and in Belgium, are involved. "The subject is international and in the group of colleagues our RTG now ensures an overlap of the various sub-disciplines of development-psychology, educational and social-psychology," remarks Professor Noack.

The University of Jena has recognised the opportunities for university research provided by the Research Training Group and has provided an old villa quite close to the Institute of Psychology, to be used as the head office. "This relatively luxurious setting is not to be underestimated in the development of the RTG's own identity. At the same time, it ensures that there is pressure to also achieve something good," says Amélie Mummendey. She knows that the development phase of an RTG is a complicated, complex matter. Different life phases and objectives collide; rules have to be made and must prove suitable in practice.

Since early 2004, Daniel Geschke has been a member of the Research Training Group. In his doctoral thesis he examines the phenomenon of acculturation, i.e. the process of different cultures growing together. For this purpose, Geschke asked the inhabitants of the district of Jena where there was considerable trouble concerning the location of a new centre for asylum seekers in the middle of last year, about their attitudes to strangers. "And that was even though it was only a matter of about 100 asylum seekers – a negligible number compared with the German majority of about 20,000 inhabitants." Geschke collected the opinions of the residents concerning foreigners in two rounds of interviews, one before the opening of the centre for asylum seekers and a second one quite some time later. In this way he wants to determine whether the original fears match the actual perceptions in everyday life.

*"Psychology is international, and therefore so is the Research Training Group."*

"The initial results of my work show, for example, that the local German residents were not willing to assimilate foreign elements into their own culture," he reports. Geschke knows that acculturation is actually often accompanied by prejudices or fear of violence and crime, although it is often of great benefit to the host population. Therefore his first results did not surprise him. His hypothesis that the perceptions of the persons polled correlate with their individual political preferences seems to be confirmed. "What I think about what the foreigners want puts me into either a positive or a negative basic frame of mind concerning them, and is also decisive in the matter of the policy I would like to see applied to the foreigners."

The majority spoke in favour of a policy of assimilation in the first round of questions; their wish was that the migrants should adapt to the predominant German culture. Geschke is now eagerly awaiting the results of the second round of questions. Have the prejudices become stronger? Or, and this would really please him, have the perceptions of the foreigner in the process of acculturation perhaps changed positively?

Psychologist Ilga Vossen is just about to complete her doctoral thesis. In the Research Training Group she has compiled data on a phenomenon that she calls "lack of fit". That has something to do with the fact that members of an organisation have ideas about what the ideal picture of a member is. "Such an ideal typical prototype becomes, for example in a company, the standard for the assessment of the staff," says Vossen.

Lack of fit now describes the individual variance from this ideal picture, the ideas about being dependent upon the context and the sector. Only a few years ago the significance of the lack of fit for the selection of applicants was experimentally proven – achievements, for example, were assessed more poorly.

Ilga Vossen has now analysed how women in organisations perceive themselves and found that, depending on the degree of their "lack of fit", they behave in completely different ways. "If women do not feel that they fit into an organisational structure well – for instance in a technical environment dominated by men – they identify themselves less with their own group, that is with their female colleagues." On the other hand, Vossen ascertained that a high prototypicality – women in advertising and marketing, for example – brings about a situation in which they identify themselves strongly with their female colleagues.

"This varied group identification with the female colleagues decisively influences the extent to which women dedicate themselves to a company and how much they achieve," concludes Vossen, because "women are willing to commit themselves more to a company if they are perceived as prototypical." ***db***

# Women's hearts, men's hearts

When the heart no longer beats properly the quality of life is very adversely affected. About 10 percent of all people over 70 years of age suffer from such a cardiac insufficiency, where the pumping action of the body's most important muscle is restricted. The consequence is usually heart failure. One of the most frequent causes of cardiac insufficiency is myocardial hypertrophy, an abnormal overgrowth of the heart muscle. We know the phenomenon above all from competitive athletes, although quite normal everyday stress also contributes to the growth of the muscle. High blood pressure, a valvular defect, or a hereditary disposition are further potential factors. At the beginning this effect is perfectly healthy since the heart simply adjusts to the additional strain. At a later stage, however, the hypertrophy has fatal consequences, which start with, for example, the supply of blood to the enlarged organ no longer being guaranteed or the metaplastic processes being deregulated.

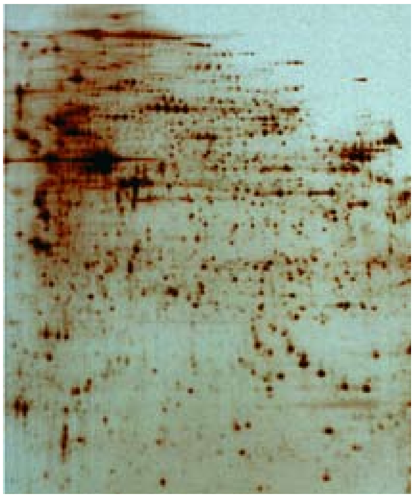
It was only during the last ten years that doctors have learned through studies of the population that the hearts of men and women function differently. Young women are apparently better protected from cardiovascular disease than men; however, once menopause has set in, such diseases not only occur more often, they also show more severe development, causing the women to die earlier. But why is that the case? In animal and cell culture experiments gender-specific influences have not yet been adequately researched. "We have taken on the task of filling the gap in our knowledge," says Professor Vera Regitz-Zagrosek, spokeswoman of the Research Training Group "Sex- and Gender-specific Mechanisms in Myocardial Hypertrophy," in which groups from the German Heart Institute in Berlin, the Charité Hospital, the Max Delbrück Centre for Molecular Medicine, the Free University and the Humboldt University are cooperating, with funding by the DFG. In earlier times, biomedical and pharmaceutical research neglected gender-specific differences. Male experimental animals were at the forefront and clinical studies mainly involved men.

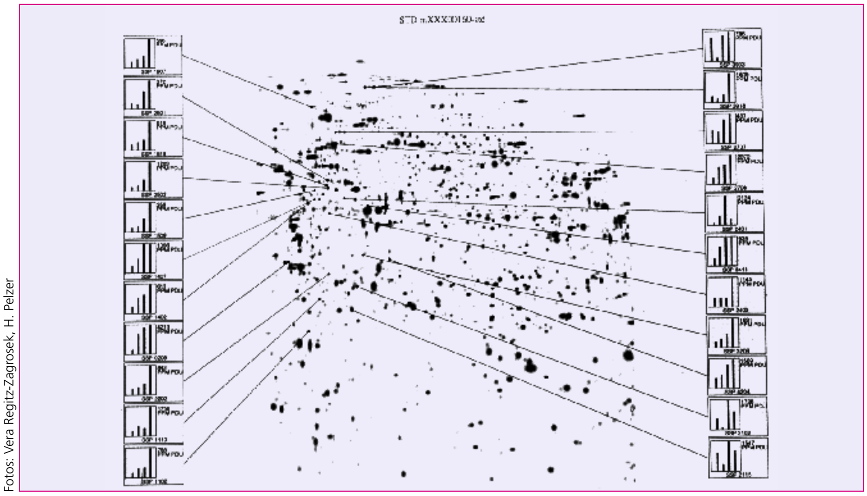
The finding that women are more seriously affected by myocardial hypertrophy after menopause encourages the assumption that oestrogen plays a decisive role. Oestrogen could have a protective function, as the ovaries in this period of life gradually stop producing this sexual hormone. Experiments with animals have already confirmed this assumption – rats with a lack of oestrogen developed a hypertrophy, while others, which had oestrogen administered, did not. Thi Hang Pham would like to find out more about the reasons for this. The biologist, who was born in Vietnam and grew up in Germany, is writing her doctoral thesis on the effect of oestrogen on the heart.

> *"Our dialogue with medical researchers sharpens our focus on clinical problems."*

The steroid hormone not only influences the regions that prepare the female body for reproduction by, for example, programming the mammary glands for milk secretion. It also has effects on the brain, the liver and the pancreas. In the cardiovascular system, it influences the growth processes of the heart, the formation of connective tissue and also the content of calcium, one of the most important biochemical substances that ensures the contraction of the muscle. Oestrogen is a messenger substance that works by setting cell receptors in motion. These receptors, which are located on the cell surface or in the cell interior, convey a message from the exterior of the cell into the cell interior and/or to the cell nucleus. Substances such as oestrogen develop their effect only by setting these receptors in motion, for example when the organism is exposed to stress. "I am trying to find out how the oestrogen receptors function and how they differ between men and women," says Thi Hang Pham, since men also have the female sexual hormone, but in a very much smaller quantity. The doctoral candidate is concentrating on the interaction partners – where proteins interact with the receptors, on what circumstances stimulate this interaction and on what the molecular reactions look like. She is also taking a close look at the metabolic pathways, and she wants to find out what happens if she switches the receptors off or switches them on too strongly. Her medium is yeast, into which she incorporates oestrogen receptor domains while searching a gene library for possible interaction partners. As yeast is only a limited model, she will later validate her results on the basis of experiments with animals.

Ultimately scientists would like to know whether the possible protective function of oestrogen receptors could be used therapeutically. This is, however, an extremely difficult task. "What is useful at one point, is harmful at another," Thi Hang Pham says, because different types of oestrogen have conflicting characteristics. The fatal damage this hormone can cause has been seen from the side effects that can occur during oestrogen treatment of women during menopause; it can promote breast cancer and endometrial cancer. If it is necessary to use oestrogen at some time, an exact determination of those





Fotos: Vera Regitz-Zagrosek, H. Pelzer

*Oestrogen can influence the activity of proteins. Cardiac fibroblasts, cells which build up the connecting tissue, were stimulated with rising concentrations of the hormone; with gel electrophoresis the proteins were cut open (left). On the right, the evaluation – the points show protein spots, the quantity of which increases or decreases in accordance with increasing oestrogen concentrations.*

signal transduction pathways that suppress a hypertrophy is vital.

For the differences between men and women, however, it is first of all the genes on the X or the Y chromosome that are responsible. In his doctoral thesis Jörg Isensee, who has a Master's degree in life sciences, would like to identify the hereditary factors whose regulation is influenced by gender. In order to determine to what different degrees certain genes are switched on or off, he examines cardiac tissue of both sexes and from several age groups. He is interested in protein expression: the synthesis of a protein according to the building plan encoded in the DNA of a gene. With DNA microarrays he can experimentally compare the expression of several thousand genes. On the glass surface of a microscopic slide a miniature robot arranges the DNA sequences in rank and file and fixes them. "I hope that I can find candidate genes that are already switched on differently in women than in men in the healthy heart, and that are involved in the development of hypertrophy," he says.

Sexual hormones also have an effect on protein expression since the most important oestrogen receptors are also transcription factors, which means that they bind oestrogen and at the same time switch genes on in the cell nucleus. A higher concentration of the hormone apparently amplifies this effect and triggers a signal cascade. Jörg Isensee hopes that he will ultimately obtain a clearer picture of the gender differences in the heart.

"The lively and positive cooperation between the working groups yields a lot of synergies," Vera Regitz-Zagrosek believes, and the fellows of the Research Training Group profit from their examination of other disciplines and methods. The biologists particularly appreciate the dialogue with medical researchers: "We are very much focused on the molecular details and hence it is good to learn how to see the whole body through their eyes," says Thi Hang Pham, and Jörg Isensee adds, "In that way we identify the medically relevant issues and practical clinical problems." Of course this applies in reverse as well; since after all it is only the progress in molecular biological research that is able to clarify more and more fundamental mechanisms involved in the cause and development of diseases.

Aysun Karatas makes use, for example, of the clinically quite thoroughly examined effects of hypertension. The biologist, a native of Istanbul, is investigating in her doctoral thesis what gender-specific factors independent of hypertension promote the development of a hypertrophy. If blood pressure-increasing substances are administered to mice, the result is damage to the kidneys and a hypertrophy of the left ventricle within a few weeks. If the blood pressure is lowered by medicines, she can study the damage in isolation from the hypertension. Aysun Karatas is now carrying out comparative research on male and female mice to see what could provoke the enlargement of the left ventricle in each case. Her interest is focused on calcineurin, a protein that binds calcium. Does hypertrophy develop when the signal transduction pathway of calcineurin is disturbed? And is it again the oestrogen that activates the metabolic pathway of the calcineurin? Answers to this are to be found by using knockout mice, lacking the gene to produce the oestrogen receptor.

Medical research on the sexes is still a young subject area and Vera Regitz-Zagrosek emphasises, with pride, the pioneering work being performed by the Research Training Group in this field. The natural scientists and medical researchers involved are learning on an interdisciplinary basis and at an international level. "The fact that the Centre for Gender in Medicine could be founded at the Charité Hospital in 2003 is also something we have to thank this RTG for."

***mk***

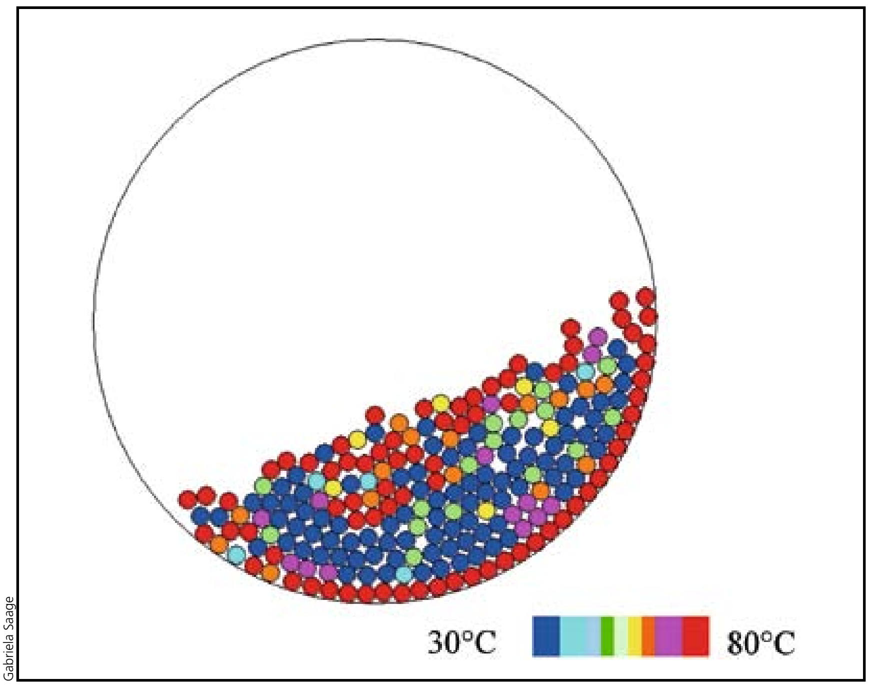
# Big things in small packages

Several films on the website of the Research Training Group "Micro-macro Interactions in Structured Media and Particle Systems" convey a graphic impression of the research work in Magdeburg. The solid-state physicist Gabriela Saage has, for example, placed a discrete element simulation of a thorough mixing process for granules on the net. This simulation is quickly downloaded and started and shows a rotating drum containing balls, which become thoroughly mixed as it rotates. To make it easier to follow the process closely the balls are marked in different colours. "A typical situation that we have in drying processes," comments Professor Evangelos Tsotsas of the Institute of Process Engineering. "From food to plastic granules, from catalysts to pills, material commodities are mostly solids, which at some point during their production or handling have to be dried," he says, adding, "and that is expensive". About ten percent of total industrial energy consumption is used in drying processes.

To enable optimisation of the energy expenditure for the transformation of moisture into steam, engineers are trying to illustrate such drying processes using mathematical modelling and computer simulations. By examining the whereabouts of individual granule particles at given times, they hope to draw conclusions regarding better process conditions, for example to determine the optimum particle size for the drying process. To achieve this, close cooperation with mathematicians and physicists is necessary.

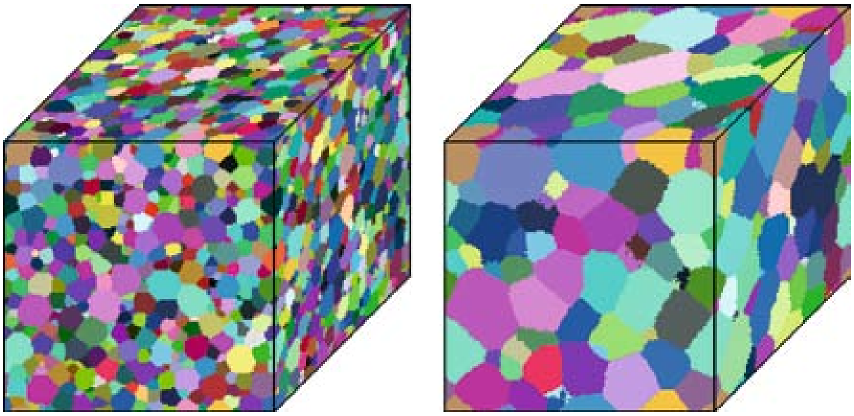
In fact many substances and materials in nature and in technology have a microstructure that, to a large degree, determines their macroscopic behaviour, and it is often easier to study and describe on the small scale the mechanisms responsible for behaviour on a large scale. To do this one must filter out and examine the information relevant to macro-behaviour, "since not everything to be found at the micro level is important for an understanding of the macro-behaviour", explains Professor Gerald Warnecke, mathematician and deputy spokesman of the RTG. "For this purpose we use statistical methods and mathematical models, which we can partly take over from other contexts, but usually we have to adapt them or develop them completely from scratch in an interdisciplinary dialogue with engineers and physicists." The result is that in the Magdeburg RTG computer simulations are being produced that can then be checked to see whether the calculated sequences tally with the reality in the experiment. For mathematician Warnecke this is a stimulating challenge "which is all very complex and usually not achievable with existing mathematical methods".

For example, in her doctoral thesis Dana Zöllner is developing a mathematical model for the growth of grains in polycrystalline materials, since in polycrystalline substances, such as metals, changes in grain structures caused by, for example, heating or cooling have a decisive effect on the macroscopic properties. "There are various approaches for modelling this micro-structural development," reports the doctoral candidate. "One possible method is the Monte Carlo simulation based on the Potts model, which was presented for the first time in 1984 for the simulation of grain growth in two dimensions," she adds. Meanwhile the performance of computers has increased considerably, enabling 3D simulation at reasonable cost.




Gabriela Saage

*2D simulation of the heat transmission in mechanically mixed bulk material: temperature distribution in the bulk material.*


Dana Zöllner

*With a modified Monte Carlo algorithm Dana Zöllner succeeds in simulating the growth of a crystalline micro-structure in three dimensions.*

In order to achieve a three-dimensional simulation of a grain structure whose growth characteristics correspond to a real structure, Dana Zöllner has developed a modified Monte Carlo algorithm with which she can already excellently simulate the temporal development of the crystalline micro-structure of very large grain structure in three dimensions. In a Monte Carlo simulation, work is done in a model with randomly selected values; in this case it is the lattice points of the crystals and their change against time. Zöllner implemented the algorithm in an object-oriented programming language so that during the simulation she can observe the grain structure and also the data of the structure.

"At the moment they are still ideal typical growth processes," she says. "We have a long road ahead of us until we can illustrate our simulations so close to reality that in metallurgy, for example, experimental efforts would no longer be necessary." In a first step, she believes, the general algorithm now available could be extended in such a way that, for example, occlusions in the material that curb the grain growth could also be simulated.

Mariya Nacheva from Bulgaria had already obtained her degree in engineering in Magdeburg before she joined the Research Training Group. In her doctoral thesis she is now dealing with the controlled cooling of metal surfaces at very high temperatures by means of drops of liquid. She is not experimenting in a metallurgical laboratory either, and for her, too, what is important is the elaboration of the basics for later computer simulations which could replace or shorten more expensive experiments in reality.

In industrial practice, for example, steel is tempered by its being cooled swiftly from the red-hot state in a liquid medium. In this case, what is known as the Leidenfrost problem occurs: a vapour film forms between the hot surface and the cooling liquid, and this prevents direct contact between the metal and the liquid.

It is only below the Leidenfrost temperature that this vapour film collapses and the direct contact with the cooling liquid then leads to accelerated cooling of the metal.

*"Most of the fellows of our Research Training Group come from abroad."*

It is obvious that the position of this Leidenfrost temperature exerts a great influence on the future properties of the material. It is dependent upon the characteristics of the cooling liquid and naturally also the way the liquid is applied to the hot metal.

In her work, Mariya Nacheva is now developing a mathematical micro-model for a representative volume element in which a single drop of cooling liquid can be observed, with the alteration of the influence parameters of its application to the hot metal surface above the Leidenfrost temperature, because "the greatest part of the heat transferred to the droplets by the hot surface is transmitted in the initial phase of direct contact", she reports. Future work will also involve integrating the time-dependent spreading of the drops as a function of the drop diameter and the speed of their application to the hot metal surface, as well as their surface roughness. Nacheva mentions, "It is only on the basis of a micro-model developed in such a complex manner that we can make statements about the characteristic heat transmission coefficient of a spray at the macro level."

*"I found the Magdeburg Research Training Group in the Internet."*

While studying mechanical engineering at the Indian Institute of Technology, Sreedhar Kari came across the website of the RTG in Magdeburg and decided, at short notice, to apply for a fellowship in Germany. In his doctoral thesis he is trying to develop, at the micro level, a mathematical model for the macro-behaviour of a composite material in which piezoelectric ceramic fibres are embedded in a soft basic matrix. His work also integrates physical, technical and mathematical specialist knowledge.

"Kari's uncomplicated approach to Magdeburg is typical of the development of the Research Training Group "Micro/macro Interaction in Structured Media and Particle Systems," says Gerald Warnecke. "We first considered striving for international cooperation with other universities, but internationality has more or less established itself of its own accord in a different way. Fifteen of our eighteen doctoral candidates come from abroad." ***db***

# Messages from the Earth's history

Foto: Christine Franke

*On board the research vessel Meteor: Gravity cores are won from the seabed.*

Many geoscientists have a particular predilection for foraminifera. These unicellular marine organisms have existed for many millions of years. What makes them useful is the fact that they form a calcareous shell that remains preserved over long periods of the Earth's history; the information on the past that is stored in them provides an outstanding climate archive. "What interests us is how during the history of the Earth the climate and environment situation have changed and how extreme climatic situations came about," says Professor Helmut Willems, spokesman of the International Graduate College "Proxies in Earth History" at the University of Bremen, EUROPROX. "With these findings we can better understand global dynamics and find climatic models for future developments."

Because there were, of course, no thermometers or other instruments in primeval times, scientists have to rely on proxies – in other words organisms, for instance, that today live in their own quite specific ecological niches and can be traced far back into the history of the Earth – like the fossil archives of tiny creatures such as coccoliths, dinoflagellata or the foraminifera mentioned above. These are what fascinate Elisa Guasti, a geologist from Parma in Italy who has just completed her doctoral thesis. She is a specialist in the Paleocene epoch that started 65 million years ago. At that time an enormous shallow sea called Tethys covered an area from Spain to Indonesia. When Africa and Europe were pushed together, the seabed sediments were raised and, over time, solidified to form rock. In Tunisia, Jordan and Egypt a search is now on for traces left by the Tethys Sea in the rock formations there.

During the Paleocene a greenhouse atmosphere prevailed – it is generally believed to have started with the global catastrophe of a meteorite impact, which also led to the extinction of the dinosaurs. Flora and fauna recovered slowly. The end of this epoch, the transition to the Eocene, was the climax of this warm age. About 55 million years ago the temperatures in the waters of the tropical oceans rose by several degrees Centigrade. Elisa Guasti finds data concerning the environment during that 10 million-year epoch in the calcareous shells of the foraminifera. The individual types can be distinguished by the morphology of the shells. In the samples of the rock Elisa Guasti carefully registers the statistical frequency of the various types. Scientists already know whether they prefer a warmer or colder climate, and so the water temperature at a given time can be determined. This can be deduced even more precisely from the ratio of the oxygen isotopes 18 and 16 that were stored in the calcium carbonate of the shells at the time they formed; the isotopes are distinguished by the number of their neutrons in the atomic nucleus; the warmer the water, the higher the ratio. Also, the salt content of the ocean was apparently high at that time, which allows conclusions to be drawn concerning the water circulation. In warm extensive seas plankton multiply and thus the quantity of organic material increases. From the ratio of the carbon isotopes it is possible both to deduce the production of oceanic carbon dioxide and to follow the circulation of the water.

Journeys through time into the Earth's past make clear to what a great extent the oceans, atmosphere and biosphere interact. At the end of the Paleocene it is likely that gas hydrates on the seabed, which released methane and carbon dioxide, produced a greenhouse atmosphere; today it is human beings who are polluting the environment with gases and other harmful substances, for example by over-fertilising. It is with these anthropogenic effects that Helena Filipsson is working. The Swede has completed her doctorate at the University of Göteborg and is now conducting postdoctoral research in the Research Training Group that deals with the question of how the marine environment in the Gullmar Fjord on the west coast of Sweden has changed over the last 2,000 years.

*"Because Bremen has such a good reputation for our subject we are pleased to be in Germany."*

In present-day Europe the ice bound to the north and south poles, and the North Atlantic drift and the Gulf Stream, ensure that we have a temperate climate. Sediment samples from a 7.5 m long drilling core that Helena Filipsson brought back from an expedition to the Gullmar Fjord provide the material for her studies: like her Italian colleague she examines foraminifera in order to read off the environmental and climatic changes from the distribution of species, the ratios of oxygen and carbon isotopes, as well as the deposits of organic carbon. "The sediments have a high accumulation rate; it amounts to one centimetre a year," she explains. "In that way we have an ultra-high time resolution." The climate exerts a considerable influence on the sensitive system of the North Atlantic – and vice versa. The North Atlantic oscillation, changes in the pressure ratio between the Iceland low in the north and the Azores high in the south, is the decisive factor for short-term climatic variations. It has an effect on surface temperatures and the water exchange in the depths of the fjord. Helena Filipson is studying such changes, and at the same time investigating whether or not environmental pollution overlays these effects.

The two experts on foraminifera were pleased to come to Bremen, they assure us, "because the specialist area of marine geo-science has such a good reputation here". For example the DFG Research Centre Ocean Margins is also located here. A further advantage is the internationality – not only do young scientists from various countries do their doctoral studies here, they also cooperate with partner universities in Amsterdam and Utrecht. "Because the need for more internationalisation arose during the research work of the Research Training Group, we integrated further partners into the second funding phase currently in progress – the Massachusetts Institute of Technology (MIT) in the USA and the universities of Southampton and Bordeaux," says Helmut Willems. In the long term the introduction of a "European doctoral degree" in the sense of the Bologna Agreement is envisaged.

It goes without saying that the research is not restricted to fossil messages from the past. In order to develop and try out new proxies, and to refine existing ones and to design models from them, an interdisciplinary approach is necessary. Among the eight specialist disciplines, geochemistry and geophysics play just as great a part as palaeontology.

Foto: Christine Franke

*Christine Franke removes a sediment sample from a drilling core.*

Christina Franke points to a cryogenic magnetometer; a small conveyor belt carries sediment cubes into a measuring container, sheathed in a protective cover, which measures magnetic signals at the extremely low temperature of -268.9 degrees Centigrade, the boiling point of liquid helium. In the "Marine Geophysics" working group the geologist identifies magnetic nano-particles and micro-particles from pelagic sediments of the equatorial Atlantic along a very complex east-west profile. The samples contain, in addition to microfossils, quartz particles, clay minerals or magnetic minerals. Magnetite, for instance, is one of the classic ferrimagnetic minerals that are highly suitable as proxies. Since the Earth's magnetic field has repeatedly changed in the course of the Earth's history, and because the orientation of the ferrimagnetic moments in the mineral grains, similar to a "frozen" compass needle, is stored, she can date the sample quite precisely. In addition the successive sediment layers do not simply lie on top of one another. Ocean currents or wind will transport particles over long distances. She can also determine the origins of such particles with the help of magnetic examinations. "In the magnetic signals we have seen that in the western part of the equatorial Atlantic the fine magnetic fraction and the coarser one are obviously not as coupled as in the east," she explains, "and that is related to the load of sediment particles". Her work supplements that of her colleagues. For example, she can explain whether and when the magnetic material was diluted by the introduction of carbonate, since high productivity increases the non-magnetic carbonate percentage in the sample.

*"The introduction of a European doctoral degree is envisaged."*

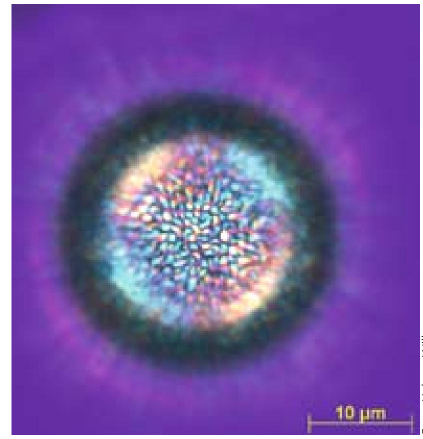



Foto: Helmut Willems

*Calcareous dinoflagellata in the transmitted light microscope – these unicellular organisms indicate warmer temperatures of the surface water, for instance in the older deposits of the Quaternary period.*

"The nice thing about working here," says Helena Filipsson, "is that we get to know the methods of other working groups and in that way look beyond the quite narrow horizon of our respective areas of work". The aim of the next stage of EUROPROX is to join together the parts of the jigsaw puzzle even more, to produce an overall picture of certain periods of the Earth's history. "We want to apply for a research vessel so that various working groups can jointly take samples and examine them in one place. With the multi-proxy approach we want to supply the modellers with enough data for a picture of climatic change," says Willems. ***mk***

Foto: Mahyar Mohtadi

*Unicellular marine organisms, the foraminifera, tell the story of past climatic situations. The species can be distinguished by the pattern of the calcareous shells.*

Interview

# Fit for excellence

Susanne Albers, holder of the Chair for Parallel and Distributed Computing at the Department of Computer Science at the University of Freiburg, obtained her doctorate in the early 1990s as a fellow in the "Informatics" Research Training Group at the Saarland University. Following that she carried out research and taught at the Max Planck Institute for Informatics and at various German universities. In addition, she spent a year as a postdoc at the International Computer Science Institute in Berkeley, USA. Albers participates as a university teacher in the Freiburg Research Training Group "Embedded micro-systems" and is a member of the DFG Senate and Grants Committees on Research Training Groups.

**?** *How can one find a suitable Research Training Group after completing one's studies?*

**!** In my case it was the recommendation of a professor followed shortly afterwards by a corresponding advertisement in the press. Today many people also find a Research Training Group matching their subject via the internet – either they browse through the pages of the DFG or of the university. The websites of the RTGs are easy to find and often provide very extensive information. Most of the sites are also in English, as many persons interested in RTGs are from abroad.

**?** *What memories do you associate with your time in Saarbrücken?*

**!** The "Informatics" Research Training Group was an essential element of my later scientific career, since without the RTG I would not have been involved with cutting-edge research so quickly and I wouldn't have learned how to be scientifically self-reliant at such an early stage. In short the RTG intensified and accelerated the processes I went through.

**?** *What do you attribute that to?*

**!** It is simply a fantastic idea that during doctoral studies one can concentrate completely on research work and not to be tied up with additional teaching or administrative obligations. During my time in the RTG, I quickly learned that to produce good research results, work must be done in depth. But to be able to penetrate those depths one needs to be able to concentrate fully on a task; it's easier to get to the top if one is not distracted. Moreover the time spent on doctoral studies becomes shorter in that way. I remember fondly the times when a working day was still a whole day for research.

**?** *That sounds almost like monastic silence.*

**!** Not at all. All of the members of the Research Training Group met for a seminar once a week and we were able to exchange ideas and experiences there. We gave lectures in turn and all became acquainted with one another's work, projects and results. At those seminars I got food for thought for my own doctoral thesis, even if the subjects were quite different. But one always picks something up: how to tackle an issue; if a certain approach would also be of advantage in my work, etc. During the discussions sparks leapt across.

**?** *Is that the reason why you still commit yourself to the Research Training Groups today?*

**!** Naturally, the whole matter is a process that the DFG initiated in 1990 and has gone on developing since then. I find it exciting to have been there at the beginning and to now continue to support this process and be able to make my own contributions. During the course of the last 15 years, the DFG has continuously fostered and improved the Research Training Groups programme. This deserves credit, because as a result, here in Germany, we have something that's very successful and that does not exist elsewhere.

That's why the Research Training Groups are so attractive. Meanwhile the applicants come from every country imaginable and many Research Training Groups have become internationalised, having established cooperation with universities in other countries. These ensure that the members of the RTGs travel abroad for research stays and conferences: a period of only a few weeks at a university in another country is an experience which is important for the career and is also personally enriching. Science is international, and according to my observations the RTGs are exactly the right structure for making progress in the international business of science, and for succeeding in the long term.

*Marion Kälke and Dieter Beste spoke to Susanne Albers*

# Research Training Groups
# Data and facts

***Research Training Groups*** (RTG) are university training programmes, funded by the DFG, that are set up for a limited period to promote early-stage researchers.

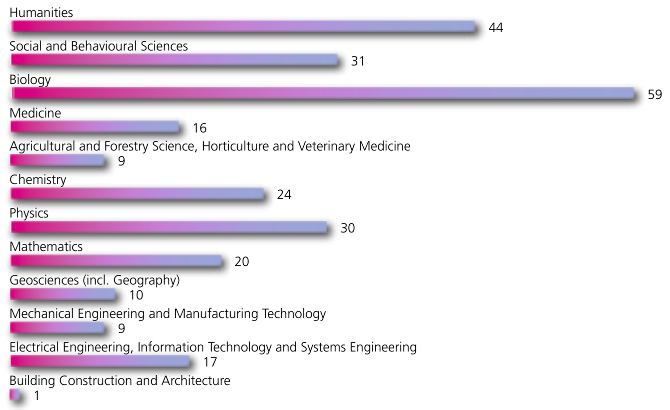
In the RTG, ***doctoral candidates*** are given the opportunity to carry out their work within the scope of a coordinated research programme supported by several university teachers.

A ***programme of study*** complements and, as a rule, extends the individual areas of specialisation of the members of the RTGs and structures their cooperation. An interdisciplinary orientation of the research and study programme is desired.

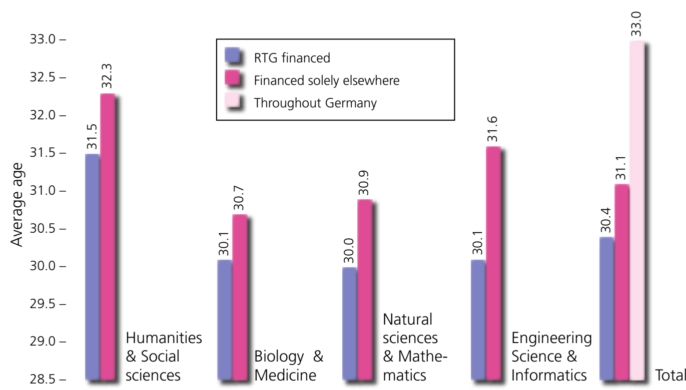
***International Research Training Groups*** (IRTG) enable the joint training of doctoral candidates between a group at a German university and a partner group abroad.

- ➜ The DFG currently funds about 270 RTGs, including more than 40 IRTGs.
- ➜ In these RTGs approx. 6,000 doctoral candidates are writing their theses.
- ➜ The number of doctoral candidates from abroad is approaching 30%.
- ➜ A total of 41% of doctoral candidates are women.

**www.dfg.de/gk/en**




*Distribution of the Research Training Groups (RTG) according to subject area*




*Average age of doctoral candidates upon completion of doctoral thesis between April 2003 and March 2004.*

At ***www.dfg.de/gk/en*** persons interested in working toward a doctoral thesis can find a list of all current Research Training Groups that announce their fellowships on their websites. Universities wishing to propose RTGs should seek advice from the DFG Head Office beforehand as, due to the high level of interest, only the very best and most suitable proposals can be funded.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