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Culture is a solid factor affecting the appeal of a location. A key aspect of image policy is the need to present local history and architecture and the centres of commerce and culture in such a way that they also appeal to an international audience. Taking Berlin and Moscow as examples, ethnologists are studying how culture is turned into capital in metropolises.

**Tracing the Footsteps of Prehistoric Giants**

Sauropods were some of the largest land animals that ever lived. Despite the fact they were herbivores, these enormous dinosaurs could reach a weight of 50 tons. Now, researchers are trying to solve the riddle of how these immense organisms functioned and how dinosaurs were able to evolve to attain such a formidable size.

**Desert Dust and the Continental Climate**

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**Cover**

A view of the Balad Seet oasis in the al-Hajar mountain range, which has been inhabited for over 2500 years. Researchers are studying the changing subsistence strategies in remote oasis settlements, looking at mountain oases in particular.
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half years ago, when the Initiative for scientific community just two and a half years ago only think of themselves and lead an isolated existence, far removed from real life. In fact, anyone who is in touch with reality is surely wondering why “Excellence Initiative” failed to be amongst the front runners in the vote. The DFG justified its decision to pick climate disaster as its word of the year because it concretely defines the topic that had a major impact on the German population in 2007. But if the point is to define what moved the country the most – literally, in terms of what helped to move forwards – then Excellence Initiative really should take first place.

And although even we at the DFG felt engulmed by the term at times, as the Excellence Initiative demanded a strong and rapid boost – one which needed to be announced and the initiative a strong and rapid boost – one which needed to be announced and the initiative a strong and rapid boost – one which needed to be announced and the initiative a strong and rapid boost – one which needed to be announced and the initiative a strong and rapid boost – one which needed to be announced and the initiative a strong and rapid boost – one which needed to be announced and the initiative – it becomes apparent that more than a third of all German universities have ideas or strategies that will be capable of competing at the cutting edge of international research within the next few years. At a regional level, although admittedly to a lesser extent because of the new federal states, a diverse image of scientific excellence is also evident, also when it comes to the range of subjects offered, which is due in part to the great success enjoyed by the humanities in the second round of the initiative.

All of these excellent ideas and strategies will give the German scientific community a strong and rapid boost – one that will not be restricted to the scientific community, but will also engulmed by the entire country and society too. Many of the ideas now being worked on in the projects and institutions selected under the third pillar of the Excellence Initiative will lead to innovations that in turn will generate economic growth and prosperity. The graduate schools will provide the right environment for training future leaders at the highest international level, both for science and research as well as for companies, associations and organisations. The clusters of excellence not only have the potential to facilitate new forms of cooperation between universities and non-university research institutions, but also between the scientific community and business and industry, which will help to accelerate the essential transfer of research findings into applications. And, last but not least, the institutional strategies to promote top-level research will enable the best universities to prove themselves as society’s “workshops of the future” in the truest sense of the word.

The opportunities these presents have already been recognised, especially abroad – perhaps even more so than here in Germany. At least, this is how some of the comments by some of the international reviewers following the decisions in the second round of the initiative in mid-October could be interpreted. Ekhard Salje, the world-famous mineralogist from the University of Cambridge, a Fellow of the Royal Society and President of the Royal Society, for instance, said that Germany needs to jolt itself into action. The Excellence Initiative has certainly given the country a jolt through the German scientific community and especially through the universities.

The Excellence Initiative is a great boost for the German scientific community and will also benefit the country and German society as a whole. It is impossible to emphasise strongly enough that it is particularly those institutions that are still seen by some as being inherently inflexible that were able to present themselves as being particularly innovative, as could only be wished of certain other, ostensibly innovative parts of German society. Especially the universities, which for many years have had to cope with even worsening financial and staffing conditions and mounting changes that came hand in hand with increased freedoms that came at a high cost – they in particular have taken up the gauntlet, in a converted act demanding great effort by all those involved, to face this change, have beenbufferedfaretowhateftful fiction of equality and opted for the competition of inequality that excellence brings to light. What some supposed was a rigid, immovable system has proved itself to be astonishingly flexible, and the term has been antipastoed as unexpectedly modern. If only the same could be said for the German health and tax systems, then there would be no cause for concern about Germany’s future.

Matthias Kleiner

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Times of Change in Omani Oases

For millennia, highly developed oasis farming, alongside fishing, has formed the basis of life for the sedentary people of Oman. Researchers take a deeper look at the changing land use strategies in remote mountain oasis settlements.

By A. Bürgert, K. Hammer, E. Schlecht, J. Häser and S. Al Khanjari
Famed as the origin of frankincense, a major copper producer in ancient times, and the birthplace of the legendary trader “Sinbad the Sailor”, who represents the phenomenal wealth of oriental merchants, Oman was barely accessible to foreigners until 1970. As an enlightened Islamic Sultanate, the country has since experienced an uninterrupted process of cultural and economic transformation. In former days, Oman was a country of nomads who bred the fastest camels in the world, of oasis farmers, fishermen and of seafarers, who were already trading with India on a regular basis, using their sturdy boats made of reeds, and later wood, in around 3000 B.C. Today the society’s welfare is based predominantly on the oil industry and on services. The traditional oasis economy as the material basis and key formative element of Omani culture has taken a back seat, becoming an exotic peculiarity and a tourist attraction. In recent years, many of the oases that have become easily accessible via newly constructed tarmac roads have turned into “housing estates under trees”, while remote settlements have become weekend residences or have been completely abandoned. Recent interdisciplinary studies have made it possible to represent and evaluate the way in which remote mountain oases in Oman function and have highlighted opportunities for their development. The study presented here looked at the mountain oases of Maqta in the Jabal Bani Jaber mountain range (a small “scattered oasis” settlement 1050 metres above sea level), ‘Ayn and Ash Sharayjah (two small core oases at an elevation of 2000 m a.s.l.) in the massif of the Jabal al-Akhdar, the small oasis of Al-Sawjahrah, which has only recently been connected to the road network and public infrastructure, as well as Balad Seet (a large core oasis at 1000 m a.s.l.) in the northern Al-Hajar mountain range. All of these sites are characterised by their use of the “Aini Aflaj” water supply system, a spring-fed canal system developed in Oman in regions with an annual precipitation of 100-200 mm, whose origins are believed to date back to between 1000 and 500 B.C., as well as by intensive interaction between terrace crop farming and animal husbandry. Observations of grazing goats, periodic GPS collar tracking and feed intake studies showed that once or twice a day, the herds with often a few hundred goats and some sheep are taken to graze the sparse mountainous pastures surrounding the oases that provide over 50% of their total intake; in the evenings their diet is supplemented with high-protein fish, high-energy dates, kitchen leftovers and alfalfa. The terraces, which are many centuries old, have been built up over the millennia with great care using 10,000s of tons of wadi sediments. They are used intensively for crop farming, which is characterised by large surpluses of added carbon and nutrients coming mainly from livestock manure. Studies of plant morphology and molecular genetics have revealed that the local varieties of wheat grown as landraces on these terraces, which are currently disappearing rapidly, are unique worldwide. The newly discovered five varieties of bread wheat and four varieties of durum wheat emphasise the ancient function of these mountain oases as sanctuaries for genetic resources. Comparative fingerprinting studies with wheat accessions from the world’s germplasm collection provided evidence for the ancient trade relations Oman maintained with all major countries in the region. The first example is the territory of Maqta which extends over an area of about 25 square kilometres. To the present day, the central settlement with its 59 stone buildings, which are predominantly used for storage, as well as for the 16 terrace systems, fed by 22 tiny springs, which cover a total area of just 4.5 hectares. Due to below-average precipitation during the period studied (2002-2004), many cultivated terraces were abandoned and one of the ancient varieties of wheat discovered there has now become extinct. As a result of its isolation and the precarious water supply, this oasis settlement is acutely in danger of being abandoned completely, in spite of state infrastructure aid and transfer payments. Irrigated farming in Maqta started only about 600 years ago. Prior to
this, the springs and pastures were used periodically by nomadic herds- men with their flocks. This is also visible in radiocarbon records which do not show settlement remains but several tombs dated to the Bronze Age and Iron Age (3000–600 B.C.). Famous are the limestone-built towers on the Shur plateau which were discovered in 1991 and 1992. Due to comparisons with simi- lar structures elsewhere on the Ara- bian Peninsula they could be dated to the 3rd millennium B.C. Howev- er, they were probably not only used for burials but also as markers in the landscape. They are situated on the Shur plateau where four main wadis originate and probably once were monumental territorial markers for the nomads.

Very close to the settlement of Maqta it was possible to find an undisturbed area of sedimentation in a depression where a 20 metres deep cut could be made for climatic studies. Such studies are most important for Oman to investigate whether the dramatic alterations in the settlement history over time could be partly explained by climat- ic changes. The sedimentation pro- file reaching over 18,000 years back into the Pleistocene era was used as a palaeo-climate record after suc- cessful radiocarbon dating of mol- lusc shells, luminescence analyses of quartz minerals and the evalua- tion of pollen diagrams. In contrast to earlier periods, when shifts of the Indian Summer Monsoon were reflected in large alterations of the moisture regime, the data gained from the profile provided evidence of only minor climatic changes since the tower tombs were built.

A second example: due to their spectacular location on the steep mountain slopes, the terraces on the Jabal al-Akhdar massif are famous as “Hanging Gardens” far beyond the borders of Oman. GIS-based analyses of high-resolution aerial photographs made with a small, remote-controlled airplane and ground measurements on the thou- sands of plots, some of which are as small as a single square metre, al- lowed a representative assessment of carbon and nutrient flows at the village level. The farmers who live on the steady decline in precipita- tion that has taken place over the past few decades, but 30-year old photographs of the area indicate that the perceived water shortage is more likely due to the rapid con- struction of new settlements on the high plain of the Saiq plateau and the accompanying intensive water- ing of domestic gardens coupled with an extension of tree cultivation on the terraces. The recent rapid growth of tourism will increasingly become another reason for the oc- currence of water shortages. But the oasis dwellers themselves also use more water today than they did just 30 years ago as toilets, showers and electric washing machines have be- come commonplace in many of the small mountain villages. A switch to (certified and thus marketable) organic farming methods, as would appear possible without much dif- ficulty from a cultivation point of view due to the very sparing use of mineral fertilisers and the almost total absence of pesticides to date, would open up new marketing op- portunities for the products from the oases, keeping the hard work in the gardens worthwhile.

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Cultural Science and the City

By Wolfgang Kaschuba, Alexa Färber and Cordula Gdaniec

Germany: A Summer’s Fairy-tale: for Berlin, World Cup 2006 was the occasion of an extravagant staging of the city as host to “friends” from around the world. Meanwhile, in Moscow, the municipal managers were discussing a new strategy to create a positive image for their city. There was a connection between these things: in the global ranking of major cities and their standard of living, which is published regularly by corporate consultants for international tourists and business people, the capital of Russia has a regular spot among the lowest placed cities, while Berlin is always in the top twenty. It is time for the negative portrayal of Moscow in the western media, which is based as much on daunting visa procedures as on crime reports, to be transformed into a more “civilised” image, says Mayor Luzhkov. But Berlin also continues to promote its established image as an international cultural metropolis through the art scene. Taking the examples of Berlin and Moscow, cultural scientists are investigating how to make capital out of culture.

As Emerging ‘World Cities’, cultural groups to the sustainable development of major cities. The term “creative classes” refers to intellectuals and to those working in the media, in artistic occupations and in knowledge-intensive technology sectors, but above all to parts of the ethnic minorities and to urban gay communities and subcultures. Their visibility in the city and their commercial and cultural activities, in other words their “creativity”, is considered to be in itself a decisive factor for sustainable economic development.

Perhaps that seems like a really simple and manageable formula for success. To cultural scientists, however, it sounds a bit starry-eyed. For this reason, one of the goals of a DFG-funded research project, with the title “Urban Culture and Ethnic Representation: Berlin and Moscow as Emerging ‘World Cities’”, is to take a closer look at Richard Florida’s creativity thesis. A comparison of cities as diverse as Berlin and Moscow ought to reveal whether this programme is really applicable to the development conditions of all major cities. The project also inquires into the specific social and cultural living conditions that face immigrants in such an ambivalent way in these two cities. The initially inviting “praise of diversity” and the fear of ethnic economies and gastronomies are always counterposed by decidedly repellent debates about “parallel societies” and Islamic fundamentalism. In this way, the status of minorities also becomes a mirror of our self-perceptions. Using a research perspective that attempts to approach the social actors and their life-worlds, cultural anthropology can provide an insight into the social and cultural microsystems that make up society.

Since German reunification and the collapse of the Soviet Union, Berlin and Moscow have had to reposition themselves politically and culturally, to an extent that few other major cities have experienced. With regard to the use of urban culture, the two cities follow distinctly different strategies. Moscow attempts to maintain or extend its position as an economic hub – now under the banner of aggressive capitalism. It thus glories in the construction of Europe’s tallest building, and stamps residential areas, administrative zones and hotel complexes out of the ground, bringing about structural change in the city centre.

In contrast with Berlin, which long ago established its central position on the world map of culture as a cosmopolitan and creative city, Moscow is rather slow and intermittent in opening the stages of the city to culture and the arts. There are historical reasons for this. In Moscow, the active international networking of the Russian art scene can only be...
observed after the collapse of the Soviet Union. The best example of this is “Art Streika”, an informal gallery project in the unused garages of the “Red October” chocolate factory on the Moskva island directly across from the re-built Church of the Redeemer. The artistic director of Art Streika describes this new space as Moscow’s “SoHo”, in reference to the legendary artists’ quarter in south Manhattan. The municipal government has given its approval to the project. However, in spite of the positive response to this temporary artistic use of the premises, they have no further interest in the long-term preservation of art at this central location. It is much more concerned with the relocation of the factory to the city limits, so that a luxurious apartment-office complex and recreational centre can be developed on this site, which is to be known as “Golden Island” and is intended to boost Moscow’s reputation as a commercial boondock.

Berlin, on the other hand, against a background of wretched economic development, long ago discovered the value of culture as a central economic factor. In the city’s self-portrayal, theatre, art, music scenes, fashion and knowledge industries, which are considered to be the driving forces of the so-called “creative industries”, have been strategically upgraded from “soft” to “hard” location factors. It is true, that there is now a preponderance of small and micro enterprises, but this diversity and the arts appear open and attractive to people visiting or relocating to Berlin.

The city’s administration and marketing department also stress these elements of Berlin’s image. By declaring culture to be the city’s central resource, they are reinventing the myth and reality of the cultural metropolis of Berlin: the scene cultures for younger and creative people, the historical and artistic European metropolis of the 20th century for the educated middle-class and the tourists.

This concept also entails a distinct emphasis on outstanding cultural events, pop culture, the gay and lesbian street parade on Christopher Street Day, the Love Parade, youth and music scenes and the staging of ethnic diversity in the Carnival of Cultures. This strategy has even led to a new appreciation of immigrant and minority cultures. Today, they form one of Berlin’s most notable drawing points and are considered to add to the commercial potential of the old and new cultural metropolises. In texts and photographs, in films and artistic productions they rejuvenate the city’s atmosphere and climate. The “climate of tolerance” in Berlin counts as a decisive factor for newcomers to the city – for immigrant minorities as well as for international tourists or for Richard Florida’s “creative classes”. This ethnic diversity is also invoked by cultural activities. Against this background, a case study examines how local international artists critically engage with the theme of “strangers” in the metropolis. Others create new cultural and commercial Berlin labels. In keeping with this, Berlin was named the City of Design by UNESCO at the start of 2006 and shortly afterwards it proudly assumed the “Designcity” label as part of the “Designmats’ festival. The culture industry has therefore already become a part of the Berlin “product”, and its professionals have long seen themselves as representatives of the city. That is “Imagineering”.

Field research has shown the disparity between this situation and that in Moscow, which even today has hardly begun to advertise its cultural capital. In contrast to Berlin, the city itself has not yet become an object of representation. The cultural added value of being a Muscovite artist, designer or product rather seems to be taken for granted and does not serve as a label. Artists here are hardly concerned with the city itself and the topic of the city’s ethnic, religious and sexual diversity appears in only a few works. In this respect, the city’s public sphere still seems to be politically regulated space, in which cultural diversity and any kind of cultural contradiction have very restricted opportunities for expression. Quite the contrary: in May 2006, the city received worldwide negative publicity, when the municipal government wanted to ban a gay pride event and then, when the participants gathered, nonetheless, failed to protect them from attacks by right-wing extremists. The question, which is welcomed in other cities is subject to harassment here; imagineering in Moscow is often a throwback to the stone age. It may be said of Berlin and Moscow that culture, art and creativity are becoming ever more important, though this is always subject to global business cycles and local rivalries. Richard Florida’s snapshot from the USA certainly cannot be transferred wholesale to the European situation, because local social and cultural conditions need to be more accurately reflected. The urban myth cannot be arbitrarily planned and styled – even though peripheral culture has long become the principal thing, and not only in major cities.

Commitment and stability are required: “I am the city” – a campaign that clearly states its position by the Berlin city magazine “city”. Right: The Moscow shop window of a “Berlin Döner Kebab” takes away. In Moscow, too, city culture is indebted to many models and impulses from outside.
A loudspeaker is used to apply sound waves to the wall, so that loose areas stimulated by the vibrations can be detected optically. Depending on its size, shape and thickness a loose section of plaster exhibits a specific oscillation pattern, known as an oscillation mode. This phenomenon is familiar to any driver who has experienced how loose parts of the car start to rattle and vibrate at a certain engine speed. The resonant frequency of each loose section of plaster creates a specific oscillation pattern. Some such patterns contain barely detectable oscillations along characteristic lines, may appear to indicate good adhesion of plaster that is actually loose. Therefore, in order to identify loose sections beyond any doubt, the wall’s oscillation patterns have to be measured at a variety of frequencies. Furthermore, to ensure that the sound waves do not damage the wall, vibration amplitudes need to be kept to a minimum. The team conducting the project therefore attempted to carry out the measurements at vibrations of less than 20 nanometres – less than one thousandth of the thickness of a human hair! To detect such minute movements, a high sensitivity non-contact measuring technique was needed.

A laser light wave, which is backscattered from the wall, is used as a sensor. The light wave reaches the observer slightly earlier if the oscillating surface is moving towards the observer at the moment it is scattered, and slightly later if it is moving away. This variation can be measured by superposing a second laser light wave onto the light wave that is scattered by the wall. The interference pattern obtained from this superposition of two light waves depends on the time shift of the light waves relative to each other – a phenomenon referred to by physicists as the light’s phase shift. If the peaks of two light waves coincide there is constructive interference and the light is amplified, whereas if a peak and a trough coincide there is destructive interference and the light is weakened. The size, shape and thickness of loose areas of plaster exhibit a specific resonance pattern, known as an oscillation mode.

The instrument works by recording a series of images in quick succession, which are then processed by a computer. The data is converted in such a way that already during the measurement procedure oscillating areas observed by the video camera can be recognised on the screen by their slowly flickering brightness. This type of display gives the observer an indicative impression of movement. The physicists in the research team needed to learn to respect the uniqueness of historical structures and the conservators and restorers needed to be able to understand the results and gain confidence in the performance and reliability of this high-tech method. Final results produced by the computer are presented as a plot of the oscillating, i.e., loose areas.

The new technique was finally put to the test on the frescoes in a cemetery chapel at Kamenz, Saxony. The adhesion of the layers of plaster covering the walls and ceiling was examined one square metre at a time. The frequency of the sound was adjusted in steps of ten Hertz, and the reaction of the wall to each sound was recorded. For the evaluation it was calculated how often an oscillation was detected for each position on the wall. The data obtained was assigned colour values, so that all of the areas where there was no longer good adhesion to the substrate were eventually displayed in yellow or red. The new laser-optical technique also passed the test in comparison to results obtained using the conventional percussion method. It benefited from the advantage that the damaged areas shown on the video image could be located precisely and automatically. Manual mapping performed by a conservator, on the other hand, can easily contain errors that creep in during the mapping process.

Another example of where the new method has been applied is the church at the Benedictine Convent of Saint John Müstair in Grisons, Switzerland, which has been de-
The Limits of Growth

Tracing the footsteps of giants: How the bodies of 50-ton prehistoric dinosaurs worked and the evolutionary steps that led to this gigantic size

By Martin Sander, Jürgen Hummel, Nicole Klein and Marcus Claus

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Acoustic-optical inspection of frescoes and wall paintings would be an official method, if not for the annoying noise levels it that generates. Although the vibrations in the plaster are minute, the volume of sound needed to generate them is immense. This is also due to the fact that low frequency sound cannot be targeted at one specific area, but fills the entire church. What is needed, therefore, is a sound transducer that emits sound straight at the target area of the wall, something like the beam of car headlights. A device is currently under development that should emit ultrasonic at two inaudible frequencies, which combine by nonlinearity on the way to the wall to generate the low frequency sound. This could finally allow the new technique to become accepted as a diagnostic tool for restorers.

**Apatosaurus** and **Brachiosaurus** were two of the largest land animals that ever lived, the sauropods. These gigantic dinosaurs were several times heavier than elephants, the largest of them weighed 50 tons according to a conservative estimate. Every young child can easily recognize a sauropod and will point out the small head on the long neck, borne by a massive body with four legs, to less knowledgeable grown-ups. With the exception of the brachiosaurs and the camarasauurs, the long neck was probably held horizontally, with the long tail used as a counterbalance. **Brachiosaurids** and **Camarasaurids**, on the other hand, held the neck in an upright position like a giraffe, and had a correspondingly shorter tail. The sauropods were herbivores (plant eaters), and enjoyed great success with this way of life for over 140 million years, from the Late Triassic (250 million years ago) until the end of the Cretaceous Period, thus surviving through almost the entire Mesozoic Era.

The greatest diversity and range of the sauropods lived in the Late Jurassic, with the most famous finds made in the North American Morrison Formation and the African Tendaguru Beds, which are now on display at the Museum of Natural History at the Humboldt University in Berlin. In the Cretaceous Period sauropods were less numerous on the northern continents, but they remained diverse and widespread on the southern continents until they became extinct, along with the other dinosaurs, about 65 million years ago.

During the long period of their existence, the sauropods saw dramatic changes in global geography, such as the break-up of the supercontinent Pangaea and far reaching changes to the contemporary ecosystems. This involved not only climate change and fluctuations in sea level (including the “Cretaceous Greenhouse World”), but also the appearance of angiosperms (flowering plants) from the mid-Cretaceous Period onwards.

A DFG Research Unit is studying how these gigantic creatures functioned as living organisms and, on the basis of this, how they were able to attain such an enormous size through the course of their evolution. This study is based not only on data from fossilised bones and skeletons, but also on the microstructure and chemistry of the bones and fossilised eggs and very often on comparisons with present-day animals. Understanding the sauropods’ energy metabolism plays a key role in understanding “gigantism” as a whole. It is not so much a question of what drove the evolutionary increase in body size, but of what limited it. Presumably the giant dinosaurs functioned far more efficiently, in terms of one or more of their vital functions, than other land animals. Two examples taken from the research group’s project work illustrate this. In order to understand gigantism in evolution, it is first necessary to study the growth of individual animals. Although you could be forgiven for assuming that this would be impossible for animals that have long been extinct, a special feature of the fossilised bones does offer a window onto their lives: the macrostructure, which is often perfectly preserved, can be viewed under the microscope, thin slices of bone, referred to as thin sections, reveal not only the course of collagen fibres and of the vascular system, but even the remains of bone cells. Comparison with the microstructure of present-day animals, for which the growth and metabolic rate are known, allows fascinating paleobiological conclusions to be drawn. This is because bone tissue of the osteoderms is always subjected to the same rate. The studies have revealed that the sauropods – with a few isolated exceptions – had a tissue, which is described as fibrolamellar bone tissue, which is only found today in large warm blooded mammals such as cows, elephants and pigs. Sauropods must, therefore, have grown at about the same rate as these animals. Annual growth rings, which appear occasionally, show that they sometimes grew at a rate of more than a ton a year!

But at what stage of their evolution did this rapid growth rate, which is almost unimaginable in anything but warm-blooded animals, begin? Investigation of the geologically oldest sauropod, *Iasosaurus*, discovered in Triassic deposits in Thailand, has shown that even this, the earliest known sauropod, must have grown at a very rapid rate. A comparison of the microstructure of the bones with a close relative, *Platodontosaurus* from Germany (also known as the “Swabian lindworm”), has...
The impressive skeleton of the Brachiosaurus brancai, on display at the Museum of Natural History in Berlin. Unlike most sauropods, Brachiosaurus held its neck in an upright position, and its forelimbs were longer than its rear limbs. It had a total length of 23 metres.

It has only been possible to draw conclusions about what the dinosaurs ate from the shape of their teeth and jaws, supplemented by palaeontological studies of the flora of the Mesozoic Era. This research group has taken a different approach. Although we know that the large herbivores that exist today obtain sufficient nourishment from leaves and grass, it was necessary to investigate the nutrient content of the plants in the Jurassic Period. Since flowering plants had not yet evolved, the flora at that time consisted of gymnosperms such as conifers and ginkgos as well as ferns and cycads. Although most of these groups of plants have survived to the present day, they no longer play a significant role as a food source for animals, which would lead one to assume that their nutritional value may be too low for them to be of interest to cattle, antelopes or elephants. The researchers therefore decided to use methods from agricultural research to assess the nutritional value of this “dinosaur fodder” in comparison to modern-day forage crops and thus determine which of them would have been best suited as forage crops for dinosaurs. These experiments were conducted using the “HFT method” (Hohenheimer Futterwert Test), in which the digestion in an herbivore’s stomach is simulated under controlled conditions.

Overall it was found that, in comparison to present-day leaves and grass used as fodder, the Mesozoic plants were perfectly suited for nourishing large herbivores. Also, several surprising findings enabled the researchers to draw conclusions about the sauropod’s diet. Araucaria (such as the monkey puzzle tree from Chile or the Norfolk Island pine) have a high nutritional value, although the nutrients they contain can only be extracted by digestion after a prolonged retention time in the gut, lasting about three days. Because large animals have a longer digestive tract and thus prolonged retention times, these conifers, which were very common in the Mesozoic Era, would have been ideally suited as fodder. This sits well with the idea that the sauropods may have used their long necks to browse higher trees. Perhaps the most surprising finding was that the primeval horsetail had the highest nutritional value, higher even than grass. In the Mesozoic Era these plants probably grew on the shores of rivers and lakes, rather like reeds today, meaning that a long neck would also have been useful for grazing in such locations. The question remains of why modern-day herbivores do not exploit this resource. One explanation would be that the high silica content of the horsetail foliage leads to rapid abrasion of the teeth (hence the old name, scouring rush, which refers to its former use for polishing metals). For sauropods this would not have presented a serious problem, since their teeth were primarily used for plucking off foliage and not for chewing.

A consideration of the issue of reproduction, in addition to that of nutrition, perhaps brings us a bit closer to an explanation of gigantism. Every animal in a given population requires a certain fraction of the land area it occupies as its food resource base. The larger the species, the fewer individuals can obtain sufficient food in a given land area. The large animals that exist nowadays, such as elephants and tigers, consequently have a low population density, which leads to a greater risk of extinction, as the population is unable to regenerate fast enough after a catastrophic event has occurred. This problem is exacerbated by the fact that the rate of reproduction drops significantly as body size increases. The maximum body size of land animals, therefore, seems to be determined by the size of the land mass on which they live. One way of overcoming the dilemma of population densities and reproduction rates that decline in response to increasing body size may be represented by the egg-laying of the dinosaurs. The number of offspring produced by birds, for example, does not decrease with increasing body size, but remains steady. Egg-laying thus could have allowed significantly faster population recovery in these very large animals than giving birth to live young, thus lowering the risk of chance extinction. Dinosaurs could thus have had stable populations at very low population densities, which would, in turn, allow for very large individuals, or indeed giants.

Eggs, and even entire sauropod nesting grounds, have been found in northern Spain and Argentina, for instance. Data on clutch sizes in these nesting grounds and on life history (deduced from the fossil remains found) can be used as a basis for model calculations on the rate of reproduction in sauropods and so to test the hypothesis that egg-laying permitted gigantism. This is just one of several exciting questions that the research group is still addressing. Although it will not be possible to shed a conclusive light on the evolution of gigantism, the understanding of the complex factors governing maximum body size has advanced considerably, and continues to do so.

The pink: Under the microscope, the thin section of sauropod bone appears coloured in polarised light. Below: The fossilised neck bones of a Barosaurus being excavated at a dig in Wyoming, USA. Barosaurus was one of the dinosaurs with the longest necks.

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Desert Dust over Europe

From Morocco to Europe: Scientists are studying the pathway and weather effects of a five-kilometre-high cloud of Saharan dust in a large-scale experiment

By Jost Heintzenberg

The impacts of desert dust from the Sahara on climate and weather extend far beyond the expanses of the African desert region. To examine the numerous consequences of the impact of the dust, scientists from the SAMUM (Saharan Mineral Dust Experiment) Research Unit have, for the first time, followed the movement of a massive, approximately five-kilometre-high plume of desert dust from Morocco to Southern and Central Europe.

The researchers were supported in their work by the European Aerosol Research Lidar Network (EARLINET), which consists of more than 20 lidar stations located throughout Europe. Lidar stands for “light detection and ranging” and is used to measure the distance and size of atmospheric features by means of laser beams. The first EARLINET station reported a four-kilometre-high dust cloud over Barcelona on 15 May 2006. The cloud continued to move to the northeast and was measured by the Leibniz Institute for Tropospheric Research at six to seven kilometres over Leipzig on 16 May 2006. The dust cloud then turned to the south and southeast and was sighted over Central and Southern Italy on 18 May. The Saharan dust was then also detected over Greece on 20 May.

Prior to the measurements in Europe, three light radar devices began their measurements at the first SAMUM station in Ouazarzate in Southeast Morocco on 12 May. This station houses the world’s only so-called Raman lidar devices. At the same time, a second ground station near Zagora began its work as close as possible to the dust source area. The experiment was complemented by two research aircraft, the “Falcon” and the “Partenavia”.

Why invest so much research effort in a climatically and logistically difficult area in Northwest Africa? Approximately 3500 million tons of atmospheric aerosol particles are emitted annually worldwide. Half of this large quantity of fine particles is the result of desert mineral dust. At 50 percent, the largest source of dust from a single desert is the Sahara, some 10 percent of which eventually reaches Europe.

The effects of the quantities of desert dust on processes in the earth system range from influencing weather and climate to the fertilisation of tropical rainforests. SAMUM is concentrating on the topics of weather and climate, as there are important questions on the significance of the impact of the dust which are still unanswered. Moreover, Germany has many years of research experience and is able to conduct a broad range of unique measurements.

The impact of the mineral dust on incident solar radiation and the thermal emission of the earth system affects weather and climate. The reflection of solar radiation by the dust results in an energy loss for the earth system. But dust also absorbs solar radiation, which means an energy gain in the dust layer. The mineral dust absorbs radiative energy in the thermal spectral range as well. At the upper limit of the atmosphere, the net energy effect of the dust fluctuates around zero, though this does not mean that it can be neglected, since there are large energy losses close to the ground, which are important to the biosphere.

The overall effect of the dust is complicated by the feedback which occurs between energy balance, atmospheric dynamics and cloud processes. The energy gained through the absorption of radiation in the atmosphere influences the stability of the atmosphere and, thus, of wind movements in horizontal and vertical directions. The wind at ground level is the driving force that lifts the dust up into the air. As a result, this feedback influences the dust source. The formation of clouds and precipitation are dependent in a complex manner on the dust particles on which the cloud droplets form.

In order to determine the impact of mineral dust on the energy balance of the earth, a series of dust properties must be determined. This begins with the distribution of dust particle sizes. The particle diameters span more than three orders of magnitude, from 50 nanometres to over 50 micrometres. For this purpose, various measurement and collection processes were used at the ground station in Zagora and in the research aircraft. Following the field experiment, the researchers analysed the collected dust particles in the laboratory with spectrometers and an electron microscope. The optical material properties of the particles were also determined. The opti-
A nalysis shows that the dust particles in the Sahara dust cloud are of irregular shape. Lidar as a method of detection was able to detect the shadow of the dust particles. Lidar also has the ability to measure the vertical distribution of dust particles. Lidar devices are able to make measurements from the ground to great altitudes, they are only able to do so from a single location. For this reason, it is necessary to complement these measurements with data collected on the aircraft. With a lidar device directed downward from the “Falcon” into the dust cloud below, it was possible to measure vertical sections of dust layers along the flight path. In addition, the “Falcon” determined dust-size distributions and average radiative properties of the dust-filled atmosphere. The most important radiation measurements, however, were made with the “Partenavia”, which is better suited to make measurements of the lower atmosphere due to its slower speed. The “Partenavia” was able to measure the vertical distribution of dust particles as well as measure the vertical distribution of dust particles. The information content of satellite measurements is, however, limited. In a cloudless sky, satellite sensors over land primarily see the sunlight reflected on the ground. In order to precisely distinguish the small, additional amount of sunlight which is reflected by air molecules and dust particles from the surface reflection, the latter must be known with a high level of accuracy. By flying at low elevations on days with low levels of dust, the “Partenavia” was able to collect this information which is essential to the satellite meteorologists from SAMUM on regional weather processes. For 2008, the research group is planning another large-scale experiment on the Cape Verde Islands, which lie in the primary transport direction of the Sahara dust cloud off of the coast of West Africa. There, the researchers plan to examine the ageing and climatic effects of the dust as it travels long distances towards South America and the Caribbean. During the dry period in the West African winter, large quantities of soot and other aerosol materials mix with the mineral dust. As a result, the optical properties of the dust cloud and the associated climate effects are influenced in a way which has not been explained up to now – the SAMUM Research Unit plans to examine this phenomenon. 

Under the microscope: Dust particles are not spherical, but rather have an irregular, crystalline shape. Using laser beams, so-called lidar systems gather information on the vertical distribution of dust particles as well as on the various particle shapes. Below: A highly visible lidar beam in the night-time sky.
Moving Like Worms: Without “Legs”

By Klaus Zimmermann

Locomotion has always exuded immense fascination. Matching nature’s feats of efficiency, flexibility and speed, for example, the flight of the hummingbird, the speed and agility of the cheetah running, or the graceful swimming of the dolphin, has posed a challenge to engineers for centuries. Flight, in particular, is a form of locomotion which allows mankind to learn a lot from nature. Yet it is not the propulsion and lift generated by birds using their muscles that is copied in aircraft, but rather the secret of how lift is created using the shape of the wing that led to the successful construction of artificial wings, which has enabled mankind to build so many different kinds of flying machines. Even now, mankind strives to develop ever-faster means of locomotion, albeit sometimes at immense energetic expense, to better nature’s leading position in this field.

Planes, trains and automobiles have long allowed us to travel at high speed, yet “walking” motion and humanoid robots still constitute a major area of research when it comes to robotics inspired by nature. Alongside walking machines, the concept of “legless” motion, as demonstrated by snakes and worms, is receiving increasing interest amongst researchers. Who hope that worm-like systems will prove an efficient form of locomotion in applications such as the inspection of pipes and sewers or for rescuing people burned by earthquakes. Applications in medical technology are also envisaged, for example for diagnostic systems or for minimally invasive surgery. Robots with legs or even wheels are particularly hard to imagine for use within the human vascular systems. Such applications make new demands on the systems’ size, drive mechanisms and operating principles. One of the key criteria is that such robots need to work as autonomously as possible. In order to work efficiently in pipelines or areas that have been hit by an earthquake, the communication and power supply both need to be wireless.

The use of magnetic fluids, also known as ferrofluids, whose properties and flow characteristics can be controlled using magnetic fields, present a new solution to this problem. Researchers at the Faculty of Mechanical Engineering at the Technical University of Ilmenau are cooperating with partners from Russia to study wave motion. Such undulatory motion enables locomotion through interaction with the environment. Ferrofluids are suspensions of ferromagnetic particles typically about ten nanometres in diameter in a carrier fluid. Commercial ferrofluids contain magnetite (Fe₃O₄) particles suspended in a viscous fluid brought about by a wave on the material interface sets up a flow in that liquid. This causes mass transport, a principle which is fundamental to the digestive system, but is also exploited in peristaltic pumps, for example. The challenge for the mechanical worm is to create such waveform surface deformation using ferrofluids in a magnetic field.

So what role do ferrofluids play in artificial worms? Theoretical and experimental studies have shown that the peristaltic motion (contraction and extension) of a viscous fluid brought about by a wave on the material interface sets up a flow in that liquid. This causes mass transport, a principle which is fundamental to the digestive system, but is also exploited in peristaltic pumps, for example. The challenge for the mechanical worm is to create such waveform surface deformation using ferrofluids in a magnetic field.

To accomplish this, a fluctuating magnetic field is used to create a travelling wave on the surface of a layer of ferrofluid. The field strength depends on a number of the fluid’s properties. From a technical point of view, the ferrofluid needs to be encapsulated in an extremely thin membrane in order to prevent the membrane from reducing the waveform deformation of the surface and the transferable forces too much. The first applications are therefore based on the use of magnetic elastomers, which are plastics that are solid, but are elastically deformable. One example is a worm made up of segments that can move along a tube using the well-known and much-used “inchworm” principle (to put it in technical terms: the so-called “segmented worm”). Without “Legs” - The development of a Formula 1 racing car demands a high degree of engineering expertise. For basic researchers, studying the methods of motion used in nature, such as that of the cheetah shown below, is becoming increasingly important. This has led to legless motion, like that seen in snakes or worms, attracting the interest of researchers.
Employing the principle of concertina locomotion (the method of locomotion used by snakes) the magnetic elastomer moves when it is driven by a magnetic field. Examples such as this demonstrate that recognising and understanding nature’s mechanisms for generating motion, force or transmission can inspire the development of technologically feasible locomotion systems.

If we don’t want to stop at simply copying nature and building ‘Heath Robinson’ solutions, it is essential to build mathematical models and simulate selected biological systems of locomotion, modelled at various levels. Recent developments in micro- and nanoscale technology and new materials and production technologies make it possible to turn new ideas into reality, particularly at the micro- and nanoscale. At a macroscopic scale, the biggest challenge scientists face is the need to save materials and energy in connection with transportation applications.

Locomotion in the macroscopic world, as a slow worm or as a high-speed wide-bodied aircraft, based on a biological role model or using unnatural wheels, will remain an exciting field of research in the future, and is already a route to success.

Doenst started studying human medicine in Göttingen in 1988. An early decision with far-reaching consequences led to him spending a year at the famous lab run by the cardiologist and cardiac metabolism specialist professor Heinrich Taegtmeyer at the University of Texas–Houston Medical School from 1992 until ‘93. I had a flash of inspiration there and it became clear to me that I wanted to continue doing research,” Doenst recalls. An exceptional dedication to science also made its mark on his thesis in biochemistry on the topic of cardiac muscle mitochondria.

After obtaining his doctorate in Göttingen in 1996 the young medic commenced his clinical training at the University Hospital of Freiburg. Once he had completed his time as an intern he finally qualified as a consultant cardiologist in 2003. Simultaneously, Doenst also pursued his scientific ambitions. A two-year research project took him back to the University of Texas–Houston Medical School as a postdoc and DFG research fellow. On his return to Freiburg he initially led an Emmy Noether independent junior research group from 2000 onwards. Together with the research group he had built up he studied the “protective effect of insulin in patients with ischaemic heart disease”. “These studies revealed,” Doenst explains, “the direct effect that insulin has on the energy consumption and performance of the diseased heart.”

In 2004 Doenst then qualified as a university lecturer. It was at that time that he also assumed the position of a senior doctor in the Cardiology department in Freiburg. Previously he was able to broaden his experience – in particular in the field of heart valve surgery – at the University of Toronto. His most recent appointment to date was when he moved to the Heart Centre Leipzig in the autumn of 2006, where he was one of the first Hessenberg (research) professors appointed in Germany. This makes him one of the most outstanding researchers eligible for appointment as a professor, whom the Hessenberg Professorship—created by the DFG, the German Research Foundation—is intended to help prepare for leading positions in science, while at the same time pursuing advanced research.

“I see the Hessenberg Professorship not so much as a distinction, but as an obligation,” says Doenst. And he emphasises the freedoms this appointment gives him to pursue his work. Even though the time pressures resulting from combining clinical medicine with research are by no means to be underestimated, Doenst is convinced that the two are complementary. “Being able to research the problems I see on a daily basis on the operating table”, Doenst underlines, “is just as challenging as it is important to me.”

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**There Are Two Hearts Beating in My Chest**
Torsten Doenst, a heart surgeon from Leipzig, combines his clinical work with pioneering basic research.
The Deutsche Forschungsgemeinschaft is the central self-governing organisation responsible for promoting research in Germany. According to its statutes, the DFG serves all branches of science and the humanities. The DFG supports and coordinates research projects in all scientific disciplines, in particular in the areas of basic and applied research. Particular attention is paid to promoting young researchers. Researchers who work at a university or research institution in Germany are eligible to apply for DFG funding. Proposals will be peer reviewed. The final assessment will be carried out by review boards, the members of which are elected by researchers in Germany in their individual subject areas every four years.

The DFG distinguishes between the following programmes for research funding: In the Individual Grants Programme, any researcher can apply for financial assistance for an individual research project. Priority Programmes allow researchers from various research institutions and laboratories to cooperate within the framework of a set topic or project for a defined period of time, each working at his/her respective research institution. A Research Unit is a longer-term collaboration between several researchers who generally work together on a research topic at a single location. In Central Research Facilities there is a particular concentration of personnel and equipment that is required to provide scientific and technical services. Collaborative Research Centres are long-term university research centres in which scientists and academics pursue ambitious joint interdisciplinary research undertakings. They are generally established for a period of twelve 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. Transregional 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 international exchange. They are open to international participants.

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

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

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

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

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