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the Cradle of Humanity ▶ Mycorrhizal Fun-
gi and the Cloud Forest ▶ Dynamic of Panic

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The Ancestors of Mankind

The "Cradle of Humanity" lay in Africa. This has been demonstrated by paleoanthropological research and numerous fossil finds. The hominid fossil found in Malawi include the remains of *Homo rudolfensis*, who made tools and who lived some 2.5 million years ago. In retrospect, the use of tools marked a decisive step in the developmental history of mankind.

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On the Tracks of an Ecosystem

The cloud forests of the Andes are among the most biodiverse regions in the world. Researchers studying the flora of southern Ecuador have found that symbiosis between trees and mycorrhizal fungi plays a very important role. These "coil fungi", are not only found in tree roots, but also form symbioses with other plants, with far-reaching consequences.

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Heading Towards Higher Safety

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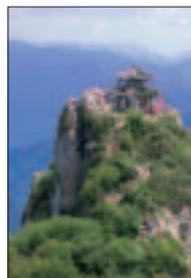
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Chinese grouse can be found in mountain forests. Researchers following their trail at the Lianhuashan Nature Reserve have revealed new insights into their way of living (Page 16). Cover: Siegfried Klaus

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Over 16,000 individual projects conducting basic research, backed up by €1.4 billion in funding were approved by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) in its various programmes and across the board of scientific disciplines in 2005. This simply breathtaking number of different research projects gives rise to at least as great a variety of research findings, which are published in innumerable publications and discussed at conferences and lectures both nationally and internationally.

But are important findings able to find suitable transfer paths into commercial application and social use simply through their publication and presentation to experts? The German government has announced a significant increase in research funding in Germany, so it is perfectly justified that voices are now calling for the theory that "science generates economic strength" to be substantiated.

On the one hand this is a challenge faced by the strategic processes of those disciplines which are in a position to contribute towards the development of a "research economy". The DFG intends to initiate and moderate such strategic processes within the disciplines even more in future than it has in the past.

On the other hand, knowledge transfer – ideally through human capital mobility – of findings resulting from DFG-funded projects conducted within companies, partnerships and associations and public institutions needs to be improved effectively. In this respect the hopes and expectations are firmly fixed on the creative young generation of scientists. They have the ability to tackle fundamental scientific topics and to work on solutions, either in partnership with companies or in their own start-up companies, in order to take development right through to the prototype stage – which, in the widest sense, may be taken as being the stage where a research finding can actually be transferred to a practical application. The DFG needs to promote these transfer processes more vigorously and

should cooperate more with institutions such as the "Hightech Gründerfonds". The great opportunities that exist can only lead to success, however, if companies choose to exploit these methods of cooperation more vigorously and actively than they have in the past. A new culture of knowledge transfer, from every discipline, both to existing companies and start-ups, is one of the key topics on which the DFG will focus in future.

As far as I am concerned, however, this in no way means that the DFG needs to abandon its consis-

out of or are affiliated with Collaborative Research Centres. Since the recent reform of the Collaborative Research Centre programme, another 30 Transfer Projects have also offered (industrial) partners the opportunity to cooperate directly in the work being carried out by a Collaborative Research Centre. These existing opportunities are not sufficiently taken advantage of at present. Approximately €8.2 million are currently approved for Transfer Projects each year – corresponding to just about 2 percent of the budget allocated to Collaborative Research

Prof. Dr.-Ing. Matthias Kleiner

Knowledge Transfer through Human Capital Mobility

The existing opportunities for exchanging research findings between university research labs and commercial R&D are in need of a boost

tent bottom-up and broad approach to funding outstanding basic research in every discipline. One thing is certain; it will not allow itself to be guided in its decisions by the short-term potential to exploit research findings. After all, the funding of applied research is not really the job of the DFG.

The DFG's funding mechanisms already allow for funding of cooperation projects between academic and industrial researchers on an equal footing. Prime examples of this are the 60 or so Transfer Projects currently underway in 18 Transfer Units, which either grow

Centres. Richard Lambert, the former editor of the Financial Times for many years and an expert on innovation, wrote a widely acclaimed independent review of business-university collaboration in the UK commissioned by the British Government in 2003. In his report, he came to the conclusion that "The best form of knowledge transfer comes when a talented researcher moves out of the university and into business, or vice versa."

In response to this, the Engineering Sciences Division at the DFG Head Office developed a concept for boosting knowledge transfer

which aims at the improved use of existing opportunities for knowledge transfer between universities, businesses, associations and public institutions. The Senate and Joint Committee recently approved this concept as a pilot project for a limited period on the recommendation of the Executive Committee.

The aim of this pilot stage is to build on the results of particularly successful DFG projects which have a high potential for knowledge transfer. To demonstrate this, such projects are requested to submit very detailed reports of their results.



In addition to the quality of the science, a convincing demonstration is required concerning the potential of the findings obtained for further development in the scientific, economic or social domain. The best reports, from this point of view, can serve as the basis for continued funding, with two simultaneous goals: either, cooperation with a business, an association or a public institution – as already tried and tested by the DFG – with the goal of common research and implementation of the research findings (“Transfer Projects”), or – entirely new for the DFG – cooperation with a yet-to-be-established

business, supported by “Hightech Gründerfonds”, for example, which is funded by public and private capital, or with private venture-capital companies, by means of funding for joint research projects (“Start-up Projects”).

Both the leaders of the research projects, and especially the research scientists conducting the research, are entitled to submit brief proposals for additional funding in order to continue the work with the aim of facilitating knowledge transfer when the report of the results is submitted. Where the research is to be conducted is purely up to the applicants. Thus, if it makes more sense to perform the research work at the partner’s labs, then that is perfectly possible. This funding mechanism aims, in particular, to promote transfer through human capital mobility. It is intended to give an added boost to knowledge transfer in every scientific discipline and is therefore explicitly

not restricted to the engineering sciences.

In the spirit of the Lambert review, this new transfer concept aims, on the one hand, to enable talented project collaborators to perform independent research projects in an appropriate economic and social environment, and, on the other hand, allow the research findings to be harmonised with the needs of the company or institution. Conversely, the partners with whom the researchers are cooperating have the opportunity to become familiar with new scientific discoveries and can incorporate these findings and any

developments derived from them into their own plans. In this way, good science performed locally is intended to stimulate a demand for more results. This prevents the classical route of technology transfer from remaining a one-way street, allowing it to expand to every scientific discipline as knowledge transfer.

This is in keeping with the way I see myself as an engineering scientist, because I see three main areas of responsibility in the future. First of all, there is a particular social responsibility of securing and improving peoples’ quality of life. We are called upon to contribute to this by making scientific and technological progress, which is derived from the insight and new discoveries made in basic research in all research disciplines. This leads me to the second area, scientific responsibility, which calls for engineering scientists to be personally and actively involved in scientific discourse and to live up to the same criteria and benchmarks set by the international scientific community as scientists in any other discipline. In addition to these responsibilities, engineering scientists are – thirdly – obliged to bear the technical and economic responsibility for the conversion of research findings and innovation into useful inventions and end products that benefit the economy and society as a whole. If the transfer processes – from insight to application – are successful, then new scientific questions emerge, thus initiating new research. Engineering science, just like every other scientific discipline, needs to be open to such interaction, this give and take, and to expect the same from its partners.

A handwritten signature in blue ink that reads "Matthias Kleiner".

Professor Matthias Kleiner

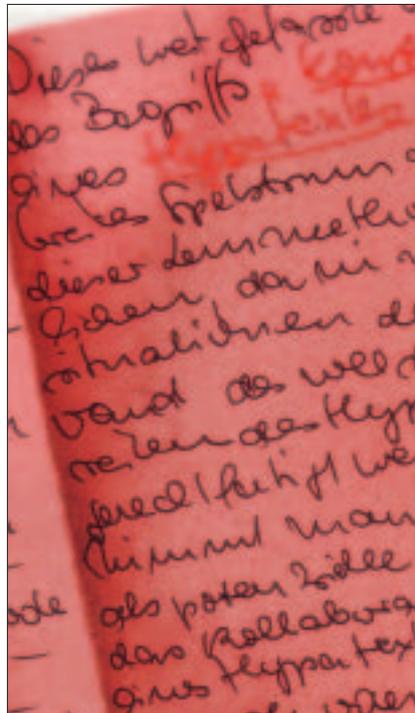
Matthias Kleiner is the President of the DFG (since January 2007).

The Best Route to Obtaining New Knowledge

Learning online: How can students be helped practically in producing hypertext documents for web pages? Psychological studies reveal how to improve learning by using new media effectively

Anyone who has used the internet is familiar with the scenario: It is impossible to read through the web pages presented on-screen from start to finish, like a book. Instead, you have to choose, by clicking on the hyperlinks, which route to follow through the information and how thoroughly or superficially you wish to deal with the subject at hand. That is what is called the hypertext principle used by the internet. The benefit of using hypertext is that information is broken up into discrete blocks, so-called nodes, which are then connected to form a complete document using links (called hyperlinks). This makes it possible to create documents that are easy to read on-screen. At the same time, almost any quantity of information can be linked or interconnected to form a network or "web". As well as this, hypertext makes it possible to link not only text and static images, but also dynamic content such as animations, film clips and audio files.

These developments resulted in hypertext becoming a research topic that is not only of interest to computer scientists and web designers, but also to empirical scientists, for example psychologists. The majority of studies deal with the conditions and difficulties involved with the reception of hypertext documents. Examples of such studies include research into the risk of disorientation when following a large number of links and studies into the effectiveness of teaching materials that are provided in hypertext format. In contrast, the production of



The internet is the realm of "hypertext". Content is broken down into discrete blocks of information, like electronic fragments of text. These are then combined to form a complete document using (hyper)links.

hypertext documents as a method of teaching and learning has received little interest so far. Preparing a hypertext document in such a way that the information it contains is logically structured and written in a way that is easy to understand requires a great deal of attention to the content within the subject area in question. It might initiate more attention than

conventional (chalk and talk) teaching.

Teachers and lecturers wishing to use the production of hypertext in this way are, however, faced by a total lack of empirically based advice on how to design projects of this nature. They are left to themselves to decide how to introduce the task to their students and how to conduct the lesson.

Observations of pupils and students who were given the task of producing hypertext documents as projects in class stimulated a series of experiments designed to look into the question of how it may be possible to help pupils and students produce hypertext documents. These experiments were based on psychological theories of traditional writing. Psychological research on writing has looked at the topic of learning through writing for a long time. This research has revealed that learning through independent text composition is achieved best if the student is able to make a connection between the so-called rhetorical structure of a text (for example the lab report for an experiment in the sciences) and the content and information that needs to be presented. It was therefore assumed that the production of hypertext documents would contribute to learning if the particular structural characteristics of these documents were related to the subject being taught.

In the experiments, students who had experience with word processing software, but no experience in writing hypertext, were asked to produce a hypertext document



The concept of learning by using hypertext is not a new idea: On this book wheel, designed by Agostino Ramelli in the 16th century, a foot pedal was used to turn a wheel to which books were attached, allowing individual pages and relationships to be found more quickly.

using specified nodes, in other words, short blocks of text, on a subject that they were basically unfamiliar with (the technology and history of the internet). To introduce the experiment they were told how to use the hypertext software, that is, how to open and link the individual pages of text. All of the subjects taking part in the experiment mastered the practical side of using the software after a little practice. They were then asked to think out-loud while working on-screen, and their activities were recorded both by the computer and on video. This made it possible to analyse the process of producing hypertext and allowed comparison of the resulting hypertext documents. The subjects participating in the experiment also had to take a test to determine their prior level of knowledge of the subject of their hypertext. After they had completed the hypertext document, their newly acquired knowledge on the subject was tested.

One of the fundamental prerequisites for it to be possible to learn through producing a hypertext document is the development of a basic understanding for the hypertext format and its peculiar requirements. The experiment therefore assessed the impact of the different metaphors, which were used to communicate to the students a basic idea of the structure of a hypertext document. The most common metaphors used for hypertext documents are the book metaphor and the room metaphor. In the book metaphor, hypertext documents are compared to conventional books. The information nodes are the pages and the links are compared to the reader's ability to turn to a different page in the book. In the room metaphor, hypertext documents are compared to virtual rooms containing information, within which the user can move around to find information. In

this metaphor the nodes are seen as individual areas where the user can access information, whereas the links are the routes between these areas.

In this experiment the book metaphor was found to be capable of giving the subjects a basic understanding of hypertext documents. As in a book, where information is presented in a linear sequence, the hypertext documents produced by the students who adhered to the book metaphor were characterised by a low number of links and very limited scope for navigation.

The room metaphor, in contrast, gave rise to an understanding of hypertext documents that emphasised the networking of information. The hypertext documents produced by the students who adhered to this metaphor contained a lot of links between the individual nodes and provided plenty of scope for navigation. This metaphor thus seems better suited to highlight the unique nature of hypertext in a way that is helpful to understanding the complexity of the subject matter. It also makes it possible to consciously develop various internal references in the subject matter and to implement them in the hypertext document. In the light of these findings, it seems advisable that the topic of hypertext should be introduced using the room metaphor.

When hypertext documents are being created, particular attention needs to be paid to including links in a well thought-out way, because these links are used to physically establish the relationships between the contents of the nodes. The hyperlinks found on the internet are often not labelled, and the users are left to decide for themselves what



Complex structure: An important part of the learning process when producing hypertext documents is planning the information blocks and the links. This process can be aided by the use of a metaplan board to visualise the links between the individual text nodes. For the web pages that are subsequently put online it is important that they facilitate on-screen reading and navigation.

the relationship may actually be between the pieces of information that are hyperlinked. This is one of the causes of disorientation when using the internet. The second experiment therefore proceeded to look at the effect of the students being asked to define the type of each link. They had to decide whether the link was, for example, based on a causal relationship, a part-whole relationship or a class-member relationship. Indeed, the experiment revealed that these students thought more thoroughly about the internal connections within the topic being looked at than a control group did. As a result of this more thorough examination of the topic, they gained a better understanding of the internal connections in the subject matter

than those students who included links without defining the type of relationship. For projects where pupils or students are called upon to produce hypertext documents on their own it is therefore advisable to ask them to explain the relationship that they want to highlight by including a link, and why they view this relationship as sufficiently important to warrant including a link at that point in the document.

Psychological research on learning and instruction dealing with conventional texts has shown that assuming the reader's point of view helps the author to gain a better understanding of the facts being presented. As far as hypertext is concerned, it is assumed that this format allows the situation and information requirements of different target groups to be taken into account even better than linear text documents. A group of American researchers led by Rand Spiro at Michigan State University proposed a theory – highly respected in the field of educational psychology – which claims that it is possible to develop much greater cognitive flexi-

bility through hypertext learning environments than by learning using conventional text documents, and have backed their theory up with preliminary observations. They claim that the same information can more easily be presented from multiple perspectives, since the hypertext can be accessed via different links, meaning that it is understood in different ways. The third experiment applied this theory to the creation of hypertext documents and analysed its validity.

This allowed the study of knowledge acquisition by students who were required to link the nodes in their hypertext document from two different angles (from the reader's point of view) in succession. First of all they were asked to imagine a target group with a definite objective, and to include all of the links that seemed important for this group of readers. Next, they were asked to link the same nodes again, but this time with a different target group with a different goal in mind. The process, the finished hypertext documents and the additional learning effect were compared to the results and the knowledge acquisition achieved by a control group, which had thought about the production of the hypertext documents equally thoroughly, also in two stages, but without being told to consider the target groups. This experiment revealed that being asked to consider the target group significantly improved the thought which the authors gave to the structure of their hypertext documents, and thus the structure of the subject matter. In particular, this led to improved comprehension of the internal relationships within the subject matter. The same applies to the ability to transfer knowledge and skills beyond their initial learning situation. For this reason, it is recommended that the network structure should be used for knowledge acquisition, in that learners take different readers' perspectives into consideration and add appropriate links to the hypertext for each perspective.

Prof. Rainer Bromme
Dr. Elmar Stahl
Universität Münster

Beside the Cradle of Humanity

The roots of humanity are to be found in Africa. Fossils point the way to the forebears of modern man and his history – as shown by new excavations in Malawi

In September 2006, a very special person celebrated his 150th birthday: the Neanderthal. When his bones were discovered in a small valley of the river Düffel in 1856, although it was not immediately recognised, scientific history had been made. After all, these were the first fossilised remains of a human – a sensational find, which, in a way similar to Charles Darwin's theory of evolution, shook the foundations of the contemporary worldview. According to the Church's dogma, man was the result of a unique act of creation by God. The birthday boy is still the cause of scientific controversy in his discipline, paleoanthropology – or the science of extinct peoples – although there is no longer any doubt concerning the existence of our fossilised predecessors. After his discovery, the Neanderthal did not remain on his own for long: numerous other finds, for example in Belgium, France and Gibraltar, led to the conjecture that humanity had originated in Europe. A seemingly obvious assumption, for if humanity was a product of evolution and not of creation, then it must at least have had its roots in Europe, which was then considered to be the centre of the world.

But the flaws in the Eurocentric world view of paleoanthropology quickly came to light. By the end of the last century, the cradle of humanity had shifted from Europe to Asia. Ernst Haeckel, a zoologist from Jena and an avid supporter of the theory of evolution, had identified *Pithecanthropus alalus*, the speechless ape-man, supposed to have lived on an immersed South

East Asian island, as the forerunner of modern humans. Inspired by the "Asia fever" unleashed by Haeckel, the Dutch military doctor Eugène Dubois travelled to Java and immediately found what he was searching for. *Pithecanthropus*, which he discovered in 1891, is classified today as the Asian *Homo erectus*.

Until the beginning of the new century, the so-called "dark continent" was a blank space on the map of paleoanthropology. Although Charles Darwin had already proposed in 1857 that the two morphologically related creatures, humans and chimpanzees, might have their origins in Africa, he seemed, in contrast to Ernst Haeckel with Asia, to have been mistaken. The first discovery in Africa took a long time to come to light, and when a fossilised human skull was finally found in Broken Hill (today Kabwe) in Zambia in 1921, it appeared, from a geological point of view, to be a very young specimen. However, the great coup was accomplished three years later. The "Taung Baby" from the southern border of the Kalahari in Africa, which was more than one million years old, was not only older than all other fossilised human remains, it also turned the dominant scientific worldview on its head – upright walking rather than the large brain was the beginning of human development.

This discovery was difficult to come to terms with, particularly in England, where ten years previously, there had been much ado about a hoax, the *Piltown Man*. The anatomy of the counterfeit "fossil" combined four-legged motion with a

The first pre-human discovery from Africa: the "Taung Baby", presented by Phillip Tobias, paleoanthropologist at the University of Witwatersrand in Johannesburg, South Africa. The skull is more than one million years old and was discovered on the southern rim of the Kalahari.

large brain, characteristics corresponding to the scientific doctrine of the day, and its "discovery" retrieved the cradle of humanity back from Asia to England. No wonder the discovery of the pre-human from Africa, the so called *Australopithecus africanus*, was hushed up for almost a decade. The *Pitldown Man* hoax wasn't exposed until the 1950s, by which time it was already evident that the actual origins of humanity lay in Africa, and not the United Kingdom. The discovery of new pre-human fossils in the South African caves at Sterkfontein, Swartkrans and Kromdraai in the 1930s and 1940s, swept the discussion of Europe as the origin of mankind from the table for good.

Although these discoveries settled the European dispute about the continent of origin of the first humans, the title "Cradle of Humanity" was to become a bone of contention between the regions in Africa: with the southern, eastern and north-eastern parts, and their respective bone hunters, contending for the title. These disputes were not only about the age of the fossils, but also about their beauty and completeness. Following decades of concentration on the traditional locations of fossil finds in South and East Africa, the excavation project "Hominid Corridor Research Projects" in Malawi, funded by the DFG, managed to fill a glaring gap in the findings and simultaneously discovered the oldest evidence of a distinctive branching of the "hominid family tree". It was not long before more locations of finds emerged: with the hominid remains from Chad, the human family tree was extended into a much more finely ramified "family bush".

But where exactly in Africa did humanity become human? The



out Africa", was already formulated decades ago by Phillip Tobias from Johannesburg, with his pan-African origin hypothesis. Thanks to new finds in Kenya, Ethiopia and Chad, which are also the oldest geologically, his vision has been impressively confirmed. Furthermore, the suspicion that in searching for the ominous "missing link" science has been on the wrong tracks is gaining ground. The single common ancestor of human-apes and humans probably never existed.

The African rainforest, home of our human-ape ancestors, originally extended from the west to the east coast of Africa and shrank to its current size between nine and seven million years ago as a result of global and regional climate change. The immediate consequence was the emergence of a zone with bush and river landscapes on the periphery of the tropical rain forest. This was the ideal environment for the development of upright walking. Given a geographical extent of at least four million square kilometres, it is un-

likely that only one single form of upright walking developed. The invention of tools was a further key step in the evolution of mankind, which used these to free itself from dependence on the environment. Curiosity and the beginning of a foresighted way of life probably played a determining role at this milestone in our ancestors' developmental history. One of the first foresighted human species was *Homo rudolfensis*, for which there is some evidence that he was able to make and use tools.

This 2.5 million year old find, which makes it the first member of human kind, came from Uraha in northern Malawi. Sixty kilometres to the north, near a village called Malema, the research team discovered a piece of an upper jaw from a robust pre-human, which, like *Homo rudolfensis*, was also 2.5 million years old. The simultaneous emergence of the robust nutcracker-humans with giant teeth and strong chewing muscles and of the genus homo demonstrates that the

alternative to having large teeth was the beginning of tool culture. The continuity in the use of tools, from the first stone tools 2.5 million years ago up to highly-sophisticated communication systems, computers and automobiles, is even today the common element in the evolution of modern man. But is this really the case?

The so-called "lands of the south", especially the African continent, have for a long time played no further part in the accelerating mechanisation of the world. If *Homo erectus* "invented" fire while still living on the "dark continent", he had already left 1.5 million years after the invention of the first stone tools. In our world of knowledge, where the internet, radio and television are everyday facts of life, we take it for granted that this knowledge about our own origins, which is so crucial to humanity, can be shared. Shared with all descendants of the first foresighted person –

A unique family photo. Most of the ancestors of humanity from the last six million years were black. The reconstructed ancestral portrait gallery also includes *Homo neanderthalensis* (top right) and the first tool maker *Homo rudolfensis* (bottom right), whose oldest remains come from Malawi.

Homo rudolfensis. But in Africa, the source of the forebears of humanity, prehistoric humans and modern humans, neither progress through human invention nor knowledge of human origin is well established.

It is the task of science to research, to understand, to provide new knowledge and communicate its results. It is therefore appropriate

that knowledge about the cradle of humanity should be disseminated in Africa, the cradle itself. Malawi for example, the country where the research team carried out

its excavation: since Scottish, Irish and English missionaries went there in around 1890, the northern periphery of this small African state has been largely forgotten. Thinly populated and for this very reason rich in resources, the north lost influence in the political regime of the "Life President", Dr. Hastings Kamuzu Banda. The "theft" of excavation finds from the region was now perpetrated by the central government, rather than by colonial rulers.

Paleontological discoveries in this region, which has been under dictatorship for 30 years, are an effective,

albeit rare, instrument for spreading knowledge and creating a cultural and historical identity for the region. In Northern Malawi, fossils of dinosaurs and hominids are becoming emblems of democracy. The exhibition "From Dinosaurs to Democracy", which opened recently in the Culture and Museum Centre in Karongas is, for the first time, telling

240 million years of the earth's history. Eighty years after Africa was established as the origin of humanity by science, this centre in Karonga now offers the native people a chance

to touch, explore and scrutinise their own natural and cultural history. Our science, paleoanthropology, which began with the discovery of the Neanderthal almost 150 years ago, is now having a reactive effect on society. It is enabling the democratisation of knowledge in a country that was one of the cradles of humanity. A small step for science, a giant leap for mankind.

*Prof. Friedemann Schrenk
Stephanie Müller M.A.
Forschungsinstitut Senckenberg
und Universität Frankfurt*

Paleontological discoveries are an important instrument in the creation of a regional identity in Africa



The Love Life of the Zebra Finch

Behavioural geneticist Wolfgang Forstmeier investigates the fundamental basis and consequences of sexual behaviour

As an Emmy Noether fellow, Dr. Wolfgang Forstmeier is the Head of a DFG Independent Junior Research Group at the Max Planck Institute for Ornithology in Seewiesen, Bavaria, which is investigating sexual behaviour taking zebra finches as their subjects. In this interview with "german research", the 35-year-old researcher talks about the love life of zebra finches, infidelity in the bird kingdom and the special opportunities afforded by working at a non-university research institute.

"german research": How did you first get into ornithology?

Forstmeier: Initially, it was thanks to my enthusiasm for birds and their great diversity. My interest was kindled as a teenager, with a pair of binoculars in my hand so to speak; so once I had finished school I went on to do my "Zivildienst," the alternative to military service, at the Bavarian Society for the Protection of Birds (Landesbund für Vogelschutz), before starting my degree in biology at the University of Würzburg in 1992. I finished my degree with a final year project on ornithology.

Your PhD thesis, which won the Science Prize of the German Zoological Society (Promotionspreis der Deutschen Zoologischen Gesellschaft) looked at the Dusky Warbler, a species that had barely received any research interest previously. What did you discover?

I was particularly interested in gaining a deeper understanding of the Dusky Warbler's mating habits, based on observations in the field over several months in Siberia as well as studies of their molecular genetics, which I did at the Ornithological Station in Radolfzell. Their highly individual behaviour, with individual birds displaying lasting "personality traits," have

been a topic of great interest to me ever since.

As a postdoc, your research took you – via a fellowship from the DFG followed by a Marie Curie fellowship from the EU – to the University of Sheffield.

Yes, I started working on zebra finches in Sheffield in 2002. Being like the "white lab rat" of the bird world, it is very easy to breed and has been studied closely. I took a closer look at



the mating habits of the female. On returning to Germany in 2004, I brought 450 zebra finches back with me – we drove in my van all the way from Sheffield to Seewiesen.

What was the attraction of Seewiesen for you?

The Max Planck Institute for Ornithology is an institute with an international reputation, which offers outstanding working conditions, not least when it comes to aviculture. The emphasis on research into behavioural and evolutionary biology was also ideal for me – it was the ideal environment for my Emmy Noether project.

Your project is all about the love life of the zebra finch. What's so remarkable about that?

They exhibit great variety in their reproductive behaviour. On the one hand, there is the notorious Casanova, who is constantly courting females, but is subsequently an absent, disinterested father. And then there is the reserved, almost shy, zebra finch, which develops into a very caring father.

And how are the zebra finches when it comes to fidelity?

(Laughing) Zebra finches are actually socially monogamous. Having said that, we have observed that about one in three of their offspring are the product of extra-pair copulation. The main question I am addressing is, whether the mothers – depending on their environment – are able to influence the subsequent reproductive behaviour, including the fidelity or infidelity, of their male offspring. We are also interested in whether the aggressiveness of individual males is due to genetic effects or is determined via maternal non-genetic effects. What we are trying to determine and evaluate is the question of how strong and how influential, not least at an evolutionary level, maternal effects are.

What are your plans for the future?

My Emmy Noether project lasts until the end of 2008. Beyond that, I've got plenty of new and exciting ideas for my next research project, although I can envisage working either at a university or in a non-university environment. Mind you, complex studies in behavioural genetics rely on certain essential prerequisites – for instance the apparatus required and the aviaries – that are almost exclusively to be found at non-university research institutes nowadays.

This interview was conducted by Rembert Unterstell

The Green Treasure of the Pharaonic Physicians

In ancient Egypt, medicinal plants played an important role in the treatment of illnesses. Present-day laboratory investigations of the pharmacological properties of these plants are very enlightening – and not just for chemists

Ancient Egyptians placed a high value on the knowledge of the pharmacological properties of medicinal plants, and their success in treating illnesses was well-known throughout the entire Eastern Mediterranean area. Although the ancient Egyptian physicians based most of their work on experience and traditions, modern pharmacology takes a different approach to studying the healing properties of plant substances. The results of modern scientific investigations, however, sometimes differ from those obtained using ancient folk methods.

In order to isolate plant's healing components in the laboratory, the dried or fresh flowers, stalks or roots are first shredded and then extracted several times using a solvent such as ethanol (alcohol). Once the ethanol has been evaporated, the resulting raw extract is distributed between polar water and a relatively non-polar solvent, such as chloroform. The non-polar compounds migrate into the non-polar chloroform phase, while the polar compounds remain in the aqueous phase. As "like" always dissolves "like", this separates the mixture of substances into its polar and non-polar constituents. Both phases are then dried by distilling off the chloroform and the water.

In order to obtain an initial estimate of the number of compounds contained in a particular plant, the chemist uses a physico-chemical separation process known as thin-layer chromatography. This method is used to separate a mixture of sub-



A medicinal plant used by ancient Egyptian physicians: the leaves and the roots of the ashwagandha were administered to patients suffering from mild insomnia.

stances on thin coatings of silica gel or aluminium oxide on glass slides or aluminium foils. A very small quantity of the mixture being investigated is dissolved in a solvent and is then applied to the separating layer where it is eluted with a suit-

able mixture of solvents. The compounds are separated because they are adsorbed by the layer to differing degrees, depending on their polarity, non-polar compounds traveling further than polar ones. The compounds can be viewed either with a UV lamp or by spraying the thin-layer chromatography plate with a spray reagent.

Larger quantities of substances on the milligram-to-gram scale can be separated into their components using column chromatography. The separating material is poured into a glass or metal column together with a solvent so that it settles into what is known as a "column packing". The mixture being separated is dissolved in a solvent and then applied to this packing. In the next step, solvents or solvent mixtures are added continuously to the column and the mixture separates. This chromatographic separation is repeated until pure compounds are obtained. Modern techniques, such as medium-pressure and preparative high-pressure liquid chromatography are able to separate almost any combination of components. Parallel to chromatographic separation, the pharmacological properties are studied using simple tests. If a certain test shows a positive reaction, the mixture is separated further until a pure compound is obtained, which is then subjected to further pharmacological investigations.

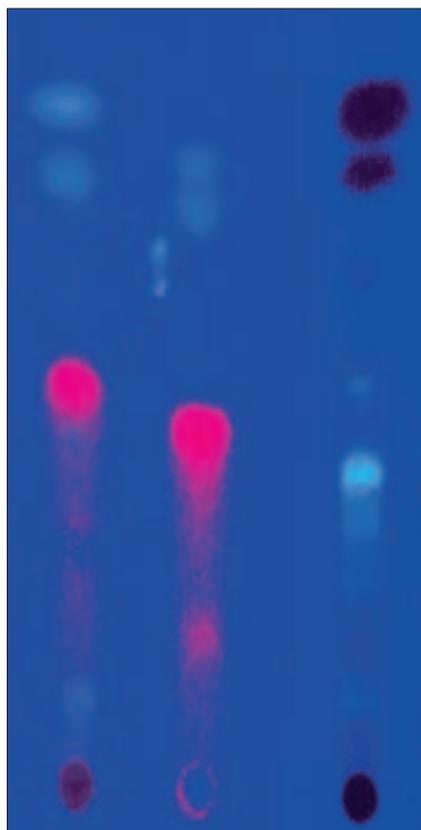
The structure of the compounds obtained in this way is determined by various spectroscopic methods. Mass spectrometry is used to determine the molecular weight and 11

composition of the compound. Glucose, for example, has a molecular weight of 180 and comprises the elements carbon, hydrogen and oxygen ($C_6H_{12}O_6$).

Laboratory investigations of ancient Egyptian medicinal plants can detect hundreds of compounds that could play a role in the treatment of illnesses. Researchers sometimes are able to isolate those substances which are responsible for the properties of the plant extract. It is quite exciting when modern science is able to isolate the compounds primarily responsible for the pharmacological effects of plants used 4000 years ago to treat illnesses.

In ancient Egyptian folk medicine, for example, the leaves and roots of the ashwagandha (winter cherry, *Withania somnifera* L.) were used to treat mild insomnia. Consequently, the plant should contain

After thin-layer chromatography, the individual compounds are visible under UV light. Below right: The bark of the pomegranate tree was successfully used in ancient Egyptian medicine as a remedy for tapeworms.



compounds which have a calming effect. At present, the use of this plant is undergoing a great revival in ayurvedic medicine, which ascribes stress-relieving properties to it. In fact, it has been possible to isolate a compound from the aqueous root extract of ashwagandha which has a calming and stress-relieving effect. Extracts from this plant have anti-oxidative properties and help boost the immune system.

We know, too, that Egyptian folk medicine used a certain Zygophyllum species (*Fagonia indica*) to treat skin diseases and the early stages of cancer. It is interesting to note that recent studies of this plant have shown that the hydrolysed ethanol extract contains both ursolic acid and oleanolic acid. These two triterpene acids exhibit an anti-carcinogenic effect; triterpene acids have a skeleton consisting of 30 carbon atoms. So-called triterpene saponins were also isolated from the Zygophyllum species. These compounds consist of a triterpene moiety and a carbohydrate moiety. Saponins are usually bitter-tasting chemical compounds which have

foaming properties, and plants containing saponins have been used in the folk medicine of various cultural groups to treat coughs, rheumatism and gout since ancient times. The leaves of saponin-containing plants are also used in diuretic, kidney, bladder and laxative teas.

Triterpene saponins exhibit a wide range of effects. They are toxic to fungi and snails, and have anti-inflammatory and anti-viral properties. They are expectorants and radical scavengers, and also have a favourable effect on the cardiovascular system. The use of triterpene saponins to enhance the immunogenic effects of antigens is of particular importance. In this case, the triterpene saponin is administered together with adjuvants and a specific antigen, usually a virus, in order to boost the reaction of the immune system to that antigen. Experiments with vaccines for herpes and influenza viruses as well as HIV have already been successful.

Some saponins also help to inhibit the growth of tumours both by destroying dangerous cells and by stimulating the body's immune re-

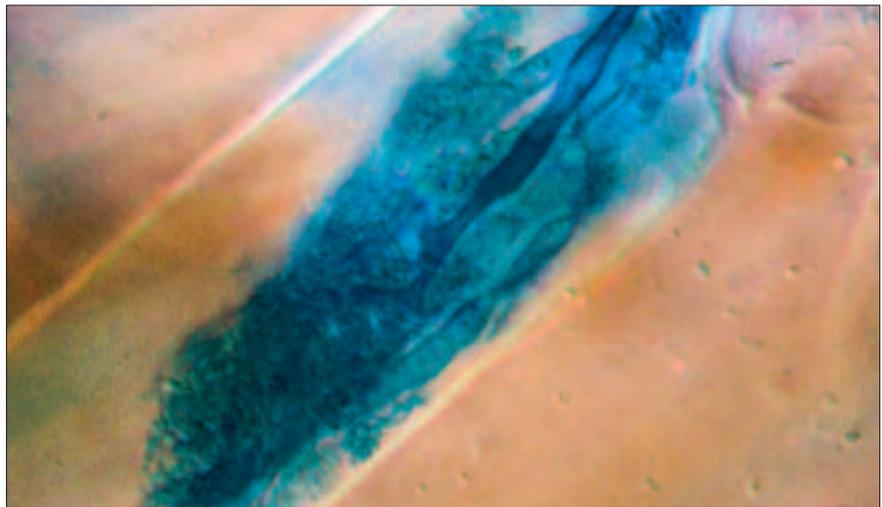


actions. Saponins isolated from *Agave cantala*, for example, inhibit the growth of cervical carcinomas and leukaemia cells, a property also exhibited by several members of the lily family. Treatment with ginseng saponins noticeably inhibits the growth of malignant tumours under the skin. A steroid saponin occurring in members of the lily family boosts the immune system and has been shown to inhibit the growth of liver tumour cells when injected into the abdominal cavity of a mouse. The subsequent blood analysis showed an increased level of the body's own killer cells, evidence of immune stimulation.

Likewise, the bark of the pomegranate tree (*Punica granatum L.*) was used as remedy in ancient Egyptian folk medicine. It was introduced as a cure for tapeworm towards the end of the Middle Kingdom or the start of the New Kingdom (in approximately 1500 B.C.). Nowadays, we know that it contains pelletierine-type pyridine alkaloids which are responsible for its effects. Pelletierine is highly toxic to tapeworms. Some modern synthetic tapeworm remedies work along the same lines – by paralysing the parasites' muscles so that the worms are eliminated along with the faeces.

Studies of medicinal plants illustrate the importance of understanding and utilising the widely diversified knowledge of global folk medicine to enable modern research to develop new and highly-effective drugs to successfully treat cancer, AIDS, cardiovascular diseases and many other illnesses. If one considers that just one percent of all chemical structures studied are natural substances and that these natural substances and their derivatives make up 35 percent of the active ingredients on the market, the scale of the growth potential becomes clear. Biomolecules which have evolved over many millions of years have much more powerful pharmacological properties than many artificial substances. The "green treasure of the pharaonic healers", therefore, should continue to be recovered and utilised.

*Prof. Dr. Karlheinz Seifert
Universität Bayreuth*



Mycorrhizal Fungi and the Cloud Forest

High biodiversity in the Andean Cloud Forest ecosystem is supported by the network of symbiotic fungi in the soil

The cloud forests in the northern Andes are among the areas with the most species anywhere in the world. They entranced already the naturalist Alexander von Humboldt when he visited this area in 1802. However, the area is so steep and inaccessible that it is still the least studied tropical biotope. Its survival is nevertheless at the greatest risk. As it cannot be directly used for agriculture, it is burnt down by the local population for producing pastures that are, finally, of only low productivity.

Since 1997, a research group supported by the Deutsche Forschungsgemeinschaft (German Research Foundation, DFG) has been studying the biodiversity and ecology of the cloud forest in southern Ecuador, with the aim of developing nature-friendly forestation and ecologically compatible concepts of use. The currently available results show that these forests differ from

what had been expected from previous scientific models. These models had been developed for the forests of Central Europe, which are dominated by one or a few tree species, with trunks of up to more than one meter in diameter. One of the main reasons for the small number of tree species in the forests of northern and temperate latitudes is the symbiosis which the roots of these trees form with specific fungi and which is crucial for the survival of both. The fungi (often the familiar edible mushrooms) are mostly linked to a specific tree species – as mushroom collectors are well aware. They start by colonising the roots of seedlings and, thus, specifically support the

Under the microscope, the fungus-root symbiosis looks like modern art. The blue stained hyphae have penetrated into the plant cells, forming fine branches, presenting a large surface for nutrient exchange.



Natural communities in the tropical cloud forest. Left: The tree trunks are covered with mosses, liverworts and lichen. Orchids grow between these. Right: The high trees are colonised by various sorts of epiphytes. As the available light is limited, plants invest in growth upwards, rather than in increasing their weight.

propagation of a tree species. In contrast, in the Andean cloud forest, very many tree species from different families form a dense, mixed forest. Their trunks are mostly only five to 20 centimetres thick, but 15 to 20 metres high. Our studies have shown that these trees also live in symbiosis with mycorrhizal fungi (mycorrhiza = fungal root). However, these fungi are unrelated to our edible mushrooms, the so-called basidiomycota, and as our studies have shown, are not restricted to a

specific tree species, but interact symbiotically with many trees. As a result, they do not restrict biodiversity in the cloud forest, but support it by a common fungal network

in the soil. These fungi do not form fruitbodies and are therefore unfamiliar to laymen. However, they develop root symbiosis with 80 percent of land plants throughout the world, making them ecologically the most important group of fungi. They were recently separated from the other fungi, being classified into their own phylum, the *Glomeromycota*, which can be translated as "coil fungi." Their hyphae form dense coils in root cells, which explains the name.

Tree growth in the cloud forests of Ecuador is particularly restricted by

phosphate deficiency. Soil science studies have shown that phosphate is almost only present in organic compounds from where it cannot be efficiently taken up by plants. The coil fungi can, however, act as mediators, by supplying the plants with phosphate, which they release from the organic compounds, take up the dissolved phosphate and transport it in the hyphae over long distances. The hyphae penetrate into the root cells, where (aside from the coils) they form finely branched tree-like

Studies in soil science have shown that tree growth is restricted by the lack of phosphate

structures (arbuscules), surrounded by the plant cell membrane. The plants absorb phosphate at the cell membrane and, in return, the fungi receive sugar from the

plant. Root symbioses with coil fungi are well developed in the cloud forest. The low level of available soil nutrients and the plant dependence on the symbiotic fungi restrict mass growth and hinder displacement of the many slow growing species by a few rapidly growing tree species. A surprising result is that it is not optimal nutrient supply that leads to stable and species-rich ecosystems (as had been previously thought), but rather nutrient limitation and the resulting pressure for cooperative exploitation of the resources, which support the devel-

opment of the highly differentiated, interacting and diverse ecosystem. Molecular studies have shown that most of these fungi are not known from other areas of the world and are therefore probably specific to the cloud forest. This knowledge is already successfully exploited in growing domestic tree species locally.

Coil fungi do not only occur in tree roots, they also develop similar symbioses with liverworts. Rather basal liverworts were found in the area, exhibiting fungal symbioses with all the typical structures found in the tree root symbioses. It was therefore investigated whether the liverworts might be capable of transmitting the fungal symbionts to the trees. Molecular data showed that this is currently not the case, as identical fungi are not shared among liverworts and trees. However, previous findings based on fossils and molecular data indicated that liverworts were the most basal land plants and, like the "coil fungi," at least 460 million years old. It is hypothesized that the liverworts started the symbioses with the "coil fungi" in order to "conquer" the land. In the course of evolution, the symbiotic fungi were transferred to other plants. Liverworts can form adhesion hairs, so-called rhizoids, and this probably greatly facilitated the development of symbiosis with the fungi. Studies of the liverworts sampled in the cloud forest showed that the fungi form adhesion pads on the rhizoids, penetrate into the rhizoids and rapidly spread up into the stem, where they colonise the moss cells. In contrast, on tree roots, the fungi form adhesion plates on the root surface and penetrate through the external cell walls into the root cells.

While we walk through our domestic forests without much difficulty between a few bushes and over





grass mats or moss cushions, in the dense Andean cloud forest, lianas wind upwards, and a great variety and density of liverworts and mosses, ferns, orchids, Aaron's rods, pineapples and ericads colonise trunks and branches. In the very steep terrain, gaps regularly arise from fallen trees or landslides and the soil can only be recolonised in such places. Plant growth in the cloud forest is obviously not restricted by lack of water or frost – as in the northern, temperate and Mediterranean woods – but by lack of light. Thus, plants invest in growing tall, rather than increasing in weight. This gives rise to new niches, in which symbiotic fungi play a special role. Ericads and orchids occur as epiphytes in great varieties in the Andean cloud forest and have fungal symbionts partly also found in liverworts. The fungi are a group of rather basal relatives of the basidiomycota, the "waxcaps," which form their fruitbodies flat on rotten wood, bark or soil. This group of fungi is certainly geologically younger than the "coil fungi," but their age was not determined so far. One indication for the later origin is that they develop symbiosis only with more derived, geologically younger liverworts. Orchids cannot develop without these fungi, and it can be assumed that the ericads in the cloud forest growing in pure humus are also critically dependent on them. It is just as true that the fungi depend on symbiosis with the plants. Molecular studies to determine the fungal partners have shown that fungal networks are only to be expected among the liverworts, among orchids or ericads not between individuals of the different families. The symbiosis between plants and fungi existed since plants first grew on land and understanding its nature can help us to grasp the complex interactions in the cloud forest. Moreover, it can make a very practical contribution to growing orchids, ericads and tropical trees.

*apl. Prof. i. R. Ingrid Kottke
Universität Tübingen
Dr. Martin Nebel
Staatliches Museum für
Naturkunde Stuttgart*



Life Sciences

The Fight for Survival in the Mountain Forest



The Lianhuashan Nature Reserve in China is home to many plant and animal species. But, as the example of the Chinese grouse shows, this habitat is under threat. Only the determined protection of the mountain forests of Central Asia can ensure the future of this unique biocoenosis

In 1873, not far from the Kuku-Nor salt lake in Mongolia, the Central Asia researcher Nikolai von Przewalski from Russia discovered a previously unknown species of Hazel Grouse: "... further down, in the forested area, a type of grouse can be found, which is much larger and darker than our European species ...". He named the new species, which belongs to the sub-family of the grouse, after the Russian zoologist Nikolai Alexandrowicz Sewerzow (1827–1885). The scientific name for the Chinese grouse (*Bonasa sewerzowi*) is still in use today. Przewalski was only mistaken in one small detail: the Chinese grouse is the smallest of all grouse worldwide, as our studies have since revealed.

Of all species of grouse, the least known-about is the Chinese grouse. Ornithologists know far more about its two sister species, the hazel grouse (*Bonasa bonasia*), which is common in Europe and Asia, and the North American ruffed grouse (*Bonasa umbellus*). A Sino-German cooperation project which compared the species and used molecular-genetic methods has now, for the first time, shown that the Chinese grouse is probably the most basic species of grouse. It has separated (or radiated) from our hazel grouse for about 200,000 years and, in this time, has developed into a distinct species.

The Chinese grouse inhabits the coniferous forests in the mountains of the Lianhuashan nature reserve. It shares this habitat with such attractive species as the blue eared pheasant, the ring-necked pheasant and the blood pheasant, as well as with forest dwellers like Tengmalm's owl and the Sichuan wood owl. Deforestation of parts of the original coniferous forests has led to an unusually rich and diverse development of species at the shrub layer. Beside dwarf bamboos there are many genera – and often many species – to be found, which also grow in central European gardens, such as barberry and European spindle, daphne and guelder rose, elder and rhododendron, to name but a few. It is mostly only the northern slopes of mountains that are



covered by conifers. Flowery meadows are typical of the dryer southern slopes, which are interspersed with sea buckthorn and willows. The grouses' diet consists primarily of willow buds and shoots for most of the year. Conifers provide them with the necessary cover. In the winter, when the grouse (which otherwise live in pairs) congregate in groups, they also use the sea buckthorn shrub and eat its orange-yellow fruit.

To date, the morphological data available on the Chinese grouse was based on the size and weight details of three males and three females only. As part of this project, the size and weight of 99 individual grouse was determined. This experiment revealed that the weight of both sexes fluctuates between 310 and 340 grams depending on the



season. The hen reaches her maximum weight during ovulation.

In appearance, the Chinese grouse is similar to our native hazel grouse, although its bright reddish-brown cap and the deep-black and white-striped tail feathers, which are visible when the tail is spread upwards, are conspicuously different. The hen has less contrasted plumage. Above all, she lacks the male's white-bordered black throat.

The territorial display and courtship of the Chinese grouse reaches its peak in the 2900 metre-high mountain forest during the first half of May. Of particular value for the comparison of the three *Bonasa* species are the sound and video recordings of their calls and of the associated behavioural patterns. Flutter-flights, in which the male takes off from the ground with loud wing beats, hovers for a moment and then lands again with an equally loud series of wing beats, are the main feature of its

Top: A male Chinese grouse performing a courtship display. Middle: Two rivals standing opposite each other. Bottom: A hen with her chicks. With the aid of birds fitted with transmitters, researchers obtained crucial information on the Chinese grouse.



territorial display in the spring and autumn. The loud territorial flights from tree to tree or from a tree to the ground, characterised by alternating flapping and gliding phases, are more seldom. Interestingly, the hazel grouse and the North American ruffed grouse have a trill song, which the Chinese grouse lacks completely. Altogether, the vocal repertoire of the Chinese grouse is comparatively "primitive".

When defending their territory, rivals stand opposite each other and try to intimidate each other with ritualised attacks. Courtship and mating habits are very similar to those of the hazel grouse. Females of both species who are ready to mate sway their heads rhythmically to and fro. Morphological and behavioural observations support the hypothesis that the three *Bonasa* species can be ordered in sequence, with the Chinese grouse as the earliest and the ruffed grouse as the most advanced. In cooperation with a Swedish-Italian research group, DNA sequences from mitochondria of the Chinese grouse could be included in a DNA comparison of all the grouse species of Eurasia and North America for the first time. This data enables conclusions to be drawn concerning the kinship relationships and the spatial-chronological phylogenetics of

the grouse subfamily. It shows that the origin of this entire subfamily of the grouse lies in the west of North America. The ancestors of recent hazel grouse evidently travelled from North America to Eurasia and there developed into the species we see today.

Furthermore, the hazel grouse and the Chinese grouse appear to be two clearly separate species, which divided about 200,000 years ago. The differentiation within the hazel grouse species took place in the past 40,000 years and the huge propagation to the west, accompanied by further differentiation, only occurred in the last 6000 to 10,000 years. Especially interesting, was the discovery that the hazel grouse's resettlement of the area north of the main chain of the Alps, after the last ice age, took place from East Asia moving westward, while the south Alpine hazel grouse (from Ticino for example) – which had already been separated from the main population for 100,000 years – returned from its refuges south of the Alps. With the help of 70 birds equipped with transmitters it was, for the first time, possible to trace the population ecology. Between 1995 and 2000, the population under investigation in the Lianhuashan nature reserve remained stable. The average annual survival rate amounted to 64 percent for older birds, but only 17 percent for young birds up to the age of 13 weeks. On the basis of 26 nests and 24 mother families, further key factors could also be determined. The clutch size of the high-mountain dwelling Chinese grouse of 6.1 eggs per nest was smaller than that of its sister species. The hatching success amounted to 63 percent, with an average of 3.6 chicks per female hatching each year. The low reproduction rate can partially be attributed to interference by mankind: people from local villages steal eggs between 10 and 29 percent of the nests. Further losses are caused by predatory birds and mammals as well as by disease. In addition, the fragmentation of the habitat had a negative impact. The territory of the Chinese grouse in 19

the Lianhuashan nature reserve, which has only 4700 hectares of forest, is separated from other forested areas by valleys with intensive agriculture and deforestation as well as by high mountains without any forest. Satellite imaging allows precise identification of coniferous forest, deciduous forest with shrubs, and open land. The habitat potential, the size distribution and the distances between all of the forests were determined for a 120,000-hectare region, which includes the main area under investigation by this project. It became apparent that the fragments of coniferous forest constitute an extremely small landscape mosaic. On average, a fragment of coniferous forest covers just 18 hectares. So far, 30 of these forest fragments have been checked for Chinese grouse and other pine forest dwellers.

This revealed that in a few cases the Chinese grouse lives in fragments of forest that are separated from other occupied fragments by up to 750 metres of open land, while for hazel grouse the critical distance is a mere 200 to 400 metres. Within the forest, the Chinese grouse fitted with transmitters travelled a maximum of three to four kilometres from where they were tagged. This knowledge provides the basis for suggestions to link forest fragments by new plantations. Rescuing the highly endangered mountain forest relics of Central and West China must be given highest priority. Not only does the survival of the Chinese grouse depend on this, but also the existence of unique mountain forest biocoenoses, with their great diversity of trees, shrubs, flowering plants and other species that are native only to China.

*Dr. Siegfried Klaus
Thüringer Landesanstalt für
Umwelt und Geologie, Jena
Prof. Yue-Hua Sun
Yun Fang
Chinese Academy of the
Natural Sciences, Beijing
Prof. Wolfgang Scherzinger
Nationalparkverwaltung
Bayerischer Wald, St. Oswald*



The Dynamic of Panic

Simulations can be used to model panic situations and pedestrian flows. The results of such simulations help make mass events safer



At first, everything seemed entirely normal; the rock group “Great White” started their concert at “The Station”, a music club on Rhode Island, right on time. But then, suddenly, the stage curtains went up in flames – and the club was transformed into a death trap. The crowd surged blindly towards the way out. Many lost their sense of direction in the thick, acrid smoke. At the emergency exit, people pushed, shoved and got wedged in between each other. Some managed to force their way out of the door to safety, others stumbled, fell to the ground and were trampled by the people pressing through from behind. Others were enveloped by the flames and burnt, 96 died. What was particularly tragic about this catastrophic blaze was that a freely accessible emergency exit remained almost unused, as was subsequently discovered.

How was that possible? According to Professor Dirk Helbing, Director of the Institute for Business and Traffic at the Technical University of Dresden, when mass panic occurs at large events “such a catastrophe dynamic can, unfortunately, often be observed”. For study purposes, the transport scientist maintains probably the largest archive of

catastrophe videos in Europe. Consequently, he has seen many similar situations that took place in other fully occupied arenas, football stadiums and airports. But, with cautious optimism, he also stresses that “panic and pedestrian research is establishing more and more human behaviour patterns, while at the same time computer based models are being developed, which help in the recognition of dangers and flaws, allowing escape routes and evacuation plans to be improved”.

Increased safety is needed in many places – in Mecca during the Hajj too, for instance. Every year, millions of faithful Muslims make the pilgrimage to the holy sites – a vast stream of people, which not only circles the Kaaba, the holiest site of Islam, but also reaches the Jamarat Bridge in nearby Mina. At this site, following the Muslim tradition, the pilgrims throw pebbles at three tall pillars, which symbolise the devil. In January 2006 at least 360 people were trampled to death at the “stoning of the devil”. At the worst accident, which took place a few years ago, 1400 pilgrims lost their lives. “The number of fatalities could be at least drastically reduced, if the findings of modern panic research were consistently put into practice”, Helbing stresses in a contemplative tone. The 41-year-old researcher, a physicist by training, is a pioneer of “digital panic research”. He is attempting to model pedestrian flows using computer simulations and thereby to predict the behaviour of people in panic situations. What is special about this approach is that, based 21

Muslims circle the Kaaba. During the annual Hajj, mass panic frequently ensues, causing a high number of deaths. Researchers studying crowd behaviour believe that the number of deaths can be drastically reduced.

on physical models derived from many-particle physics, pedestrians are considered as “particles”, which exert reciprocal forces on one another, thereby creating predictable patterns of motion. According to Helbing “several studies show that pedestrian streams are subject to physical laws similar to the flow behaviour of gasses and liquids”. The “phenomenon of self-organisation”, which can be observed in pedestrian zones every day, plays an important role in this. Pedestrians continuously form channels, so that they can move quickly and literally unobstructed. If someone steps out of

line in a busy pedestrian zone, they immediately increase their frictional resistance, as if swimming against the current. Interestingly, this walking channel behaviour is cul-

ture-dependent: in Central Europe pedestrians prefer to walk on the right (of the street), whereas in Japan and Korea they prefer the left. Even when lines of pedestrians walking in opposite directions meet at a bottleneck, the people organise themselves. The traffic is then directed according to the one-way street principle – first a group of people walks in one direction, then another group walks in the opposite direction. This self-organisation breaks down in escape and panic situations: people begin to jostle one another, rush to the exits, and push

and shove in an effort to get out more quickly. A human wave forms in front of the exit and pushes violently, trying to get out. People can fall or get trapped in front of the doors, resulting in a situation where the crowd blocks itself. “Those at the front are sometimes subjected to a pressure of several tons”, Helbing and his colleagues have discovered from their analyses. In the worst case, people can be squashed to death. Walls and entire steel constructions can collapse – the dynamic of panic which has become a tragic reality, not only on Rhode Island.

A possible solution is a thin column, placed about two metres in front of the exit, which could – according to Helbing – remove the pressure from the surging crowd and act like a wave breaker. This obstacle

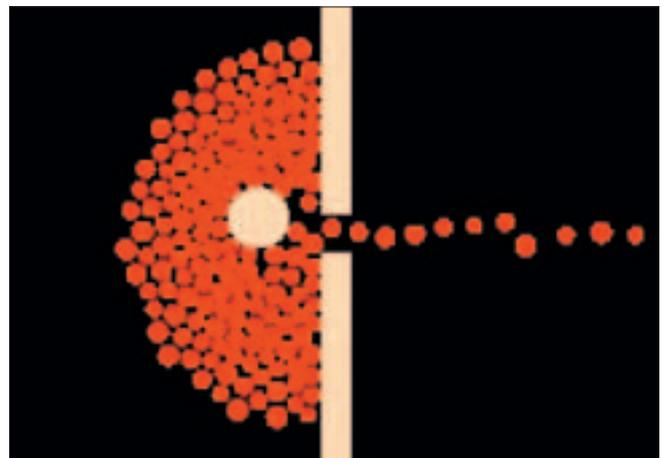
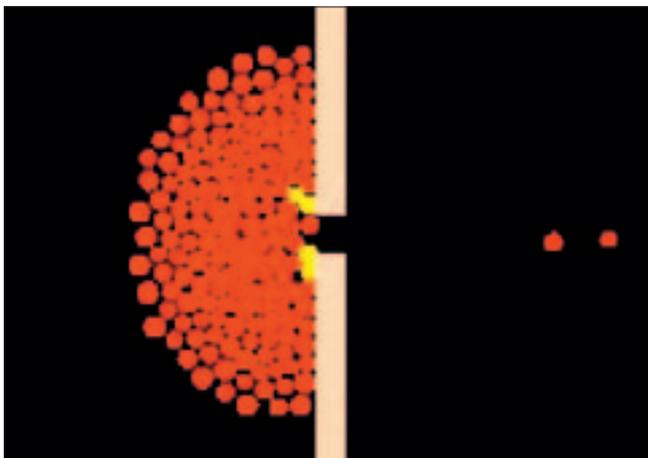
would divide the crowd of people into two currents. Significantly more people would then be able to escape to safety more quickly. The column appears to work best if it is not placed exactly in the middle of the exit, but slightly offset to the left or right. “When designing escape routes, symmetrical arrangements are usually not ideal”, says Helbing, who can also envisage practical everyday solutions, such as telescopic columns, which could be raised from the floor by remote control after the people have entered the building. Another thing the

panic researchers from Dresden discovered was that enormous pressures can build up on downward staircases when crowding occurs. However, if the steps follow a zigzag course – a few metres to the right and then a few metres to the left in alternation – this changes the direction of the momentum of the crowd, reducing the pressure. Also, escape corridors should not have convex sides. If a passage widens, the people trying to escape attempt to overtake each other, resulting in even worse bottlenecks.

On the basis of his research, Dirk Helbing recommends new optical or acoustic guidance systems instead of unclear escape route plans or emergency exit signs that may be hard to see. This could help make instinctive orientation in escape situations easier. Panic research demonstrates that bright exits, framed with light, draw people in acute danger towards them almost by reflex. The use of moving lights – light cones for example, which move towards the exits – might also be beneficial. With their “social agents model”, the fundamental researchers can simulate individual

Streams of pedestrians follow physical laws very similar to the flow characteristics of liquids and gasses

Right: Crowd panic on the terraces of the São-Januario stadium in Rio de Janeiro. Below: A computer simulation of pedestrian flows. Left: In panic situations, a semi-circular cluster of people forms in front of the exit, and the people wedge themselves more and more tightly. If a column is placed in front of the emergency exit, however, the pressure is reduced and the fleeing people can escape more quickly.





(DFG, German Research Foundation), "Computer Simulation and the Management of Pedestrian Flows under Specific Pressures with the Aid of Concrete Examples", which began in the spring of 2005 and is based at the Technical University of Dresden is contributing to this process. It is jointly lead by Professor Dirk Helbing and the Traffic Psychologist Professor Bernhard Schlag from Dresden. Among other things, the study will be looking at new psychological parameters for

pedestrians as well as interaction between tens of thousands of people on the computer screen. Each person, referred to by the researchers as an "agent", is modelled as a sphere with its own impetus, direction of movement, and speed of escape. Given a specific danger the speed of escape increases. In the absence of obstacles, the sphere quickly reaches its predefined speed of motion and rolls towards the exit. As people usually maintain a certain distance from strangers, house walls or roads, repulsive forces also come into play. The simulation also allows for a "panic factor", which is realised by means of soft spheres which can be distorted. A sphere which is pushed exerts a reciprocal force, pushing back, and a sphere which has been pushed by a force exceeding a certain critical amount counts as injured. Using this model, a wide variety of different scenarios can be enacted and the individual agents in the model, so called parameters, can be studied on the screen.

Of course, studying virtual worlds is only part of the process. The researches repeatedly need to return

to real-life crowds, also looking at more cheerful crowd phenomena, such as the Mexican wave. The astonishing result they discovered was that the jubilant wave spreads at a regular rate of twelve metres per second – irrespective of what country it happens in or how large the stadium is. Even if some members of the crowd stand up too early or too late, or don't stand up at all, the wave still spreads at a predictable speed. However, it is impossible for a single person to set the wave rolling through the crowd – it takes at least 25 people to set it in motion. The physicist believes that these and similar results may be useful to estimate the influence of a minority of violently inclined people on the majority. Faced with a complicated situation in reality, the challenge is to capture the entire situation – a fundamental problem for all simulation researchers. In order to get an approximate scientific handle on "system panic", the computer simulations that have been developed so far need to be extended, refined and supplemented with new parameters. A project funded by the Deutsche Forschungsgemeinschaft

simulation, such as human "orientation" and "learning". In addition, critical situations, such as might occur in pilgrim streams, will be simulated more realistically. Even if simulations have so far enabled us to understand many of the phenomena associated with crowd and panic situations, it is impossible for evacuation plans to anticipate unforeseeable events. Sometimes a coincidental event, such as a heavy hail shower or a goal in the final minute of a football match, can send a crowd into turmoil. In practice this means that panic can't be avoided with absolute certainty; but buildings and arenas with suitable "panic architecture" can reduce the number of victims. "As pedestrians, people are difficult to control," Dirk Helbing sums up, "we as basic researchers therefore need to have a comprehensive understanding of their behaviour, in order to devise solutions which are sensible, fair to pedestrians, and based on the latest findings in science and technology".

Rembert Unterstell

► www.helbing.org

The Deutsche Forschungsgemeinschaft

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

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

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

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

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

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.

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

Authors' Addresses

Prof. Dr. Rainer Bromme
Dr. Elmar Stahl
Universität Münster
Psychologisches Institut I
Fliednerstraße 21
48149 Münster

Dr. Siegfried Klaus
Thüringer Landesanstalt
für Umwelt und Geologie
Prüssingstraße 25
07745 Jena

Prof. Dr.-Ing. Matthias Kleiner
President of the Deutsche
Forschungsgemeinschaft
Kennedyallee 40
53175 Bonn

apl. Prof. i. R. Dr. Ingrid Kottke
Universität Tübingen
Botanisches Institut
Auf der Morgenstelle 1
72076 Tübingen

Dr. Martin Nebel
Staatliches Museum
für Naturkunde Stuttgart
Rosenstein 1
70191 Stuttgart

Prof. Dr. Wolfgang Scherzinger
Nationalparkverwaltung
Bayerischer Wald
Guntherstraße 8
94568 St. Oswald

Prof. Dr. Friedemann Schrenk
Stephanie Müller M. A.
Forschungsinstitut Senckenberg
Paläoanthropologie
Senckenberganlage 25
60325 Frankfurt

Prof. Dr. Karlheinz Seifert
Universität Bayreuth,
Lehrstuhl für Organische Chemie I
Universitätsstr. 30
95447 Bayreuth

Prof. Yue-Hua Sun
Yun Fang
Chinese Academy of Sciences
52 Sanlihe Rd., Beijing 100864
China

Illustrations

Klaus (cover, pp. 16-19); Pretzer (p. 3); Stahl (pp. 4-6); Stephanie Müller (p. 8); Ernsting/Hessisches Landesmuseum Darmstadt (p. 9); Unterstell (p. 10); Collette (p. 11); Wagner/Universität Bayreuth (p. 12.1.); Botanischer Garten Universität Bayreuth (p. 12 r.); Kottke (pp. 13-15); Superbild (pp. 20/21); Helbing (p. 22); dpa (p. 23); Querbach (back).

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

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