

forschung

Das Magazin der Deutschen Forschungsgemeinschaft

german research

Magazine of the Deutsche Forschungsgemeinschaft



2/2003 ▶ Life under the "Cold Skin" ▶ The Unemployed and the Solidarity ▶ Fungi and Plants Become Partners under Stress ▶ On the Rise and Fall of the Town of Xkipché ▶ The Fire Salamander

DFG

In this Issue

**Tracking Down
Mayan Culture**

The Mexican peninsula of Yucatan is abundant in evidence of the Mayan culture hewn in stone. At the Xkipché site archaeologists have discovered that the Mayan people evidently abandoned their houses and palaces before their demise. Was warlike conflict responsible, or was it perhaps due to an extended period of drought lasting several years? Archaeologists are searching for clues.

Page 4

**In Focus:
Mass Unemployment**

What is the real situation when it comes to solidarity with the unemployed in Germany? A survey of people in employment shows that even when times are tough the public support for social welfare benefit payments such as unemployment benefit, unemployment assistance and public assistance is strong, whereas the individual benefit payments are judged very differently by the respondents. **Page 11**

**A Partnership
between Fungi
and Plants**

Over 80 percent of all plants live in symbiosis with mycorrhizal fungi. The fine threads of the fungi can penetrate the soil further and more efficiently than the plant's roots. The molecular basis for this remarkable biocoenosis is the focus of one of the DFG's Priority Programmes.

Page 20

Commentary

Ursula Peters

Prospects for a Living Community p. 2

Arts and Humanities

Hanns J. Premm, Michael Vallo, Iken Paap

On the Rise and Fall of the Town of Xkipché p. 4

Heike Wolf, Frank M. Spinath, Alois Angleitner

Similar and Yet Still Different? p. 8

Silke Hamann, Astrid Karl

The Unemployed and the Question of Solidarity p. 11

Life Sciences

Sebastian Steinfartz, Diethard Tautz

The Fire Salamander: Source for New Species p. 14

Wolfram Kutsch, Sebastian Berger, Hanno Fischer

Studying the Curved Flight Pattern of Locusts p. 17

Hermann Bothe, Ulrich Hildebrandt

Fungi and Plants Become Partners under Stress p. 20

Natural Sciences

Andreas Greiner, Martin Steinhart, Joachim H. Wendorff,

Ralf Wehrspohn

A Gossamer Veil – News from the Nanoworld p. 23

Michael Spindler, Rolf Gradinger

Life under the "Cold Skin" p. 26



**Expeditions into
the Arctic Pack Ice**

Two researchers are set down on the ice in a pod hanging from the crane on the research vessel "Polarstern". This method is particularly advisable on thin ice, since ice cores can be drilled directly from the pod. (Page 26) Cover photo: Michael Spindler

Impressum

german research is published by the Deutsche Forschungsgemeinschaft (DFG; German Research Foundation); Editorial staff: Dieter Hüsken (editor-in-chief and design), Dr. Rembert Unterstell, Ursula Borchardt-Allmendinger, Angela Kügler-Seifert; English Consultant: Nicholas Naughton BDÜ, Translation: SciTech Communications GmbH, Heidelberg; Publisher: WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim (Germany), P.O. Box 10 11 61, D-69451 Weinheim; Annual Subscription price 2004: € 44.00 (Europe) US \$ 48.00 (all other countries) including postage and handling charges. Printed by: Bonner Universitäts-Buchdruckerei; Address of editorial staff: Deutsche Forschungsgemeinschaft, Public Relations, Kennedyallee 40, D-53175 Bonn; E-mail: postmaster@dfg.de; printed on chlorine-free bleached paper with 50% recycling fibres.

ISSN 0172-1526

If the academic debates in the review and readers' letters sections of newspapers in recent years are to be believed, the humanities are in an awkward position. It is not just that they feel marginalised in public discussion. Mutual decision-making between politics and universities is also putting them under pressure: the abolition of entire courses of study and reduction in their resources, together with an increasing number of students and overload-quotas in other areas, leave hardly any time for research; the new Framework Act for Higher Education, which includes the abolition of the "Habilitation", the introduction of junior professorships and new tenure regulations, none of which sufficiently accommodates the specific careers in the humanities; the intra-university distribution of budgetary funds according to parameters which, due to their disproportionate provision for third-party funds in cooperative associations and areas of distinction, also put the humanities at a disadvantage. And finally the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation): with its funding instruments and its programmes for young researchers it seems to be accelerating the decline of the humanities, or at least not be slowing it down.

This nightmare scenario, however, represents only one side of the coin. There is an entirely different one. Due to the not unproblematic assumption of the cultural-theoretical "renewal" that has been taking place on a broad basis and in almost all disciplines ever since the 1980s, the humanities in particular have been involved in an intensive, at times bitter, but all the more fruitful discussion about their practical as well as methodological bases. In many areas, this discussion has led to a thrust, embracing hitherto overlooked areas, leading to new questions and to disciplinary expansion. At the same time, however, it has caused each individual discipline to position itself historically within the spectrum of disciplines, by extending into the other great academic areas, and thus achieved, especially in Germany, a high standard of his-

torical reconstruction, theoretical self-reflection and a practical redefinition of the disciplines.

The results of this interdisciplinary, public discussion concerning the humanities and their cultural-theoretical basis are obvious: a high degree of internationalisation of the individual disciplines and at the same time an increasing international dissemination through its reconstructive return to the diversity of cultural-theoretical theory-building, which characterised discussions in

The humanities are thus an extremely lively community conducting discussions on the fundamental issues of individual disciplines during teaching as well as in research, internally as well as in public, and thus shaping to a considerable extent the current discussion about modern culture.

There are nonetheless problems that the Deutsche Forschungsgemeinschaft should pay particular attention to. This is not about hedge clauses which the humani-

Prof. Ursula Peters

Prospects for a Living Community

The humanities demand flexible funding instruments – special requirements must be accommodated

Germany during the early 20th century; attractive university teaching, since students are confronted from the outset with fundamental questions about their disciplines; rich programmatic research activities that take place not so much in established specialist journals but rather in interdisciplinary joint works, anthologies and conference proceedings and are mainly carried forward by young researchers; and finally, radical changes concerning the intra-disciplinary structure by introducing new courses of study.

ties certainly do not need. For many years, they have retained their percentage of the DFG funding volume (with a slight increase compared with the natural sciences), and in some areas, such as the interdisciplinary promotion of young researchers in the Research Training Groups, they have even been particularly successful. The problem is on a completely different plane to the percentages, however. Far more, as has been demonstrated by an internal survey conducted by the DFG, it is the age

factor for qualification of young researchers, individual research in projects aiming at publishing a monograph, as well as the magnitude of cooperative processes.

The bitter reaction, mainly by researchers in the humanities, to the tenure regulations of the new Framework Act for Higher Education shows that in this community age plays a different role during the qualification phase and at the time of appointment than in the other areas of academic life. Humanists

taken into account more than before when discussing the funding of young researchers on all levels, including the programmes of excellence.

The monograph, the result of individual research, is and in many branches of the humanities will, for good reason, remain the most respected way of doing research. For this reason, the Deutsche Forschungsgemeinschaft promotes individual research in all stages, especially in the case of young re-

search, which is so prestigious within the humanities. In return, young researchers would be able to gain the necessary qualifications for an appointment by carrying out replacement teaching.

A large part of research in the humanities, too, consists of cooperative associations. The Deutsche Forschungsgemeinschaft accommodates this with a special budgetary sector for long-term projects in the humanities for the joint reconstruction and safeguarding of huge stocks of knowledge. The increasingly successful establishment of the Collaborative Research Centres also demonstrates an interest in cooperation. In the context of "structural formation", it has been tried to increase the critical mass through large Collaborative Research Centres and above all through the DFG Research Centre which is so successful in other academic areas. However, due to the heterogeneity of the range of disciplines, the humanities find their own natural limits and can therefore not easily join together in large associations. For the humanities, the (distributed) Research Unit, due to its flexibility, appears to be a particularly suitable instrument of cooperative research funding. The Deutsche Forschungsgemeinschaft must explain to its member organisations (the universities) that not only DFG Research Centres and large Collaborative Research Centres contribute to their image, but also small formations that are interlinked with research groups of other universities. The humanities would benefit a great deal.



Prof. Ursula Peters

Ursula Peters, Professor for Older German Language and Literature at the University of Cologne is Vice-President of the Deutsche Forschungsgemeinschaft. The DFG's Executive Committee consists of the President and eight Vice-Presidents as well as the Chairman of the Stifterverband für die Deutsche Wissenschaft (Donor's Association for the Promotion of Science and Humanities in Germany).

may not be significantly older than their colleagues when they are appointed. It is clear, however, that in the majority of humanist disciplines the long qualification phase and the correspondingly high age of young researchers in individual cases is not regarded as a drawback. On the contrary: in many cultural and historical disciplines, in-depth familiarisation with foreign cultures and languages determines the young academics' standard and therefore also their qualification planning process. This should perhaps be

searchers, by Individual Grants Programmes, Research Fellowships, the second stage of the Emmy Noether Programme, and Printing Subsidy. For established university lecturers, funding for individual research includes Sabbaticals. So far this type of funding has tended to be seen as an exception and therefore, despite the demand for it, has not been utilised enough. An expansion of this funding instrument by including Sabbaticals in the normal proposal for a Research Grant would thus be of great benefit for individ-



On the Rise and Fall of the Town of Xkipché

Mexico possesses abundant stone witnesses to the Maya culture. As Xkipché shows, the Mayas had abandoned their houses and palaces prior to their decline. Archaeologists examine the history

The hilly region of Puuc, which lies to the north-west of the Yucatan Peninsular in Mexico, is richly endowed with residual settlements of the classical Maya culture. One area of almost impenetrable bush contains many remarkably well preserved remains of their numerous villages and towns, comprising hundreds of large stone buildings and palaces which the Maya abandoned so precipitately well over a millennium ago. In addition to the large towns, such as Uxmal, Sayil and Oxkintok, which in their heyday around 800 A.D. had up to 30,000 inhabitants, this sparsely populated area also held around 200 to 250 smaller and larger settlements, most of which have yet to be explored.

The archaeological site of Xkipché, located not ten kilometres distant from the Maya town of Uxmal, lies in the heart of the zone known as Puuc, with its characteristically closely packed karst cockpits rising to heights of over 100 metres and broad, gently rolling, valleys. Here, too, despite the uncertain and problematical water supply provided to the settlements from subterranean cisterns with capacities of up to 40,000 litres, the Mayas succeed-

ed in creating the prerequisites for dense settlement.

The prevailing opinion amongst researchers is that these villages and towns came into being around 600 A.D., and that after a rapid rise and just a brief heyday, they were abandoned again around 1000 A.D. The details of this process, and the factors which contributed to the

historical events is the accurate determination of their chronological succession, our first priority was to elucidate the temporal development of the site at Xkipché. In the Puuc area, in addition to the succession of its architectural styles, this so-called chronology rests primarily on the cross-dating of ceramic artefacts and their inscriptions with

those found in the classical centres of the Maya culture lying far to the south.

Thus within the framework of this chronological investigation, the first series of excavations between 1991 and 1997 was devoted to the largest building in Xkipché – a palace complex. This, with two

storeys and over 48, mostly well preserved, rooms, is one of the largest edifices in the entire region. At the same time a complete survey of the visible architectural remains and additional excavations in individual sections of the settlement area were also undertaken. Subsequent assessment of the finds made during these excavations produced the differentiated picture of the town which we had hoped for.

As a result of these latest excavations we can now assume that the settlement of the entire Puuc region began much earlier. The first re-



On the trail of the Mayan culture: A round altar with a stele is exposed during the systematic excavation of Xkipché. Right: The "Palace of Xkipché". With its two storeys and nearly fifty rooms, this was the largest building in the town. The Mayas abandoned it before it had been properly completed.

sudden vacating of this area of settlement, are still largely unknown. Hence one of the central aims of our archaeologists from Bonn and their excavations was to help find the answers to these questions. Since one vital prerequisite for any analysis of





A monumental building from the heyday of the Mayas: The palace complex in Sayil, some 20 kilometres from Xkipché. Pottery and flint tools were the typical grave goods on the Yucatan Peninsula.



mains of settlements and the early ceramics found in Xkipché date from the 1st century A.D., and thus some 400 years earlier than had previously been believed. But it was not until the 8th century that Xkipché experienced a true boom. In this century, as also over the following 250 years, there is evidence of brisk building activity. Apart from the work on the great monumental edifices of the, most probably, aristocratic upper stratum of society, this also embraced the local religious centre and the comprehensive construction of houses for the common people, too. Within a brief period of time, not only did huge places of assembly and pyramids arise, but large numbers of minor sacrificial shrines and temples as well. Alongside imposing architectural re-

mains, evidence of wide-spread trade relations were also found extending as far as the Guatemalan highlands 1,000 kilometres away. Columns of porters carried valuable jade, swords made of obsidian – a volcanic glass, and tuff for ceramics, in particular, over distances of several hundred kilometres, or goods were brought to the north of the Yucatan Peninsula in small ships and rafts plying up and down the Caribbean coast. In all probability, the heyday of the Puuc region ended towards the end of the 10th century or at the beginning of the 11th. At this time, the Puuc settle-

ments were abandoned precipitately by the aristocratic élite, and then a short time later by the rest of the population, too. The palace complex in Xkipché furnishes particularly impressive evidence of these processes in that the north façade and the east wing of the first storey were never completed. This fact was deduced from the worked door posts and lintels left lying before the roof-high walls by the master-builders. Other parts of the building also created the impression that the Mayan master-builders had suddenly abandoned the construction site in company with their gangs of

workers – some of whom had even abandoned their tools. What actually caused this monumental edifice to be abandoned, and the ensuing probable evacuation of the whole town, is still largely unexplained. In addition to the fragments of spear-points and axes which have been found, suggesting that fighting had taken place, there are also indications of a change in climate occurring towards the end of the 9th century. This, taken in conjunction with over-exploitation of the natural resources through the traditional system of agriculture based on forest

clearance, also played an important role. For in an area lacking any surface waters, where survival during the annual dry season is dependent on precipitation stored during the rainy one, any extended years of drought can have a catastrophic effect, something which might account for the complete abandonment of this once densely populated area.

Building on these results, in early 2000 a start was made on the conception of a fresh archaeological research project. Supplementing our excavations to date, which had been

mainly concerned with architectural styles, we now turned our attention to questions affecting the later stages of the settlement of the Puuc region and to the conditions of life of the common peasant populace immediately prior to the abandonment of the Xkipché site.

At the beginning of our four-month series of excavations in Mexico in 2002 efforts were concentrated on a special type of c-shaped building which had also been found at other archaeological sites in the region and which, according to the latest state of research, was known to have occurred very late in the table of chronological development. In Xkipché a mass of such buildings is to be found close to the largest pyramid. Most of these



The great pyramid in Chichén Itzá bears witness to the intensive building activity of the Mayas in the 9th and 10th centuries A.D. Archaeologists discovered historic architectural remains in a burial ground in Xkipché.



buildings, which are built on a platform, face to the east. The side-walls comprise only a low base wall, into which wooden posts had been inserted, probably to be combined with wattle sections interlaced with twigs and clay to form the actual walls of the building. The roof, rather like the traditional buildings still in use today, was made of holly leaves laid in thick layers and thatched onto the wooden roof construction. In the course of these excavations a number of interesting discoveries were made regarding the chronology of the buildings under investigation. Of all the buildings we had examined at this site so far, these were the latest to be built, as although they are seated on older previous buildings, they exhibit no signs of any subsequently superimposed structures. Characteristic of these buildings is their construction using stones from earlier structures, and in this context wide use was made for these c-shaped buildings of the exceptionally well worked stones removed from the façades of earlier stone structures. The simple, and sometimes provisional, character of the buildings investigated is also reflected in the way in which offerings had been deposited. Plain water vessels – some of them broken or damaged after long use – had been placed on the platform of one of the altars in the neighbourhood. No traces of their contents have survived, but they probably held food or drink. Taken in conjunction with other finds, this would indicate that the economic situation had entered a period of clear decline towards the end of the 10th century, which could have resulted from the marked increase in the population up to the beginning of the 10th century, the creeping exhaustion of the area under cultivation, and a simultaneous change in the climate. Deterioration in the food situation then appears to have led to fighting over its distribution between the individual settlements, and finally to a complete regional collapse.

*Prof. Hanns J. Prem
Dr. Michael Vallo
Dr. Iken Paap
Universität Bonn*

Similar and Yet Still Different?

*Do the predisposition of our genes or the influence from our environment influence human behaviour?
A study of twins provides new information*

Over the centuries, the phenomenon of twin birth has exerted a fascination for poets, philosophers and researchers. But systematic comparisons of monozygotic (MZ) and dizygotic (DZ) twin pairs only began with Sir Francis Galton in the late 19th century. Since then, the twin method has developed into one of the standard methods of behavioural genetic research. The major aim of this kind of research is to answer questions about the causes of individual differences in a psychological trait of interest and to decompose this interindividual variance into its genetic and environmental parts. Monozygotic and dizygotic twins are of such interest for behavioural genetic research because of the differences in their genetic similarity. MZ twin pairs are genetically identical, while DZ twin pairs share on average only half of their genome, that is they are as similar as "normal" siblings. In cases where MZ twin pairs exhibit greater similarity in a particular trait than DZ twin pairs genetic effects have important influences on individual differences in this trait.

One of the basic assumptions for such a conclusion is the so-called "equal environment assumption" which states that the environmental influences on a specific trait are the same for MZ and DZ twin pairs. The correctness of this assumption has been confirmed for a large number of psychological traits. By comparing the similarity of MZ and DZ twin pairs regarding a psychological trait, genetic and environmental influences on this traits can be esti-

mated. The portion of observable differences between individuals produced by the overall effect of specific genes is referred to as "additive genetic variance". The "shared environment" covers environmental influences which contribute to the similarity of individuals who grow up together, such as the family home surroundings or their socio-economic status. Influences, in contrast, which help to create differences between individuals growing up together are denoted as "specific environment". This might, for instance, include different friends or occupations.

Earlier behaviour genetic studies concordantly found that the shared environment is less important while, on the other hand, the specific environment has considerable influence on psychological traits. A multitude of studies in the field of personality research suggest that around 40 per cent of the differences in personality traits can be explained by additive genetic effects, and around 60 per cent by the influences exerted by the specific environment. Although the estimation of the amount of individual differences due to genetic and environmental influences is relatively simple, the identification of environmental influences is more difficult. Hence some authors conclude that children are chiefly socialised by their peer group and not by their parents, whereas others point to inadequacies in the method of investigation, which involves most of the results from behaviour genetic studies of personality being derived from questionnaire data, and especially self-reports. How-

ever, if traits of interest were exclusively assessed by self-reports this would make it harder to judge the value of these assessments, since possible distortions in perception, or other disturbing influences, would be difficult to check out.

Consequently, in a behavioural genetic study on personality at the

University of Bielefeld in 1995, peer reports of personality were included as an additional source of information. The results confirmed those obtained from self-report studies. Moreover, this study also indicates that the effects of genetic and environmental influences on personality are largely the same, regardless of

the source of information (self- or peer reports). As a model framework for personality description the so-called five factor model (FFM) was employed, an approach to describing the structure of personality. The five factors are traditionally called extraversion, neuroticism, openness to experiences, agreeableness, and conscientiousness. An extraverted person is generally sociable, active and communicative, a neurotic person is nervous, unsure of himself, apprehensive, and tends to emotional instability. Openness to experiences characterises people who welcome change, are eager to learn, creative, and have broad cultural interests. Agreeable people may be described as selfless, sympathetic, understanding and well meaning. The factor conscientiousness relates to someone who is tidy, reliable, hard-working and disciplined.

This model was also employed for the German Observational Study of Adult Twins (GOSAT). The aim of this research project was to investigate the significance of the family (shared) environment for individual differences in personality traits. In addition to this, an approach was implemented for the GOSAT which embraced a combination of objective tests, behaviour observations and interviews.

Within the GOSAT, 300 same-sex twin pairs aged between 18 and 70 were invited to Bielefeld for one day. Previously, each of them worked on a set of questionnaires, rating their self-perceived personality and their personality as rated by two peers each, so that it was possible to compare our day-long observations with the results obtained from these questionnaires. The tasks were designed to create situations suitable for the observation of personality-relevant



Where is the difference?

Monozygotic and dizygotic twins are of such interest to behavioural genetic research because of their different genetic similarity.

behaviour. Most of the time twin and co-twin worked independently on the various tasks and were attended by different experimenters in order to avoid any cross-influencing of the results.

In addition to recording intelligence and temperament traits, priority was afforded to observational data gained from unobtrusive behaviour counts on the one hand, and open video recordings on the others. The experimenters and their confederates, who had been introduced to the twins as randomly selected students of the University of Bielefeld, observed them in various situations over the course of the day, recording such details as the numbers of comments made or questions asked. The twins were videotaped in 15 of the various tasks, for example introducing themselves in front of running video cameras, building a paper tower of maximum height and stability, or demonstrating as many uses for a brick as they could think of. Seven of these 15 situations

were conducted in interaction with the confederate. Thus for instance, one task involved phoning a female neighbour at 11.00 pm and persuading her to turn her (very loud) music down. Another, completed in the absence of the experimenter, involved a ten-minute conversation about partialities and hobbies. At a later stage of the project, these videotaped situations were rated by independent judges regarding the twins' personality. These judgments were made on the basis of 35 personality scales representing the five-factor model. Additional scales were also employed to assess the attractiveness and sympathy of twins. In each situation, different panels of four independent judges rated the personality of one twin sibling on the basis of the videotaped behaviour. In order to exclude any possible influences arising from comparative judgements, different panels of judges rated twins and co-twins. Making these assessments, the situations could be viewed either individually or as a whole. Aggregations of the personality ratings made in all the situations produced a reliable evaluation of the genetic and environmental influences. These ratings were based on a total of sixty judges per twin and a broad range of behaviours from different situations. It emerged that the differences (variance) over all the personality traits

could be explained to 42 per cent by additive genetic influences, to 18 per cent by influences from the shared environment and to 35 per cent by influences from the specific environment. A minor part of the variance – six per cent – was attributable to unreliability of the measurement. Hence in observational studies, factors linked to the shared environment proved to be of greater significance than in questionnaire studies. Evaluation of the unobtrusive behaviour counts, moreover, revealed that genetic influences at the personality-trait level were especially marked when specific behaviours were aggregated over a variety of situations. In contrast to this, no genetic influences were detected when specific behaviours were examined within individual situations. This confirmed what had been expected, namely that although behavioural tendencies are anchored in the genes, specific behaviours are not.

In 1999, a study was initiated at the University of Bielefeld with the aim of detecting specific environmental factors which influence personality traits. In addition to collecting data from questionnaires on genetic and environmental influences, the study comprises new questions relating to goals in life, life events and attitudes. Apart from the data collected in this way, the videotaped behaviour in the various situations will likewise offer many opportunities for addressing further questions. In this manner, for example, objective observations of the occurrence and incidence of specific behaviour will be possible, enabling comparisons of twins and co-twins to be made. Systematic comparisons will furnish information about the significance of genetic and environmental influences on detailed behavioural styles. In the case of temperament research, too, observations of motor behavioural components will provide a supplementary method to questionnaires.

A special kind of twin reunion: For the German Observational Study of Adult Twins over 300 same-sex pairs of twins aged between 18 and 70 were each invited to attend the University of Bielefeld for a day.



*Dipl.-Psych. Heike Wolf
Dr. Frank M. Spinath
Prof. Alois Angleitner
Universität Bielefeld*

The Unemployed and the Question of Solidarity

Rampant mass unemployment and the discussion about the future of social security raises many questions. A study examines to what extent social welfare benefits are accepted amongst the population

How willing are those in work to support the unemployed? How do those in work assess social welfare benefits such as unemployment benefit, unemployment assistance and public assistance? Do people have solidarity with the unemployed in view of the rampant mass unemployment in our society? Researchers at the Mannheimer Zentrum für Europäische Sozialforschung (Mannheim Centre for European Social Research) have investigated these and similar questions. In the context of the public discussion about the sustainability of social security systems they examined to what extent benefits to the unemployed are accepted. In a number of detailed interviews, they mainly asked people about their attitudes who, through paying taxes, contribute to the social security system: people in work who have long-term, well-paid, secure, or well-qualified jobs. Closest attention was paid to the positive and negative assessments of social security benefits (unemployment benefit, unemployment assistance, and assistance to cover living expenses – referred to here as public assistance).

Contrary to the widespread opinion in public discussions, the empirical results show that people in work strongly support all three types of benefits, although they argued for it in many different ways. Most of the interviewees support the aim of the social security benefits for the unemployed (preservation of status and livelihood) as well as the associated moral concepts of solidarity



and justice. People generally approve of the redistribution impact that is associated with the benefits from those in work to the unemployed.

On the other hand, the benefits are judged in many different ways, and approval is often qualified. Critical statements, however, never lead to a complete rejection of the social security system, they merely put the essentially positive judgements into perspective. The reservations refer only to some aspects (such as types of means tests), undesirable side-effects ("abuse of benefits", condemnation of the recipients of benefits) or to groups of recipients deemed "undeserving". The greatest reservations concern certain groups of recipients who are assumed to abuse the social security

How much solidarity do people in Germany feel with the unemployed? One study shows that even in times of crisis people in work strongly agree with welfare benefits such as unemployment benefit, unemployment assistance and public assistance.

system. This suspicion grows with the length of unemployment. What is the reason for the generally positive assessment of all three types of benefits? A central point was that the interviewees whose own risk of unemployment is relatively low believe that unemployment can in principle happen to anyone. According to the interviewees, loss of employment or rapid success in job seeking does not solely depend on personal behaviour and commit-

ment. Rather, today's mass unemployment is seen to have structural reasons. An individual's scope for action is seen as limited.

The interviewees describe the consequences of possible unemployment as very threatening. They associate job loss with an often sudden and drastic loss of income. The individuals themselves should not have to bear the financial losses and shortages caused by unemployment. Even if, in the favourable case, there are savings, these can bridge only a short period of unemployment. Safeguarding the standard of living and livelihood must instead be guaranteed through the social support systems. A reduction in benefits is therefore largely opposed, as this is seen to endanger social cohesion. Poverty, exclusion and criminality are expected to increase and there is a fear of political radicalisation.

Depending on the system, however, the readiness to contribute is argued for in different ways. The interviewees are aware of the differently constructed social security systems

and the related burdens, and judge them according to the "appropriate" logic and values. The perceived purpose of the social security systems proved to be of particular importance. Justice of equity and justice of need as well as self-interest in the benefits played an important role in the assessments.

How do the interviewees assess the individual social security benefits? The unemployment benefit, which is an insurance payout and presupposes gainful employment for at least one year, is regarded as a benefit that serves to secure the standard of living and to protect its recipients from unexpected social decline. The idea of justice of equity that is linked to the insurance principle (the unemployed receive benefits depending on the amount previously paid in) is approved of. The interviewees support the idea that there is a jointly financed fund and

that each insurance contributor is entitled to benefits in the event of harm on the basis of previously paid contributions.

By way of explanation, the interviewees often fall back on ideas of mutual aid. As a reason for the readiness to support others with their contributions, the interviewees felt that they may one day profit from the benefits to the unemployed themselves. Self-interest thus plays a role when assessing social security systems based on the idea of solidarity.

Unemployment assistance, which follows after unemployment benefit, serves two purposes. On the one hand, like unemployment benefit, it is designed to maintain a certain social status. The regulations of the insurance logic such as the need for advance payments are assessed positively. On the other hand, unemployment assistance,

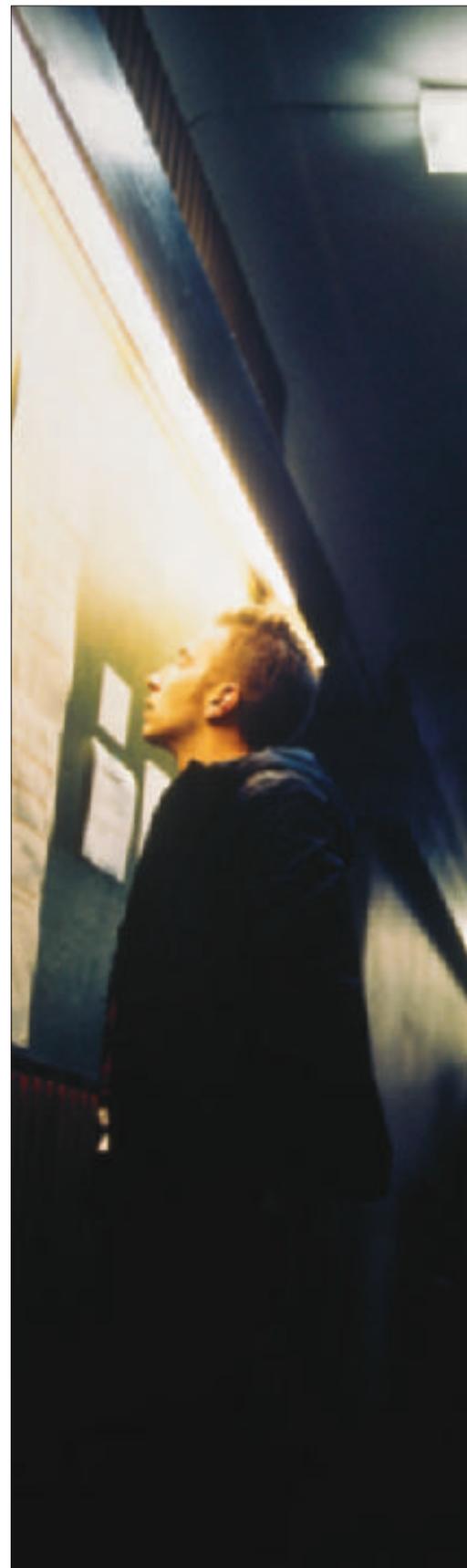
which is lower than unemployment benefit, is intended to increase the incentive to work in order to prevent long-term unemployment.

Many believe

that despite the difficult labour market it is possible to find work whilst receiving unemployment benefit or assistance. Most of the interviewees mistakenly believe that unemployment assistance is, like unemployment benefit, a temporary benefit and is merely a transition to the temporally unlimited public assistance. If the unemployed person does not find a job while receiving unemployment benefit or assistance, the interviewees believe that an almost inescapable descent into public assistance follows.

The interviewees regard the safeguarding of the standard of living as a basic requirement of unemployment assistance. Pragmatic arguments, however, are also important; in the case of long-term unemployment, financing problems are expected. Arguments of a "punitive justice" are put forward to defend the relatively low benefits when

Reductions in social benefits are largely opposed as these are believed to endanger social cohesion





Looking for work: Today, the young and the elderly are affected. According to many of those questioned, loss of employment and success in the search for employment is not merely a matter of personal behaviour and commitment, but rather is affected by structural factors.

those affected do not succeed in finding a job. The response was similar for the means test, which is rejected when unemployment assistance is seen as an insurance benefit. The means test is approved of if unemployment assistance moves closer to public assistance, or if work incentives, financing problems, or family-related allowances are given special emphasis.

The interviewees regard the public assistance as the safeguarding of the livelihood of those unemployed people who are not entitled to unemployment

benefit, such as school-leavers. The interviewees accept that the moderate public assistance should be granted indefinitely, and that previous contributions should

not be a prerequisite since the existence of a "final net" for those who need it is considered absolutely necessary. Although the interviewees do not believe that it is very likely that they will ever need to receive public assistance, they do support the principle of justice of need.

They finance such welfare benefits and accept the associated redistribution effects because they believe in the necessity of social solidarity. If there were no such benefits, according to the interviewees, society would suffer great damage. Often, feelings of moral obligation are expressed. Such feelings of obligation are often derived from the fact that they themselves have not suffered unemployment and therefore belong to the social group that is able to support the "weaker" or "less fortunate". The unemployed are typically described with much empathy, as innocently in

need, "who are not able to work". The support thus emerges from the recognition of people's distress. However, social security benefits are not accepted without reservation. A general cut in social security benefits, though, is rejected by most interviewees. In view of the prevailing circumstances, however, cuts are seen as unavoidable. The reason for this is an increasing disparity between the number of those in work and the great number of unemployed, which creates financing problems.

Long-term unemployment is regarded as a particular problem. Long-term receipt of benefits jeopardises the "balance" between contributions and benefits. The interviewees thus demand state measures to combat long-term unemployment. On the other hand, they expect more commitment from the unemployed and a greater willingness to accept restrictions as well

as to make concessions when it comes to accepting a new job. As a "service in return", the long-term unemployed should work in order to

Society recognises the needs of the unemployed but expects more personal commitment from the job seekers

take the load off the community.

Other reservations are due to considerable mistrust towards the recipients of benefits. Benefits are seen as sometimes being granted "too automatically", without the question being investigated as to whether it was the recipients' own fault that they lost their job or whether they are willing to work. The systems are therefore unable to exclude recipients who are themselves to blame for their long-term unemployment or who take advantage of the insurance schemes. This mistrust increases with the duration of unemployment and is thus directed mostly against recipients of public assistance.

*Dipl. Soz. Silke Hamann
Dipl. Soz. Astrid Karl
Universität Mannheim
Mannheimer Zentrum für
Europäische Sozialforschung 13*

The Fire Salamander: Source for New Species

What you should know about the colourful fire salamanders: how a new species arises through adaptation to its environment is of general interest

One of the central and most debated topics in evolutionary biology is the question how new species arise and how they are able to stay separated from each other. Until very recently it has been the common view that new species arise through geographical isolation, e. g. through isolation by watersheds, mountain massifs or in environmental refugia during ice ages. Such a geographic isolation prevents gene flow between the separated populations and finally (normally after million of years) both populations are not able to interbreed and represent therefore new species. This process is called "allopatric speciation" and has dominated the species discussion during the last century. However, alternative concepts predict that speciation can happen under natural conditions even without geographical separation – i. e. speciation can take place under "sympatric conditions". In contrast to "allopatric speciation", which can be seen as a purely passive process, "sympatric speciation" is an active process, mainly driven by adaptation.

New theoretical models suggest that intraspecific competition under sympatric conditions is the starting point for speciation, which then leads to the formation of differently adapted subpopulations. These subpopulations can only split into different species if intermixing is prevented by "assortative mating".

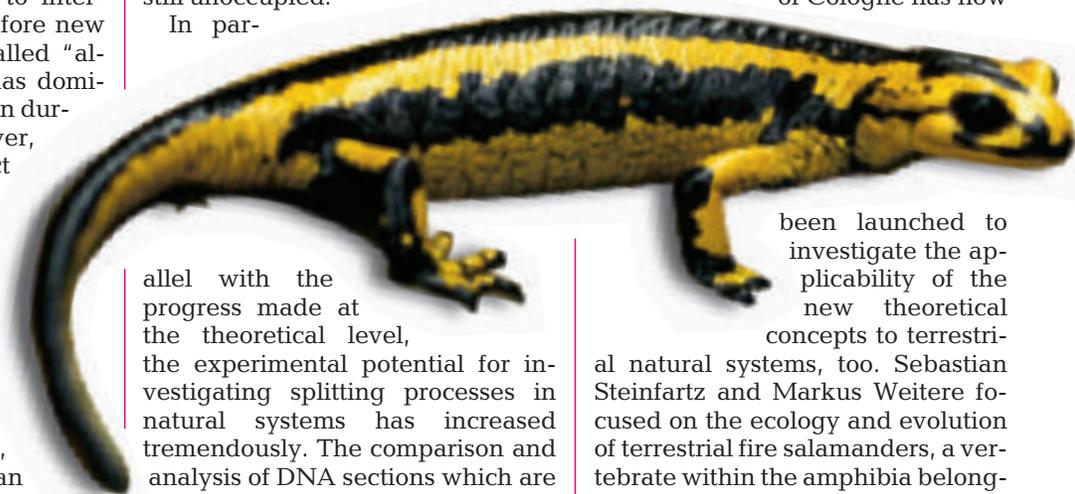
In this context "assortative mating" assumes that partners of the same adaptation type prefer mating with their own type, and avoid mating with other adapted types. Considering these two factors, i. e. adaptation in combination with assortative mating, new species can form very rapidly (within less than 100 generations) without the long time postulated for geographic isolation mechanisms. The process of adaptive speciation can be expected to occur in newly colonized habitats, where appropriate ecological niches are still unoccupied.

In par-

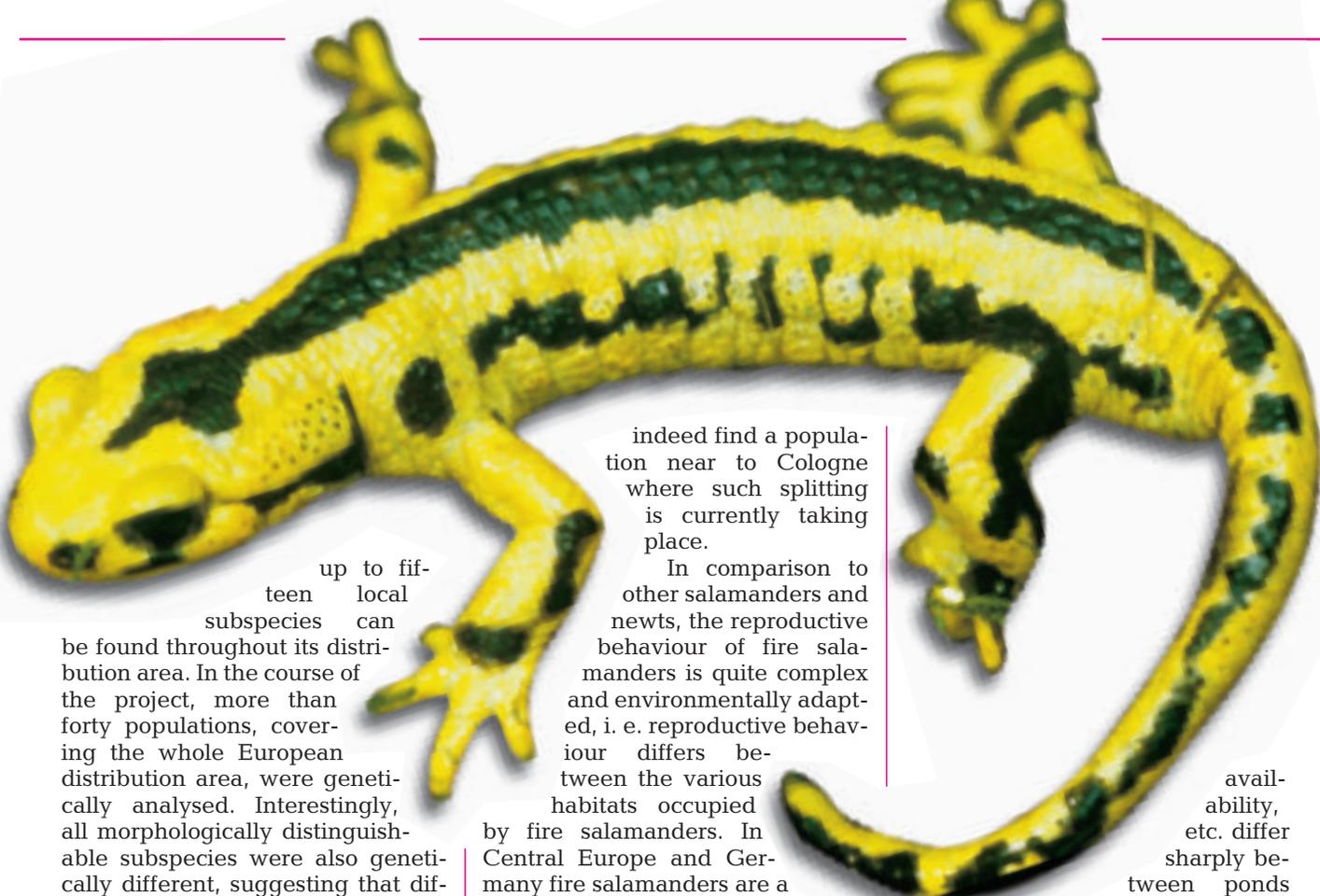
allel with the progress made at the theoretical level, the experimental potential for investigating splitting processes in natural systems has increased tremendously. The comparison and analysis of DNA sections which are located either in cell organelles as the mitochondrium or in the nucleus can be used to trace differentiation and speciation. To investigate very recent splitting events, highly variable DNA markers are required. Tandemly repeated DNA stretches which are located in the nucleus are known as "microsatellites". Microsatellites can be used for „fingerprinting“ individuals, thus making

it possible to test whether subpopulations under investigation still have genetic exchange or have already separated from each other.

Some of the best documented examples of sympatric speciation have been provided for cichlid species found in crater lakes in Cameroon. A former Ph. D. student in the laboratory in Munich, Ulrich Schliewen, showed that in one of these lakes, the Barombi Mbo, several new species had formed under sympatric conditions from a single founder species. A project at the University of Cologne has now



been launched to investigate the applicability of the new theoretical concepts to terrestrial natural systems, too. Sebastian Steinfartz and Markus Weitere focused on the ecology and evolution of terrestrial fire salamanders, a vertebrate within the amphibia belonging to the order of caudates (Caudata). Fire salamanders represent the most variable terrestrial vertebrates and have adapted to various different niches, and are thus an ideal model system for studying adaptive speciation. Its conspicuous appearance has always attracted the interest of naturalists and collectors. At least five distinct species of fire salamanders can be distinguished, and



up to fifteen local subspecies can be found throughout its distribution area. In the course of the project, more than forty populations, covering the whole European distribution area, were genetically analysed. Interestingly, all morphologically distinguishable subspecies were also genetically different, suggesting that differentiation goes beyond the subspecific level. Even within the lineage which currently colonizes Middle Europe, interesting local adaptations can be detected. This reflects the pattern that is expected from the theoretical models of adaptive speciation, which assume that after the recolonization of open niches (as is the case after an ice age) conditions are ideal for new species to form under sympatric conditions. By carrying out an area-wide investigation of Germany analysing more than 50 populations of fire salamanders, the research team under Professor Tautz tried to identify a candidate population in which the splitting of differently adapted ecotypes could be studied under natural conditions. They did

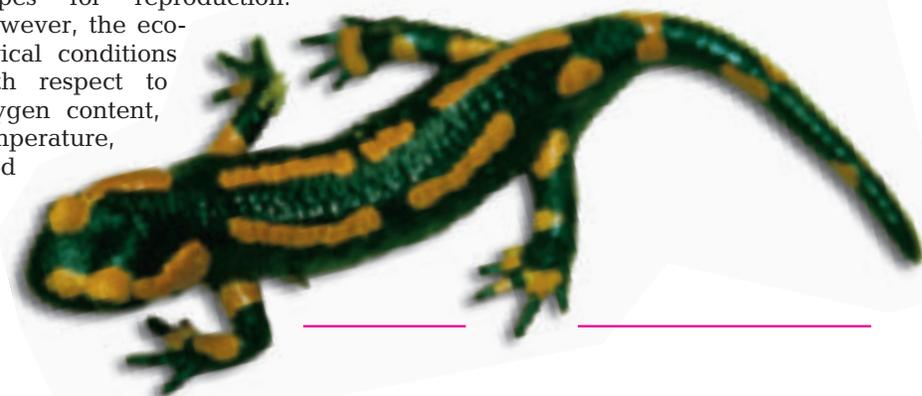
indeed find a population near to Cologne where such splitting is currently taking place.

In comparison to other salamanders and newts, the reproductive behaviour of fire salamanders is quite complex and environmentally adapted, i. e. reproductive behaviour differs between the various habitats occupied by fire salamanders. In Central Europe and Germany fire salamanders are a character species of old broadleaf forests on low mountain ranges such as the Harz Mountains and the Black Forest. Normally the females deposit living larvae in oxygen-rich streams. Until metamorphosis – the transition from the aquatic to the terrestrial habitat – the larvae are strictly confined to water. After their metamorphosis, the fire salamanders are strictly terrestrial and need up to five years to become mature. Accordingly, mating is performed on land. In some areas of Germany fire salamanders can be also found in “atypical” flatland habitats in which streams are rare. In such habitats the fire salamanders have started to use stagnant waters such as ponds and slopes for reproduction.

However, the ecological conditions with respect to oxygen content, temperature, food

availability, etc. differ sharply between ponds and streams. Low food availability, especially when taken in combination with a high desiccation risk in ponds, creates unfavourable conditions for amphibian larvae in general. As a consequence, the fire salamanders have to adapt to these conditions. The degree of differential adaptation to stream versus pond habitats was analysed under both laboratory and natural conditions. Representative stream-breeding populations were therefore studied in the Bergisches Land and the Eifel and compared to pond-breeding populations in the Ville near Cologne and Bonn. The results confirmed that the occupation of stream and pond habitats

Impressive variety: The fire salamander, a member of the Caudata, embraces numerous species and sub-species, augmented by regional and local variants. Left: A fire salamander from North-west Spain. Above: An example from the Pyrenees. Right: An animal conspicuous by its striking colouration.





has already led to genetically fixed adaptations.

To test whether the adaptation to stream- and pond-breeding also leads to a splitting of these ecotypes under sympatric conditions (as predicted from the theoretical model discussed above) an area had to be found in which both reproductive types occur in sympatry. The Kottenforst, near Bonn, is such an area. Ponds and streams are irregularly distributed across the Kottenforst and are inhabited by fire salamander larvae. The current genetic and ecological analyses suggest that pond- and stream-breeding fire salamanders are indeed in the process of speciation.

To interpret genetic patterns in terms of speciation it is necessary to know as much as possible about the behaviour of the organism under investigation. Therefore, factual knowledge regarding its movements, expansion and reproductive behaviour are crucial. Under captive breeding conditions, the male sperm of fire salamanders can be stored for several years by the females and still be used for successful fertilisation of the eggs at a later

In our latitudes, the fire salamander is a classical inhabitant of wooded hill-country. It deposits its larvae in oxygen-rich streams. Only the adult animals live permanently on land. In many regions the fire salamander may, notwithstanding, be found in flat areas with standing water.

point in time. However, the extent to which such sperm storage and multiple paternities occur also under natural conditions is an open question. Long-time sperm storage and multiple paternities do not only have an impact on the population structure, but the analysis of multiple paternities will also permit conclusions to be drawn regarding assortative mating, which is the key factor for keeping differently adapted types apart. To study the migratory behaviour of individuals, so-called "transponders" were planted under the skin of more than one hundred individuals from a selected fire salamander population. These transponders comprise a small magnetic coil, and enable individuals collected at later times to be unequivocally re-identified. It was

thus possible to track the individuals and to determine their movements over a period of more than three years. In parallel with this, it was possible to test the offspring of several individuals by microsatellite fingerprinting and to show that sperm storage and multiple paternities are indeed common in fire salamanders, even under natural conditions.

The Salamander Project is still in its initial phase. Further research effort will focus on the genetic analysis of recently diverged stream- and pond-types to obtain detailed data for testing a speciation scenario under sympatric conditions. Once the preliminary data have been verified, detailed behavioural studies and crossing experiments between both ecological types will be used to determine the genetic principles of sympatric speciation. This study suggests a shift in focus: speciation has not necessarily to be studied in tropical regions – new species arise in front of our doorstep.

*Dr. Sebastian Steinfartz
Prof. Diethard Tautz
Universität zu Köln*

Studying the Curved Flight Pattern of Locusts

Using miniaturised remote data transmission, biologists examine the flight motions of free flying desert locusts and other insects. Computer-based video technology reconstructs behavioural sequences

The flight of birds and insects has always fascinated people. The locust's ability to fly, and especially that of the species migrating in large swarms – known as the eighth Egyptian plague – has also been studied for more than 40 years. Locusts fly for hours, not only in nature, but also in a wind tunnel. Their flight is not even impaired by attaching a load of up to 15 percent of their body weight on their backs. Due to the locusts' load bearing capacity and their size, measuring devices can be attached to their backs to study their flight motions.

We are using the locust to analyse the motor programme of free-flying animals. Studies of this type are part of the field of neuroethology, which

seeks to understand those processes in the nervous system that lead to particular behaviour patterns in animals and, especially, the movements of their limbs. Such investigations are possible on entirely different levels, from the comparatively simple swimming motions of jellyfish to the complex movement sequences of mammals. The actual goal is to examine the links in the central nervous system including the brain. For example, an attempt is being made to find out how incoming nervous impulses are processed there. But it is still not possible to specifically image the activity of individual neurones in their central nervous network, even though their function is already known.

Researchers have therefore turned to the analysis of the activity of motor neurones, i.e. the nerve fibres that transfer information from the central nervous system to the muscle and thus activate it. In moving animals, motor neurones are difficult to study. The muscle's electrical activity can, however, be recorded

A flight room for studying the locust's curved flight: The subject flies through a dark corridor towards the light-coloured rear wall and then turns towards the opening on the right. Transmitters send the electrical activity of the individual wing muscles to the two receivers on the ground. At the same time, two special video cameras record the flight manoeuvre.



by means of an electromyogram (EMG) and then conclusions may be drawn from it regarding the use of the upstream motor neurones. To record the EMG of a locust, electrodes are implanted in its muscles. These electrodes are a mere 50 micrometres thin so that as little muscle tissue as possible is damaged. Potentials of a few hundred microvolts are thus recorded and then amplified in order to make them visible on an oscillograph screen or a PC. In the next step for understanding the motor programme of locust flight, the electrical activity of the



muscle is related to wing motion, a process in which computer-based video technology, such as high-frequency analysis, is employed. Formerly, motions had to be reconstructed by means of time-consuming filming procedures, but today computer programmes allow for a largely automatic reconstruction of the behavioural sequence.

The initial studies of the flight motor programme were based on an analysis of stationary flight. For this purpose, the animals were attached to a holder and suspended in a wind tunnel. The warmed airflow caused

the animals to continuously beat their wings. Many important insights were gained by this method. However, since the locusts were fixed in the wind tunnel, they received no feedback on the effects of their wing motion in these experiments. This arrangement is called an „open loop“ system whereas a complete system is based on „closed loop“ conditions. This means that the animals perceive the effects of their movements. However, closed loop conditions are only present in free flight.

But how can information on the motor programme of a free flying animal be acquired? Transmitters for wireless recording of the wing muscles' electrical activity must be developed, which enable the transmission of the EMG data over a certain distance. For this purpose, advances in electronic miniaturisation are used. Components have been developed that are smaller than a millimetre in size and from them, a transmitter powered by a button battery is assembled under a microscope. This transmitter, together with a home made aerial, weighs no more than about 155 milligrammes.

To test the transmitter's effectiveness, we placed up to four transmitters on a Madagascan cockroach and recorded the activity of the individual running muscles. The animal, when fitted with transmitters, ran through a 20-metre long base-metre area without any apparent impairment. The EMGs were transmitted without problems. The recordings were largely equivalent to those previously record-

ed from animals that were wired to electronic devices. In the next step, the research team analysed the flight motions of free flying locusts. For this purpose, fully grown females of the desert locust were fitted with the miniaturised transmitters. By means of double-channel lead, the electrical activity of two muscles could be recorded simultane-

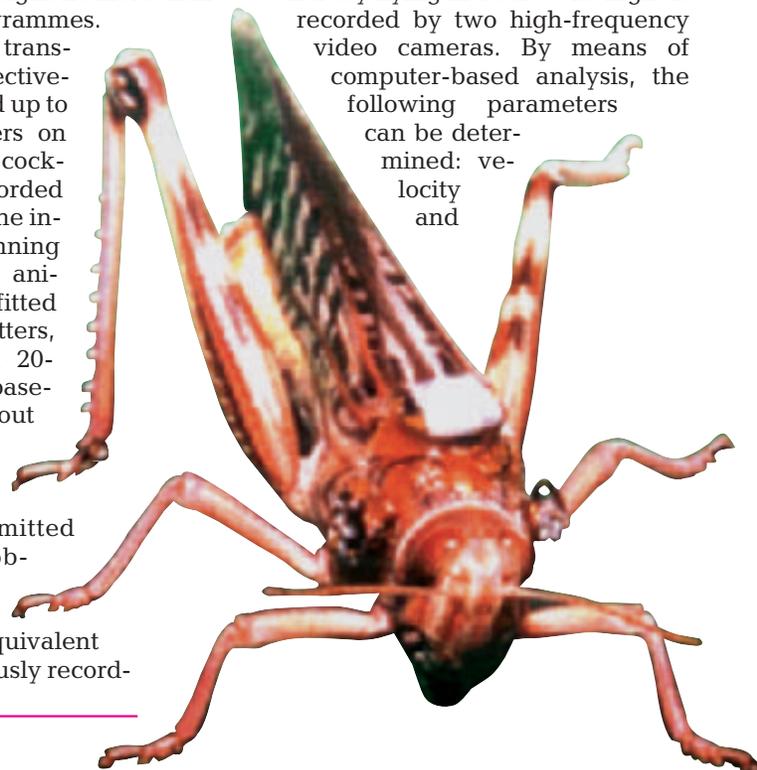
ously. The central question was: how does a locust co-ordinate its front and hind wings in curved flight?

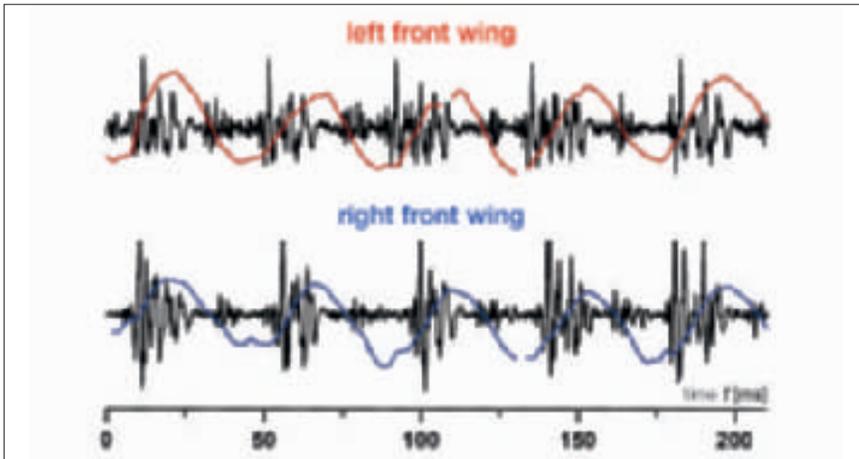
To answer this question, the research team built an arena in

which locusts were induced to fly in a curve. For this purpose, they took advantage of the fact that most insects are attracted by light sources. A black corridor was therefore built that finished with a light-coloured wall. This screen was lit up from the outside by a lamp located at the end of the right wall. When a locust is flying in the dark corridor, it first flies straight towards the light-coloured screen. However, as soon as it flies beyond the end of the right screen, it sees the bright lamp towards the side and heads towards it, thereby flying in a curve. Its flight is recorded by two high-frequency video cameras. By means of computer-based analysis, the following parameters

can be determined: velocity and

Miniaturised transmitters are used for wireless recording of the electrical potentials of flight motions





The grasshopper's flight motions release electrical voltages. These are transmitted using miniaturised wireless transmitters. This makes it possible to record the activity of two muscles simultaneously. On top the electrical discharge from the left front wing and underneath that of the right front wing.

height of the flight as well as the locust's turns in various planes. In addition, the track of each wing can be displayed. This provides the means for analysing how the animals control their wing motions.

The analyses show that locusts move their wings asymmetrically during curved flights. A similar manoeuvre is known from rowing. To navigate the boat around a curve, one side pulls more strongly on the oars than the other. The locusts fly around a curve in a similar manner. On the outer side, the time for the downbeat of the wings is somewhat longer than on the inner side. The outer wing is also pulled a bit further down than the inner wing. As a result of the differential production of force, the animal tilts towards the side and flies around in a curve.

The effect of the uneven wing motion becomes apparent very rapidly. We anticipated that movements would only show after one or two wing beats. However, the analyses show that the body's tilting motion is directly and temporally coupled to the wing asymmetry. Furthermore, in curved flight the front wings of the locust are of greater significance than the hind

wings, which confirms the assumption that the hind wings provide the main propelling force for the flight while the front wings are responsible for steering.

The electrical activity of strong flight muscles is then assigned to these free flight wing motions. We already knew that locust wings are moved by two groups of muscles that oppose each other's actions: one group is responsible for the downbeat, the other for the upstroke. By means of one representative of each muscle group, it can be demonstrated that their electrical

activity occurs ten milliseconds before the two extreme positions. In that way, muscle movement triggered by the electrical activity can be optimally used for the reversal of the movement direction.

We certainly do not yet understand the motor programme of a free flying locust, but this study provides an experimental approach that allows further research on the co-ordination of many different muscles in a wing beat. The miniaturised data transmission system will also be of special significance in the future.

*Prof. Wolfram Kutsch
Dipl. Biol. Sebastian Berger
Universität Konstanz
Dr. Hanno Fischer
University of Cambridge,
United Kingdom*

The flight motions of a locust that is attached to a holder in the wind tunnel are being studied. Left: A cockroach fitted with four miniature transmitters, button batteries and tiny ring-shaped aeri- als. The electrical activity of its leg muscles is transmitted without wires. Biologists also study the free flight of desert locusts in this manner.



Fungi and Plants Become Partners under Stress

80 percent of all higher plants live in an ecologically advantageous and effective symbiosis with mycorrhizal fungi. Investigations on the molecular basis of this symbiosis are at the centre of a DFG Priority Programme

Symbiosis is the interaction between two species with benefits for both. One widespread and ecologically highly significant symbiosis is that of plants and mycorrhizal fungi. Over 80 percent of all plants form a mycorrhiza (Greek: fungus root). The fine threads of fungi, called hyphae, can penetrate the soil more extensively and efficiently than plant roots. These hyphae mobilise

water and nutrients and transfer them through the plant roots to the shoots and leaves. In turn, the fungi receive up to 20 percent of the organic carbon formed by the plants. Only when plants have an optimized nutrient supply in the soil they save these costs and do not enter into a mycorrhizal symbiosis. This partnership is formed under diverse stress conditions, such as a lack of nutrients, drought, heavy metal contamination or infection by pathogens. Due to the more efficient nutrient supply through fungal hyphae, the plants become more resistant to these stress factors. The importance of mycorrhiza has only been truly recognised in the last twenty years; today, it has become a rather fashionable research area.



The common fly agaric (above), a native of coniferous forests, is a typical ectomycorrhizal fungus. Right: In the arbuscular mycorrhiza, the most intensive substance exchange between fungus and plant occurs in the arbuscules (treelike structures).



Several types of mycorrhizal symbioses are distinguished: In ectotrophic mycorrhiza, fungal hyphae grow as a mantle around plant roots while others extend far into the soil to mobilise nutrients. Other hyphae penetrate the outer cell layers of roots and swell in the process. The nutrient exchange between the symbiosis partners takes place at these latter hyphae, which are known as Hartig net. Characteristi-

cally, in this type of mycorrhiza, the fungal hyphae do not penetrate the walls of the plant cells. Ectotrophic mycorrhizal fungi are typical for our deciduous and coniferous trees. These mycorrhizal fungi are known to everybody from their above-ground fruit bodies as common mushrooms. Fruit bodies are formed for the fungal propagation by spores. Typical examples for ectomycorrhizal fungi are the fly agarics, yellow Boletus and truffles.

In endotrophic mycorrhiza, the fungal hyphae penetrate the cell walls of the plants, but, unlike pathogenic fungi, they do not penetrate

the living part (the cytoplasm) of the plant cells. Orchids, for example, depend on mycorrhizal fungi throughout their life cycle. They have very small seeds, whose nutrients are exhausted soon after germination. If they were not nourished by fungal hyphae at this early growth stage, they would soon die. Orchids continue to need fungi for nutrition later in life, too. As noted before, an ideal nutrient supply suppresses the formation of mycorrhiza. Since orchids can no longer live without fungi, they die when dry meadows are fertilised or when the orchids are transplanted from their natural habitat into garden soils rich in nutrients. Similarly, plants of nutrient-poor heaths and moors, such as common heather, cranberry, bog rosemary, cowberry and cross-leaved heather, are examples for endomycorrhizae.

Far more common, however, is the arbuscular mycorrhizal symbiosis. With few exceptions, these fungi colonise almost all herbaceous plants and also many shrubs and trees. Evidence of the presence of fungi of this type in plants has been found in samples up to 460 million

years old. They always remain in the soil and form structures such as extraradical (living outside the root) hyphae, spores for reproduction and, within the roots, intraradical hyphae, usually vesicles for fat storage and the arbuscules ("little trees" because of their shape, from which this mycorrhiza takes its name). The arbuscules are formed by strong branching of the fungal hyphae and are in turn enclosed by the surrounding plant membrane. Intensive metabolic processes occur between the growing arbuscules and the periarbuscular membrane of the plant. Localization by means of antibodies showed an increased formation of some enzymes that catalyse the exchange of substances between the partners. Arbuscules have a life expectancy of about fourteen days and continuously form and collapse. Gene expressions in the arbuscules and surrounding plant cells can readily be researched using modern molecular methods.

It may appear surprising that arbuscular mycorrhiza is not better researched but, both in pure and applied research, studies on mycorrhiza are faced with many difficulties. In the first place, no method has been found so far to cultivate the fungi independently of the plant, so their propagation for laboratory purposes is complicated. However,

the fungi can be cultivated in the presence of special root tissues from carrots or bacteria of the genus *Paenibacillus* until the formation of new spores. Therefore, it only appears to be a matter of time until the substances which the fungi require for growth are identified. The fungi are not divided into cells. A fungal spore has up to one thousand nuclei, whose gene composition is proba- 21



Left: Spores of arbuscular mycorrhizal fungi. The zinc violet (below) can only thrive on heavy metal contaminated soils because it is colonised by mycorrhizal fungi.





Comparative study on an alfalfa species (*Medicago truncatula*): When optimally fertilised the plants grow in heavy metal soils only if they have been inoculated with mycorrhizal fungi (upper photo). Those not colonised by fungi develop very poorly (lower photo).

show that there are, in fact, different species, but it is also revealed that individual gene sequences can deviate by 5 to 10 percent from each other within individuals. For all these reasons, it is difficult to produce mutants of the fungi or to alter their metabolism by means of specific changes in individual gene products. Some plant families, such as the mustard and goosefoot families, are not readily colonised by mycorrhizal fungi. However, recent research on Buckler mustard and penny cresses (members of the mustard family) demonstrates that the entire symbiosis programme is present but that the fungal structures are only occasionally formed in the plant roots. Considering everything that has been said, arbuscular mycorrhizal symbiosis is most certainly not an easy research field.

Still, arbuscular mycorrhiza is a subject in which pure and applied research meet. With the aid of current molecular methods, gene expression and protein formation in mycorrhizal and uncolonised control plants can be compared and defined. These molecular approaches have contributed to the identification of genes, proteins and signal substances with sometimes surprising properties. It is also possible to produce fungal material with a high and reproducible colonization potential as well as with sufficient purity for inoculating plant cultures. This inoculation material is suitable for diverse applications: It has been demonstrated that plant pathogenic organisms are repelled if the roots are inoculated with mycorrhizal fungi as they start to grow. This particularly applies to greenhouse cul-

tures that can be systematically inoculated with mycorrhizal fungi. Likewise, inoculation with mycorrhizal fungi increases the success rate of shoot propagation, for example, in poinsettias and grape vines.

Only a few plants and some arbuscular mycorrhizal fungi can live on heavy metal heaps. It was shown that the zinc violet, which occurs on such locations in the Aachen-Liège area and in Blankenrode near Paderborn, can only exist on heavy metal soil solely because of the mycorrhizal colonization. As a rule, the mycorrhizal colonisation of the roots of the zinc violet increases in parallel with the heavy metal content of the soil. A fungus was isolated from the zinc violet that transfers heavy metal resistance to plants. This could be shown, for example, with a Mediterranean lucerne species. When this plant and many others are optimally fertilised in greenhouse experiments, they can grow on heavy metal soils of most diverse composition provided the pots are inoculated with the fungus. Currently, research is underway to find out whether isolated fungi of this type can be used for replanting heavy metal contaminated soils and stabilising them against erosion. The potential usefulness could even be higher on saline soils. About eight percent of the global soils are unsuitable for agriculture because of their high salt load. Studies on diverse saline soils in Germany, The Netherlands and Hungary showed that many saltland plants form mycorrhizal symbioses and that *Glomus geosporum* is the most common mycorrhizal fungus in these saline locations. Currently, field experiments are in progress to determine whether a mycorrhizal culture can confer salt resistance to plants similarly as shown for heavy metal soils. At this time it is only a vision that soils in dry regions may one day be irrigated with seawater by systematically planting these areas with mycorrhizal fungi.

Prof. Hermann Bothe
Dr. Ulrich Hildebrandt
Universität zu Köln

bly not uniform. No sexual stages or chromosomes are known from arbuscular mycorrhizal fungi. Therefore, we do not know how the genetic information varies from individual to individual or is passed on, or how one species is distinguished from the next. Information from gene sequences and the characterisation of the external spore shape

A Gossamer Veil – News from the Nanoworld

Tube-like objects play a special role in the nanoworld. New preparation methods have been developed for making nanotubes. Such innovative procedures provide the basis for a multitude of technical applications

Miniscule objects that are so small they cannot be seen by the naked eye or by using an optical microscope are of great technical significance. This is because it is becoming increasingly evident that further reducing the size of objects with dimensions in the metre, millimetre or even micrometre range by one or more factors of 1,000 to the nanometre range provides a fascinating approach to generating new functions and creating new material properties. Here the important factor is the chemical structure of nanosystems which are also interesting in biology, since nanoobjects have the same dimensions as viruses and enzymes.

The nanometre region is subject to different laws than the world visible to the naked eye. Semiconductor devices, for example, may exhibit radically different electronic and optical properties when their spatial extent is reduced. Depending on the form of the reduced object, such structures are called quantum films, quantum wires or quantum dots. These structures are especially important for optical information technology. Even if the consequences of a size reduction are not especially spectacular, they can still be technically significant. In the case of fibres, for example, the ratio of surface area to unit mass increases dramatically with the transition to

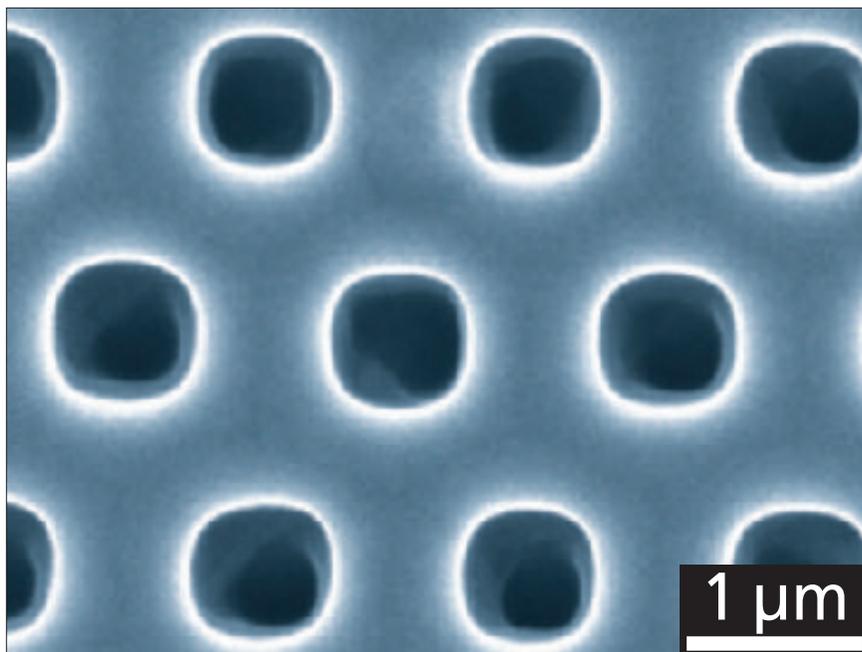
nanoscale dimensions. Typical applications are found in filtering or catalysis, which is the regulation of a chemical reaction by a catalyst.

In the nanoworld, tube-like objects play a special role. Carbon nanotubes constructed from graphite-like entities are currently stimulating the imaginations of researchers throughout the world. Such elongated objects lead to applications in sensor technology, catalytic reactions, nanoelectronics and photonics (which uses light instead of electrons).

An essential objective of nanotechnology is the development of preparation methods for nanoobjects. Depending on the intended application, such objects must be

made from polymers, metals, ceramics or glasses. The architecture of the object may be simple, as with solid fibres or hollow fibres, or the architecture may have to be complex, as with multilayer structures made from several different materials. Finally, it may be necessary to purposefully arrange the objects in a hierarchic relationship in order to integrate them into structural members.

Nanotubes are often produced using a template process, with a variety of specific methods being used. In the “tubes by fibre template” (TUFT) method, a very thin film of one or several wall materials is first applied to endless nanofibres, after which the template fibres are



A miniscule template for producing nanotubes, with regularly ordered pores and a thin polymer wall (represented by the white outlines).

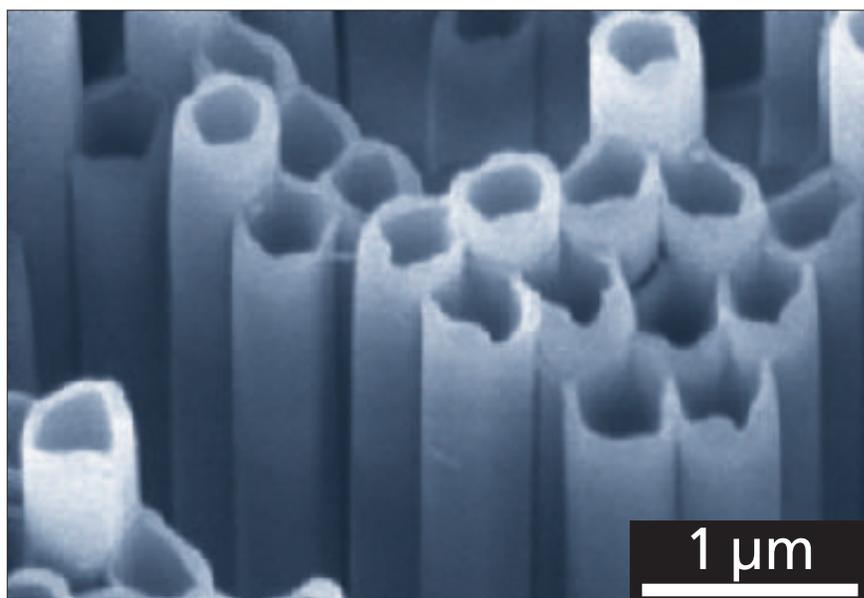
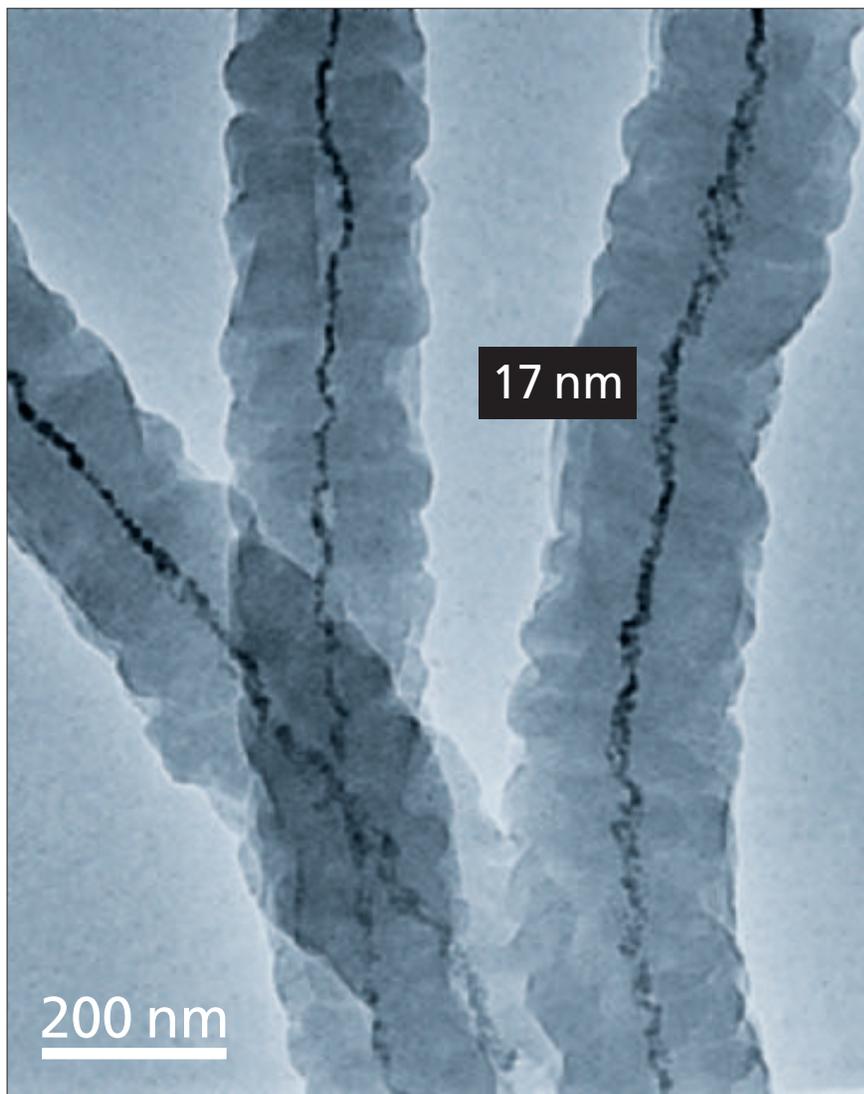
removed. This yields endless nanotubes.

Template fibres with dimensions down to a few nanometres, preferably made from polymers, can be produced in a very effective and controlled manner using the electrospinning process. With this process, nanofibres are formed using a very high electric potential. The material to be spun, in the form of a melt or a solution, is passed through a nozzle. The electric field produces a charge, which causes the material to form a fine jet that is accelerated towards the counter electrode. During this acceleration, the jet deforms, splits into multiple branches – just like a lightning discharge –, and, finally, is deposited on the counter electrode. During the spinning process, the solvent evaporates or the melt cools to a solid form. The fibres are deposited at a speed of several metres per second, and individual fibres have lengths of many metres. This process also allows extremely small metallic or ceramic particles to be directly incorporated into the fibres during spinning, so that they can be introduced into the nanotubes in the following step. The final result is an extremely fine web of fibres, which can be up to a square metre in size. This web may be so fine that it cannot be resolved by the naked eye or an optical microscope.

The second step of this process consists of applying a wall material. This is done using a technical process, such as vapour deposition or dipping, centrifuging or spraying the template fibres with a solution of a polymer material. Metallic nanotubes can be fabricated in this manner by applying a metallic coating, and nanotubes with complex structures can be produced using several coating processes in a sequence. If a template fibre filled with extremely small metallic particles is used, nanowires with diameters of a few nanometres can be produced in this manner.

For nanoelectronics, nanowires (above) with conductive metal cores and polymer insulation are highly important. Right:

24 An assembly of polymer nanotubes.



In the final step of this process, the template fibre is removed. One way to achieve this is to raise the temperature of the material, in order to decompose the polymer into easily volatilised building blocks. As an alternative, the fibres can also be removed with a solvent or, with suitable types of fibres, by using biological degradation.

For a large number of applications, it is essential to obtain well-ordered assemblies of nanotubes, and in some cases the nanotubes must also have well-defined lengths. This is very difficult to achieve with the methods described above, but it can be achieved using a technique developed only quite recently. This technique is based on a phenomenon the theory of which is not yet fully understood. If a polymer melt (polymers are compounds formed from giant molecules) comes in contact with a surface having high surface energy, such as that of a metal or an inorganic semiconductor material, an extremely thin film, with a thickness in the range of several tens of nanometres, quickly spreads over the surface. Such a film is produced even with highly viscous polymer systems. This spreading cannot result from a conventional flow process, since it occurs much too quickly. The concept is to utilise this spontaneous process to produce polymer nanotubes. This is done by bringing a suitable template with cylindrical pores in contact with a polymer melt.

The walls of the pores are spontaneously covered by a thin polymer film, which solidifies when the temperature is reduced. The nanotubes are obtained by removing the template material. This technique can be used to fabricate nanotubes from commercially available polymers, polymer alloys or polymers with special additives, such particles of metallic, ceramic or semiconductor materials, but it can also be used to form metallic or ceramic nanotubes using polymer precursors. Solids with high surface en-

ergies, including silicon and aluminium oxide, are suitable for use as template materials. The special advantage of these materials is that it is possible to generate pores with quite a wide range of diameters using special electrochemical processes. It is possible to obtain pore diameters of 10 to 1,000 nanometres with constant pore crosssection and aspect

ratios of up to 10,000 along with a high degree of regularity in the arrangement of the pores. Two different techniques have been developed for filling the pores: wetting the porous template using a polymer melt and wetting it using a polymer solution. Even with a viscous polymer melt, it only takes a few minutes for the pore walls to be covered with a film several 10-nanometres rich. A very surprising result is that even pores that are 1,000 times deeper than their diameter are uniformly and completely wetted all the way to the base.

Well-ordered arrangements of nanotubes with walls made from polymers, such as biologically compatible polymers, are interesting for a wide range of applications in biosensor technology and bioanalytics. In order to obtain isolated hollow polymer fibres, the templates

are removed without damaging the polymers. This is done using an acid or alkaline solution. These methods have proved to be highly suitable for use with a wide variety of

polymers for preparing regular arrays of hollow-fibre tubes with well-defined outside diameters and aspect ratios. Without doubt, polytetrafluoroethylene (Teflon), which is technically extremely difficult to process, represents an extreme case, but it is possible to produce Teflon tubes in this manner without problems. Since its original discov-

ery, this method has proven to be suitable for a wide variety of uses. For instance, if metal-organic compounds are added to the polymers, metallic tubes can be produced. As a point in case palladium nanotubes were prepared. To obtain a higher surface to volume ratio, which is advantageous for various applications, the porosity or roughness of their

walls can be adjusted. The applications for such tubes are found in catalytic processes and hydrogen storage for fuel cells.

These nanoobjects open the way to a wealth

of extremely varied applications. Currently, applications in photonics are being intensively researched. (Photons are the elementary energy particles of electromagnetic radiation.) For example, substances that emit light when excited, such as mixtures of semiconductor quantum dot structures and polymers or pure polymers, can be introduced into the porous template. The regularity of the arrangement and dimensions of the pores allows the emission characteristics of the luminous nanotubes to be tailored to meet specific objectives. Due to the associated special effects, such structures are called 'photonic crystals'. Attention is also being focussed on using nanotube arrays as bounded systems with well-defined forms, sizes and functions for separating gases, liquids and particle suspensions. This could be useful for the targeted encapsulation or release of medications by artificial viruses, or for microreactors. Finally, nanotubes are candidates for use as high-performance thermal insulation, for example in garments, or in ultra-light construction, where nanotubes might be used for mechanical reinforcement.

Nanotubes stimulate the imaginations of researchers – they open the way to a wealth of new applications

Attention is focussed on using nanotube arrays for separating gases, liquids and particle suspensions

*Prof. Andreas Greiner
Dipl.-Chem. Martin Steinhart
Prof. Joachim H. Wendorff
Universität Marburg
Dr. Ralf Wehrspohn
Universität Paderborn*



Seven million square kilometres of the surface of the Arctic Ocean are permanently covered by ice. Only by using a research ice-breaker like the "Polarstern" can this barely accessible habitat be explored.

Life under the “Cold Skin”

The Arctic sea ice is the habitat of an astonishing abundance of plant and animal life. These biocenoses have a momentous impact on the polar ecosystem



Freezing cold, their continents covered by massive ice caps, with ice floes to inhibit navigation – at first sight the polar oceans appear to be the very last place where life could exist.

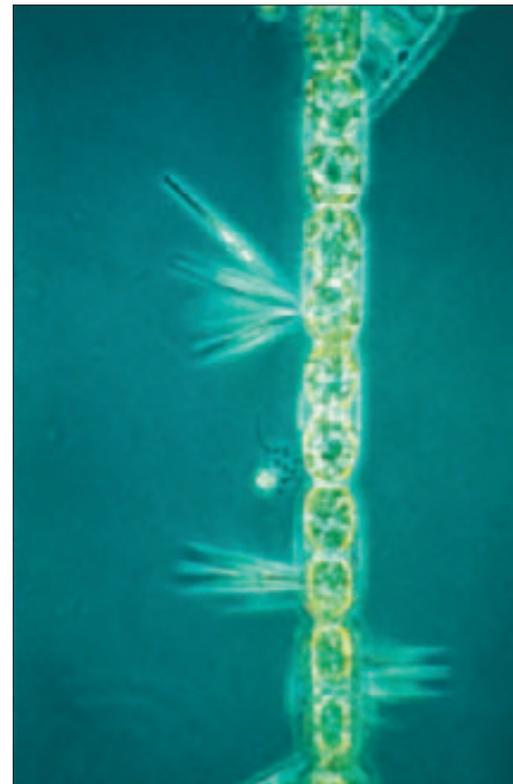
Over 150 years ago, scientists had already observed that the “cold skin” of the Arctic Ocean, the sea ice, supports life, and can assume a brown coloration from the abundance of microscopic diatoms existing in it. For many decades, biological research in the Arctic was concentrated on cataloguing the algae inhabiting this ice, and especially the diatoms. Only in the last 20 to 30 years have scientists begun to study the ecological aspects of these organisms in the ice.

The living conditions in the Arctic sea ice are unique. Whereas in the Antarctic the sea ice thaws almost completely in the course of the summer, in Arctic regions at least seven million square kilometres of the ocean surface are permanently covered by ice. Hence ice floes can

exist for periods of several years. Such differences between the two marine regions have also engendered diversity in the colonisation of their ice. Even today, access to the Arctic habitat is fraught with problems. Its pack ice is not navigable by normal shipping, and the extreme climate complicates research in the winter months.

The research undertaken by scientists from the Institute for Polar Ecology in Kiel began with an expedition on the “Polarstern”, an ice-breaker dedicated to marine research, in the spring of 1988. Their studies were initially concentrated upon the organisms in and under the sea ice, but were later extended to include the interplay between the two habitats, ice and open water, too.

The working conditions for researchers in the two polar regions vary radically. Whereas in the Antarctic, Adélie and Emperor penguins accompany the extraction of the drilling cores in the ice as inquisitive visitors, in the Arctic, it is





Researchers, complete with their equipment, have been set down on the ice to explore the pack ice. In the background, the "Polarstern" can be discerned in the commonly occurring Arctic haze. Left: A diatom colony from the sea ice. Right: A predatory amphipod clings to the underside of the ice with its hooked legs.

voracious polar bears which turn up as interested visitors to pose a threat to human beings. For this reason, research in the north demands the presence of specially trained sharpshooters with loaded rifles on the ice to watch for approaching bears. Up to now, however, they have never been called upon to intervene as the polar bears have always been discovered in time and either driven off with the aid of a helicopter, or the scientists have succeeded in retiring in good time to the "Polarstern". The scent emanating from their abandoned equipment was obviously attractive to the bears, but luckily they soon lost interest.

Equipped with power ice drills and snow shovels, we had in the meanwhile collected ice and snow samples from numerous stations for microscopic examination either directly on board ship in refrigerated containers, or in our home laboratory. The vast majority of organisms contained in these samples measured less than one millimetre. Our studies revealed that the Arctic sea ice provides a habitat for a highly diverse community embracing, in addition to diatoms,

also viruses, bacteria, proto- and metazoans such as threadworms and flatworms, and rotifers. We realised that the ice regions close in-shore and the surfaces, in particular, were distinguished by a high degree of biodiversity, and at the same time, carbon production.

Our scientists made a special study of the habitat formed in pools of melt water. These only occur in the sea ice in northern latitudes. In the summer, these pools can cover over half the surface of the ice floes and contain degrees of salinity ranging from pure fresh water right up to saline seawater. Even in these fresh-water pools on the high seas unicellular organisms were to be found which had adapted to their environment and defied winter temperatures below minus ten degrees Celsius and which, in summer, can reproduce within the space of just a few weeks.

The inside of the ice floes are permanently inhabited by animals which crawl through the narrow mesh formed by the labyrinth of minute brine channels. They consume bacteria, algae and other animals. Their consumption has not yet been measured, as working on the ice is exceptionally difficult in that

once the ice has melted, the habitat is destroyed and an artificial system is created. Furthermore, minute fluctuations in temperature produce such changes in the brine channels that much of the data published so far regarding the natural conditions can only be applied with reservations. Surprisingly, the studies conducted aboard the "Polarstern" revealed that individual plant and animal protists were just as active at temperatures between minus two

and minus four degrees Celsius as were related species in the Tropics.

The many biological substances (biomass) and the productivity of the organisms

inhabiting the ice ensure a rich supply of food, which is used by a multitude of diverse animal species, all of which live along the ice-water boundary layer. For studying these regions, the scientists employed under-ice video systems, whose cameras, measuring only a few centimetres in diameter, were lowered on long poles through holes drilled in the ice. This enabled us to document the structure of the underside of ice floes and the occurrence of plants and animals. We discovered that the habitat on the underside of

the sea ice was a highly structured, three-dimensional system of cracks, projections, holes and submerged fragments of the ice floe.

Various species of amphipod and small shrimps unique to the Arctic dwell here, most of which swim from the water at the underside of the ice to serve the ice. The animal world under the ice occupies a central position in the polar food network as it forms the link between the production of biomass in the ice on the one hand, and higher levels in the food chain on the other. The amphipods under the ice are fed upon by polar codfish, amongst other predators. These form the staple diet of the seals which, in their turn, serve the same purpose for polar bears. Thus, in the end, even the polar bear is dependent upon the minute organisms inhabiting the Arctic brine channels.

When the peripheral ice begins to melt, dramatic biological changes take place. Melting processes in the sea ice first affect the water layers beneath and between the ice floes. Here layers of fresh water are created down to a depth of one metre. The biological processes directly under the ice or in openings between the ice floes exhibit stark differences, which we were unable to record from the conventional samples on board our research icebreaker. This was because the ice reduces the light energy required

Studies show that the Arctic sea ice offers a suitable habitat for an abundance of plant and animal life



Using motor-driven drills, scientists can obtain ice cores 10 centimetres in diameter. Right: Polar organisms are studied in a refrigerated container on board the "Polarstern".



for carbon production. Should the "Polarstern" use its powerful bow thrusters or its stern propeller these layers would be immediately destroyed. In spring, the reduced salinity in the surface layer and the more powerful solar radiation lead to an enrichment with algae (phytoplankton). So-called ice-marginal blooms occur, whose concentration as a rule is higher than in open water.

Modern remote sensing techniques have revealed that these superficial processes influence the coloration of the ocean, which explains why satellite images often show such a discoloration of the ocean around the perimeter of the ice. These algal blooms around the edge of the ice are of vital importance to the life-cycles of many polar organisms. They are consumed by herbivorous zooplankton, and especially by crustaceans, who use this rich nourishment for building up their reserves of fat against the winter or for reproduction. This zooplankton, in its turn, forms the staple diet for higher levels in the food chain. Hence large colonies of birds are to be found in ice-edge regions close to major stretches of open water. In the course of our expeditions we also found that whales and seals tended to congregate along the periphery of the ice.

The Arctic sea ice has long lost its purity as a natural habitat. Multitudinous studies have shown that anthropogenic pollution, such as heavy metals, has been deposited in the ice. Just what happens to these substances when the ice melts, and where they go to, is not known, even though a portion does appear in high concentrations in the pelagic food web. This is equally true of natural deposits on the Arctic sea ice, which in places produce broad areas of "dirty" ice. These deposits originate from diverse sources, and may enter the ice as wind-blown



dust or frozen pelagic sediments. As a consequence, changes in the ice cover of the polar regions will have a considerable effect on marine, biological, sedimentological and chemical conditions. Current global climate models predict that the greatest temperature changes will be found in Arctic regions, where

they will cause a dramatic reduction in the thickness and extent of the Arctic pack-ice cover. Drastic changes can be expected in regional ice cover. Yet many species of life in

the Arctic are dependent upon the existence of perennial ice cover. So-called ice amphipods, which creep around the underside of ice floes, for example, are poor swimmers, and theory has it that after the ice has melted, these sink to the ocean floor and die. Other species are dependent upon at least an annual ice cover. Seals, for instance, spend most of their lives on ice floes, using the pack ice as a nursery, resting place and hunting ground. Hence,

Two scientists are being set down on the ice in a gondola suspended from the research vessel's derrick. This method is especially recommended for thin ice, as it enables ice cores to be extracted by drilling directly from the gondola, thus avoiding having to tread on the ice itself.

looking at fundamental biological productivity, in the case of the central Arctic, which has hitherto been one of the most unproductive pelagic regions in the world, an increase in productivity can be expected should a change take place from perennial to seasonal ice cover, with ice-edge blooms also extending from the coastal ice into the deep-water regions. In view of the predicted and, in part, already recorded, reactions of the Arctic sea-ice cover to climatic changes, we are now confronted with the task of estimating the order of magnitude of the biological consequences at all levels from the cellular right up to the all-embracing model.

*Prof. Michael Spindler
Universität Kiel*

Prof. Rolf Gradinger

University of Alaska, Fairbanks 31

Global climate changes will result in dramatic reductions in the thickness and extent of Arctic pack ice cover

The Deutsche Forschungsgemeinschaft

The Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) is the central self-governing organisation responsible for promoting research in Germany. According to its statutes, the DFG serves all branches of science and the humanities. The DFG supports and coordinates research projects in all scientific disciplines, in particular in the area of basic research through to applied research. Particular attention is paid to promoting young researchers. Every German scientist and academic is eligible to apply for DFG funding. Proposals are submitted to peer reviewers, who are elected by researchers in Germany in their individual subject areas every four years.

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

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

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

Other funding opportunities for qualified young researchers are offered by the Heisenberg Programme and the Emmy Noether Programme.

Humanities Research Centres were created in the new federal states to improve the existing research infrastructure. These centres have been established for a specific time period and serve to promote interdisciplinary research.

The DFG also funds and initiates measures to promote scientific libraries, equips computer centres with computing hardware, provides instrumentation for research purposes and conducts peer reviews on proposals submitted within the framework of the *Hochschulbauförderungsgesetz*, a legal act which provides for major equipment and the construction of institutions of higher education in Germany. On an international level, the DFG has assumed the role of Scientific Representative to international organisations, coordinates and funds the German contribution towards large-scale international research programmes, and supports international scientific relations.

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

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

Authors' Addresses

Prof. Hermann Bothe
Dr. Ulrich Hildebrandt
Botanisches Institut, Universität zu Köln,
Gyrhofstraße 15, D-509923 Köln

Dr. Hanno Fischer
Dept. of Zoology,
University of Cambridge, Downing Street,
Cambridge CB23EJ, United Kingdom

Prof. Rolf Gradinger
Institute of Marine Science, 231 Irving II,
University of Alaska, Fairbanks,
AK 99775-7220

Prof. Andreas Greiner
Dipl.-Chem. Martin Steinhart
Prof. Joachim H. Wendorff
Institut für Physikalische Chemie,
Kernchemie und Makromolekulare Chemie,
Universität Marburg,
Hans-Meerwein-Straße, D-35032 Marburg

Dipl. Soz. Silke Hamann
Dipl. Soz. Astrid Karl
Mannheimer Zentrum für
Europäische Sozialforschung,
Universität Mannheim, L7,1,
D-68131 Mannheim

Prof. Wolfram Kutsch
Dipl. Biol. Sebastian Berger
Fachbereich Biologie, Universität Konstanz,
D-78457 Konstanz

Prof. Ursula Peters
Institut für deutsche Sprache und Literatur,
Universität zu Köln,
Albertus-Magnus-Platz, D-50923 Köln

Prof. Hanns J. Prem
Dr. Michael Vallo
Dr. Iken Paap
Institut für Altamerikanistik und Ethnologie,
Universität Bonn,
Römerstraße 164, D-53117 Bonn

Prof. Michael Spindler
Institut für Polarökologie, Universität Kiel,
Wisshofstraße 1-3, D-24148 Kiel

Dr. Sebastian Steinfartz
Prof. Diethard Tautz
Institut für Genetik,
Abteilung für Evolutionsgenetik,
Universität zu Köln,
Weyertal 121, D-50931 Köln

Dr. Ralf Wehrspohn
Lehrstuhl für Nanophotonische Materialien,
Universität Paderborn,
Warburger Straße 100, D-33098 Paderborn

Dipl.-Psych. Heike Wolf
Dr. Frank M. Spinath
Prof. Alois Angleitner
Fakultät für Psychologie
und Sportwissenschaft,
Universität Bielefeld,
Universitätsstraße 25, D-33615 Bielefeld

Illustrations

Querbach (p. 3), Prem (pp. 4, 5, 6, 7), ZEFA-Virgo (p. 9), Universität Bielefeld (p. 10), ZEFA-Kappelmeyer (p. 11), ZEFA-Anousch (p. 12/13), Steinfartz (pp. 14, 15, 16), Kutsch (pp. 17, 18, 19), Bothe (pp. 20, 21, 22), Wendorff (pp. 23, 24), Spindler (Cover, pp. 26/27, 28/29, 31), Gradinger (pp. 28 b., 30 l.), Werner (p. 29 b.), Mumm (p. 30 r.), Oesch (back cover).

l. = left; r. = right; b. = below

Washington DC,
I Street NW,
Suite 540, is

the address of the DFG's liaison office in the United States. Not only are DFG grant recipients in the USA supervised from here, but information is also provided to American scientists about research in Germany, in order to promote the further growth of transatlantic research ties.

