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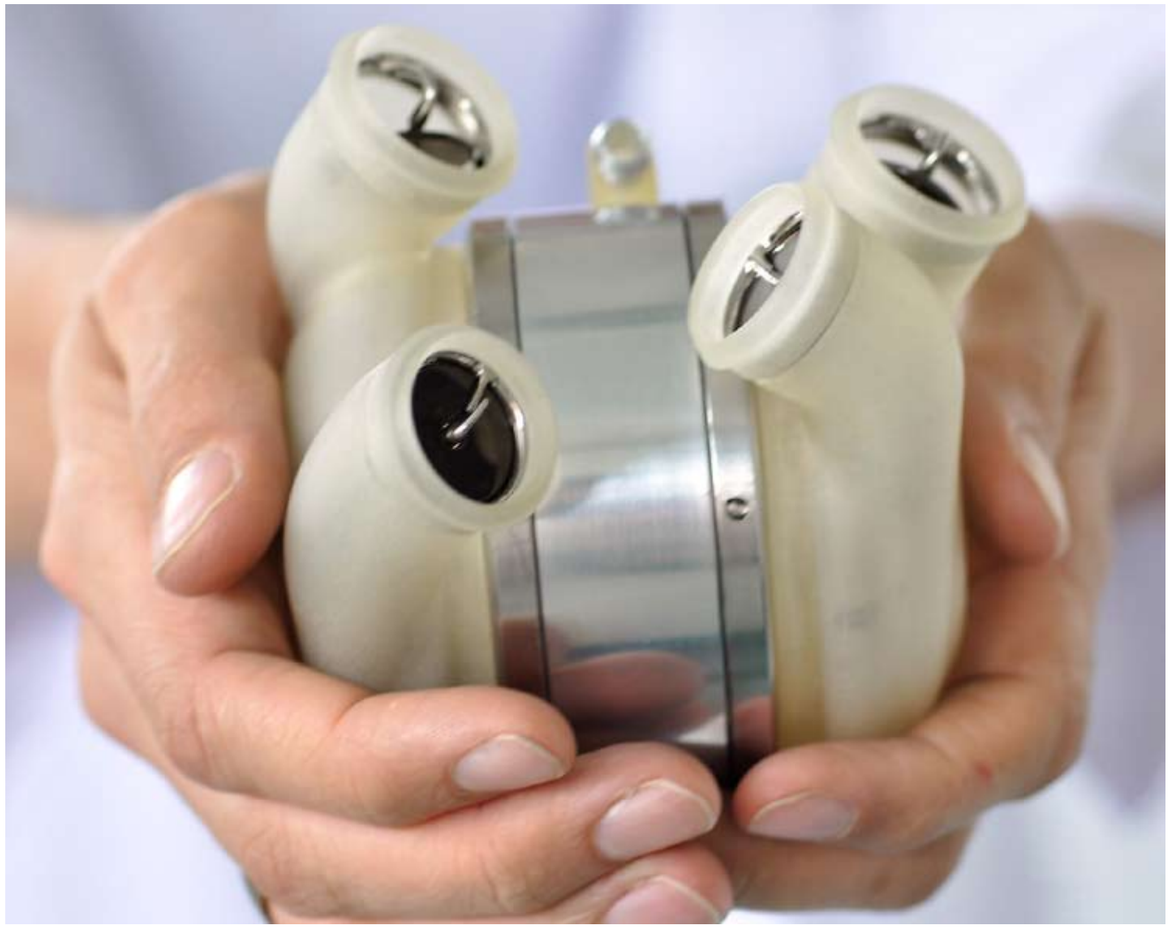

Applied Medical Technology: On the Way to the Artificial Heart | **Research Competition:** Broad-based Excellence – An Excellent Broad Base | **Cultural History:** The Working Man's Eye | **Computer Graphics:** "Thou shalt make thee an image" | **Human aDNA Analysis:** Ancient Epidemic Diseases in a New Light | **Modern Palaeobiology:** Genes and Fossils

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Cover: AME – RWTH Aachen
New hope for people suffering from life-threatening heart disease? The ReinHeart, an artificial heart, has two pump chambers with inlet and outlet valves as well as an electro-mechanical drive.

Matthias Kleiner

Broad-based Excellence – An Excellent Broad Base

The decisions for the second phase of the Excellence Initiative have been made. Once again it can be seen how this competition has furthered science and humanities in Germany and will continue to do so. The decisions also bolster the universities – the heart of the science research system.

It was a moment like so many in science: a first, important step had been taken and important results achieved – but then thoughts quickly moved to the future, to the question as to what might follow and where the results might lead.

The important results in this case were the funding decisions for the second phase of the Excellence Initiative, handed down by the scientists and policymakers on the responsible Grants Committee on Friday, 15 June in Bonn. And the thoughts directed at the future? These focused on the question as to what would follow this second phase of the competition, aimed at bolstering top-level university research, and how the institutions now receiving grants for five years would develop in detail.

Yet the first priority that afternoon, less than an hour after the close of the Grants Committee meeting, was to announce and evaluate the decisions. All those involved in the competition are in agreement that the past and current candidates selected for funding are truly impressive.

The second phase of the Excellence Initiative has again shown the extent to which the programme has already bolstered, and will further strengthen, science and the humanities in Germany as well as the German science research system. The 45 graduate schools and 43 clusters of excellence approved for funding represent forward-looking areas of research and original approaches to training early career researchers. And with the eleven institutional strategies, universities have convincing programmes for long-term development of their strengths in the context of international competition.

Novel structures at universities, new cooperative efforts between universities and non-university institutions, modernised university administrations, and several thousand new positions as well as several hundred professorships, which will also benefit academic training programmes and students in addition to top-level research: all of this will be continued from the first funding phase into the second, and would not exist were it not for this competition – at least not in this form and to such a wide extent.

Yet, the competition reveals more. The decisions, like the entire second phase of the Excellence Initiative, highlight a special strength of the German science research system. More than two-thirds of all public universities took part in the competition, while more than half made it to the final round. And the 99 approved projects come from a considerably greater share than one-third of all public universities. The Excellence Initiative promotes top-level research – and this top-level research is found very broadly and in very diverse forms in Germany.

The distribution among subject areas reveals this breadth and diversity. The approved projects originate from all major scientific disciplines. The humanities and cultural and social sciences are not only strongly represented, they have improved their position – despite all complaints concerning supposed disadvantages and inadequate forms of funding. A total of 16 graduate schools are devoted to these disciplines, representing the majority of institutions for training early career researchers, and together with six clusters of excellence make up the second-largest group overall, coming before the natural sciences and engineering sciences.

The regional distribution of funding is also impressive, and Dresden's success is worthy of special mention in this regard. All these outcomes are the result of an exclusively science-driven selection process. From the review process, including a total of 142 applications and involving more than 600 mostly international reviewers (about 25 percent of them women), to the interdisciplinary assessment in the commissions and the detailed discussions

Illustration: DFG/Ausserhofer

held by the Grants Committee – at every stage, hard scientific criteria played a key role. The scientific community is very grateful to policymakers for being able to jointly uphold this principle. This in particular allowed the best projects to be selected and approved for funding.

Such a process also entails the possibility of outcomes other than funding approval. A special feature during the second phase of the contest was the competition between previously funded institutions and new applicants. In this context, no one enjoyed a bonus, while not all expectations could be met. There are no losers, however. Simply as a result of their applications, the unsuccessful candidates gained much in terms of potential and future options, and several of them can already expect other types of funding. Meanwhile, institutions whose funding was no longer extended achieved much during those five years, and those achievements will not disappear. While these institutions have the prospect of initial subsequent funding, for two years they will also receive transitional funding, for which almost 100 million euros has been made available. In any case, no one need fear the spectre of "banishment from excellence" previously evoked by some.

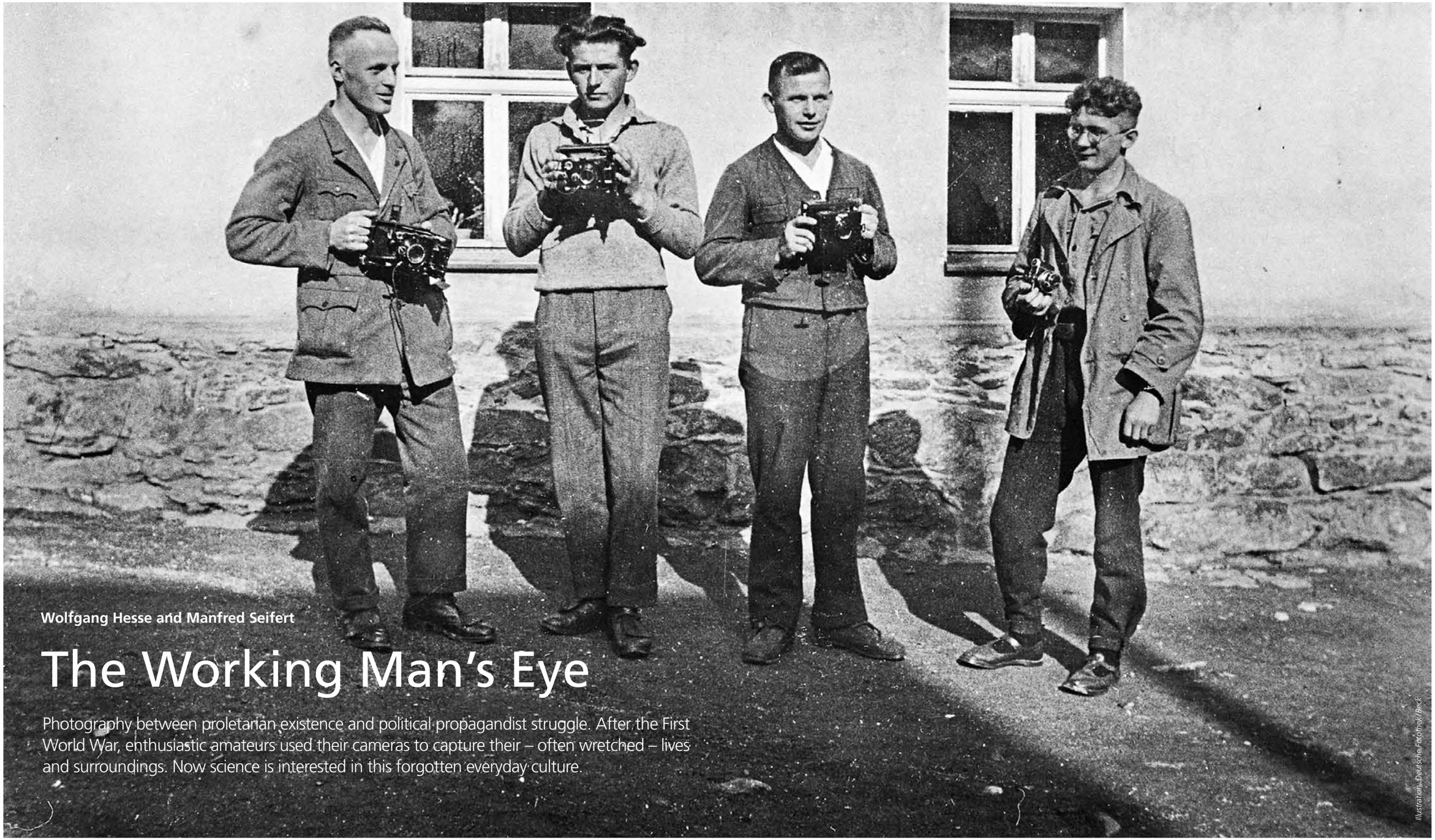
My best wishes go out to the institutions that will be able to implement their plans during the next five years. The German scientific community harbours great hopes and expectations – for the projects themselves, but not only for them. This leads us back to the question of what to expect after the Excellence Initiative comes to an end in 2017. We used to hear at this point that, if only for reasons of logic and fairness, the projects recently approved should at that time have the chance for a second funding period; indeed, hearing Federal Minister Annette Schavan state this goal very clearly during the announcement of this year's results gives rise to strong hopes.

That is one of two signals sent out in June towards the future. It is followed by another, which could not be any more fundamental: concomitant with the Excellence Initiative – and triggered by it in part yet arising mostly from the shortage of core funding for universities – a discussion has begun, centered on the structures of Germany's science research system in the future. The universities' position in this discussion has received tremendous support through the Excellence Initiative.

Whatever will be discussed in the coming months in terms of new conditions, forms of cooperation and funding models – the universities deserve to be in the driver's seat and steer new models of cooperation, due to the tremendous resourcefulness and determination that they have demonstrated in this competition. They will continue to be the heart of the science research system in the future.

Prof. Dr.-Ing. Matthias Kleiner
is President of the DFG.

See also the overview article beginning on page 14 "Rating: Excellent"



Wolfgang Hesse and Manfred Seifert

The Working Man's Eye

Photography between proletarian existence and political propagandist struggle. After the First World War, enthusiastic amateurs used their cameras to capture their – often wretched – lives and surroundings. Now science is interested in this forgotten everyday culture.

Illustration: Deutsche Fotothek/Reck

People who read the socialist newspaper "Der Arbeiter-Fotograf" (The Worker Photographer) during the Weimar Republic were militant classists. What does that mean? One example from the August 1931 issue, which was taken from the "Bilderkritik" ("Picture Critique") column, speaks eloquently for itself [photo below]: "Eat more fruit! (…) An image depicting workers' children eating half-rotten vegetable scraps from the street is, of course, horrifying to every proletarian. It is hard, while the shame is rising in our faces, to coldly estimate the correct distance and – without wavering – to press the shutter. Such a wretched picture reminds us of our duty as proletarians, and perhaps, too, of our laxity, of our failings in the great struggle for freedom for work and bread and a socialist social order. But the laws of optics are unrelenting and we, too, must be unrelenting, unfeeling as the camera, if we are to capture the downfall of capitalism in all its flagrancy."

This text encapsulates the approaches to, motifs of and problems with worker photography. It epitomises the issue with which many of these amateurs struggled – their transformation to "servants of their class". The Zurich-based communist and publicist Theo Pinkus defined the role of the famous "Arbeiter Illustrierte Zeitung" (AIZ, The Workers' Illustrated Newspaper) retrospectively as follows: "Worker photographers did not develop in order to provide pictures for the AIZ. Instead, they developed because photography is a subject of human interest and an important tool in the proletarian class struggle." But Pinkus' fundamentally democratic interpretation contradicts interpretations of party and political history. The workers' photographs housed in public and private collections do not merely serve as unique autobiographical testimony to an overwhelmingly unwritten way of life. Instead, they also document contrasting cultures, the everyday life of the proletariat, and the party agenda. The DFG project "The Working Man's Eye" at the Institute of Saxon History and Cultural Anthropology (e.V.) in Dresden is researching this subject using Saxony as an example.

Children collecting rotting fruit. In 1931, "Der Arbeiter-Fotograf" captioned this wretched image with the accusatory and sarcastic title "Eat More Fruit".

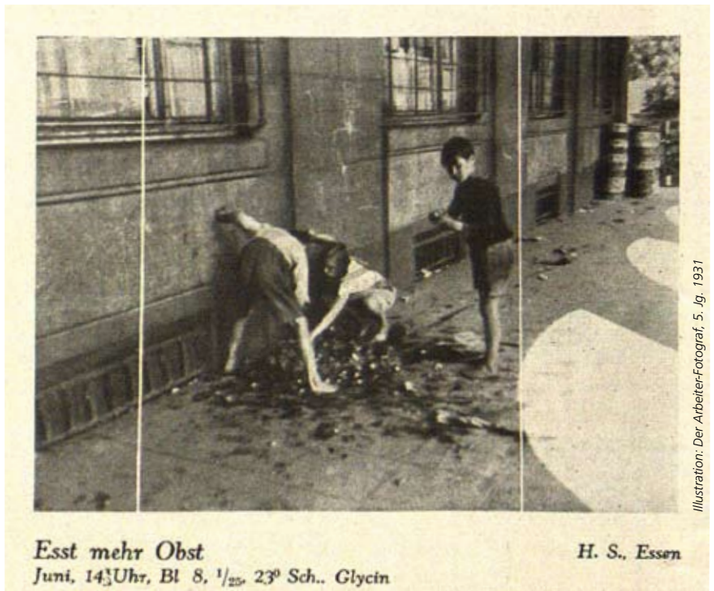


Illustration: Der Arbeiter-Fotograf, 5. Jg. 1931

What was photographed in those days? And how did papers decide between private snappers and maximum publicity, for example in the AIZ, which also featured renowned authors like Kurt Tucholsky? Usually it was the worker-created images and motifs, which were unsuitable for publication in the party media. Their editors expected professional photos, but acquiring modern photojournalistic skills was difficult for these self-taught journalists.

Here and there, photographers borrowed from conventional studio photography, as well as from journalistic and Bauhaus aesthetics, as they emulated professional artists like Frans Masereel, Heinrich Zille, Käthe Kollwitz and John Heartfield. The regular rule breaches, however, illustrate the proletarian snappers' persistence. Action shots from far away, subjects looking happily straight into the camera and repetitious group shots predominate in the collection held by the Museum für die Geschichte der Arbeiterbewegung in Leipzig (The Museum of the Workers' Movement), which is included in the project (www.stadtgeschichtliches-museum-leipzig.de > sammlungen > objektdatenbank). These are mostly pictures based on memories and direct exchange – part of a group autobiography and a direct link to the bourgeois shutterbugs. Symbolic Tendenzbilder, used to illustrate general concepts, are rare.

In this way, contradictory "documents" were created. The illustrated reports and photo montages, which bore testimony to the reality of life and to the political struggles of the late Weimar Republic, made "photography a weapon in the class struggle". Their creators' ambitions went beyond simply capturing "real life". Workers' personal photographs usually depicted a contrasting world full of petit-bourgeois hope: idyllic landscapes, family members, family celebrations. Taking photographs inside factories was prohibited, and after working hard for six days a week, the workers' only available motif was the world as it appeared on Sundays. However, the workers' parties desperately needed appealing photographs, as the boring party newspapers were scarcely being read, even by officials. The social democratic side attempted to remedy this situation with "Volk und Zeit" and the "Illustrierte Republikanische Zeitung", while the communists launched "Roter Stern" and the AIZ. The founding of the Vereinigung der Arbeiter-Fotografen Deutschlands (VdAFD, German Association of Worker-Photographers) in 1926 was the Communist Party of Germany's response to the oft-cited modern media, with its now-familiar, omnipresent images. In 1930, the SPD (Social Democratic Party of Germany) followed suit, launching its Arbeiter-Lichtbild-Bund (Worker Photographers' Association).

This modern, non-bourgeois amateur culture owes its existence to several late-nineteenth-century innovations: halftone image printing for newspapers (1882), cinematography and x-rays (1895), the "dry plate" process and roll film in the mid 1880s, and the picture postcard

Illustration: Deutsche Fotothek

Illustration: Stadtgeschichtliches Museum Leipzig

Illustration: Deutsche Fotothek

Above: A family reading the "Arbeiter Illustrierte Zeitung" (Workers' Pictorial Paper) together. Centre: A march at a "Youth Day" in Wurzen, Saxony. The protesters are carrying a banner with the slogan "Young Workers, Join us in the Fight Against Emergency Decrees". Below: Demonstration signs for Antikriegstag ("Anti-War Day"), 1932.

Illustration: Der Arbeiter-Fotograf, 4. Jg. 1930

"Our Cameras Serve the Class Struggle" – Display Case of "Der Arbeiter-Fotograf".

in 1896. These inventions heralded a fundamental shift in the way photography was used, which had risen to become the medium of choice for the industrial age since 1839.

Until the First World War, however, the majority of society was excluded from active participation. Photography was prohibitively expensive for most workers, smallholders and artisans. Even being photographed was a special-occasion occurrence. This changed, particularly during the War, when soldiers began to engage in mass photography. Easily operated, comparatively cheap cameras facilitated the rise of a completely novel amateur culture from around 1920 onwards: worker photography. The majority of society was now no longer only an occasional, picturesque or philanthropic object of photographs taken "from above". Instead, the working classes became active subjects in photographs taken "from below".

Of the approximately 20 local chapters of the VdAFD in Saxony, the groups in Dresden and Leipzig were among the most active in the country. They also participated in exchanges with groups in the Soviet Union. Favourable circumstances ensured the preservation of a particularly comprehensive collection of images taken by the Bermsgrün local group, in the western Ore Mountains, over 700 of which have found their way to the Deutsche Fotothek picture library in Dresden. These have been made available as part of the "The Working Man's Eye" project and can now be researched online (www.deutsche-fotothek.de > Arbeiterfotografie). The good source material makes it possible to reconstruct the environment and the motivations of the four young men who formed the local group in an exemplary manner.

Kurt Winkler (born 1905, a toolmaker), his brother Max Winkler (born 1904, a lathe operator), and Kurt Beck (born in 1909, a toolmaker) were joined in 1931 by Erich Meinhold (born 1909, a carpenter) from Markersbach, ten kilometres away. The four had been readers of the AIZ since 1925. Kurt Winkler began taking pictures in 1927, and purchased the magazine "Der Arbeiter-Fotograf" from 1928 onwards. His brother and Kurt Beck received their first cameras in 1928. The addition of Erich Meinhold meant that the group not only gained a member interested in political theory – instead, they also gained a particularly experienced photographer. He had begun taking photographs during his apprenticeship in 1922 and subscribed to the bourgeois amateur magazine "Der Photofreund".

All spent considerable amounts of money on their hobby. Some of their cameras cost more than a month's wages – and this despite the fact that all four had, since 1929, been "unemployed with short periods of work and living on unemployment benefits and welfare relief". Evidently their surroundings provided them

Illustration: Deutsche Fotothek

Left: Drudgery – washing clothes around 1930. Below: Sign of the times – a postcard advertising the VdAFD (German Association of Worker-Photographers).

with equivalent social compensation. Erich Meinhold remembers that "he began taking pictures because it was, at the time, something special and out of the ordinary for a worker to do." Kurt Winkler, "who helped organise sporting and political events in Bermsgrün and the surrounding area, wanted to use his camera to preserve these activities for posterity".


Der Arbeiter-Fotograf
Offizielles Organ der Vereinigung der Arbeiter-Fotografen Deutschlands
UNSERE WERBEPOSTKARTE
Bist Du schon Mitglied der Arbeiter-Fotografen?

Illustration: Der Arbeiter-Fotograf, 2. Jg. 1927/28

It was not until later that the pair recognised the "social and political value" of their pictures, not least due to the public interest they attracted. This was, for example, expressed in the keepsake photographs of sporting events, a flood, and of an exhibition in the local sports hall. Eventually, the Bermsgrün worker photographers even attracted nationwide attention in the AIZ.

"The victory of photojournalism over pure text journalism has now been definitively established in Germany. Illustration is making huge inroads into every aspect of the media – it is a 'victory of pictures over words'". As "Der Arbeiter-Fotograf" was talking about the advent of modern media in these terms, an increasing number of pictures were being used in the communist and social democratic press – and linked to reports and stories. Stylised symbolic images and picture stories could be used to illustrate complex content, as could photo montages, which became fashionable in advertising, as well as in propaganda, in around 1930. Their interpretation as part of a living everyday culture, which was reflected in demonstration slogans and advertising, on one hand, and in the media-conscious use of text/image combinations on the other, is one of the key findings of the project studying the developments in the Weimar Republic.

The state terror that followed Hitler's appointment to Chancellor of the Reich on 30 January 1933 spelled the end of organised worker photography. Pictures of dead bodies, of destroyed flats and offices, of anti-Jewish pogroms and of the storm-trooper-supervised removal of "Marxist" slogans formed part of the resistance movement during the initial days and months. GDR historiography celebrated this heroism. Discussion of the causes, however, remained taboo.

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E. Cuenca-Navalon, T. Finocchiaro, S. H. Jansen, S. Heinke

On the Way to the Artificial Heart

Artificial heart systems – the demand is huge, development is difficult: How applied medical technology is attempting to find new solutions. The role played by mechanical/hydraulic models is as important as innovative software simulation.

Cardiac insufficiency and other cardiovascular diseases are amongst the most frequent causes of death worldwide. For many people suffering from heart disease, particularly those in advanced stages who can no longer be treated with drugs, a heart transplant is their only chance. However, if a suitable donor organ cannot be found, the circulatory system must be maintained by mechanical means. These are pumps that support the heart's blood-pumping function (ventricular assist device – VAD). In other words: They help the left or right ventricle to maintain their natural pumping function. In addition, there are heart replacement systems, frequently referred to as artificial hearts (total artificial heart – TAH), that are intended to completely replace both ventricles, anatomically as well as functionally.

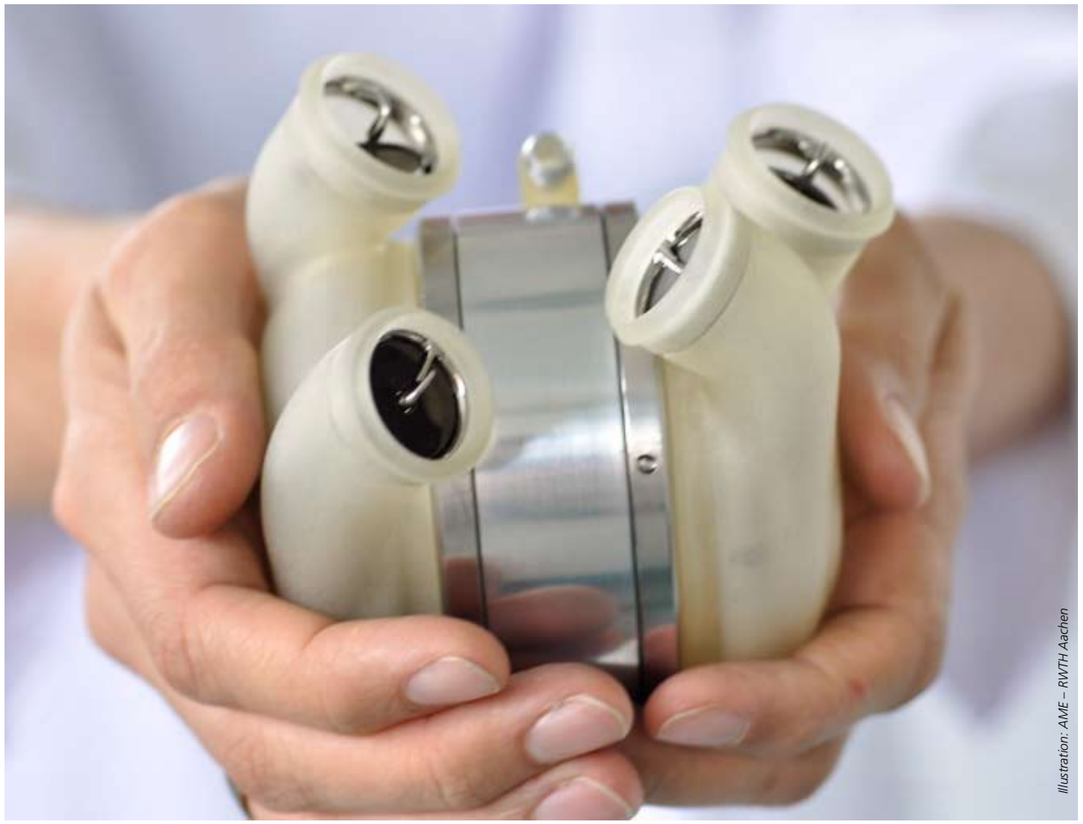

Illustration: AME – RWTH Aachen

The ReinHeart artificial heart. It has two pump chambers with inlet and outlet valves as well as an electro-mechanical drive. To effectively assist circulation, operation of the whole system (schematic drawing above) must be coordinated.

These systems are used with various indications: from bridging to heart regeneration or heart transplantation as well as long-term use in patients for whom a donor organ cannot be found.

At the Helmholtz Institute at the Technical University of Aachen RWTH, various pump systems and artificial hearts are being further developed and tested. The main question is: What is the best and most effective way of pumping the blood through the heart and circulatory system?

In principle, the VADs' function is continuous or pulsatile. Pulsatile means that blood is pumped into the circulatory system in the rhythm of the heart. These pumps work according to the displacement principle; they usually have artificial ventricles and heart valves to control blood flow. Therefore, they require a large space.

On the other hand, the continuous-flow systems, also known as rotary pumps, have a rotating wheel that pumps the blood continuously into the circulatory system. One advantage: These blood pumps are relatively small and have a long useful life. The disadvantage is that the high speed of rotation can damage the blood. In addition, a change in pulsatility can reduce the circulation in certain organs. This is a shortcoming which some researchers assume can be offset through increased pump output.

Up to now, a number of VADs are at the development stage as well as in clinical use. On the other hand, artificial hearts have not yet had any relevance to speak of in daily clinical life. Artificial hearts still face problems such as biocompatibility and mechanical durability. In addition, the problem of matching the pump output to the needs of individual patients has not yet been satisfactorily solved. Therefore, currently only one artificial heart system is being implanted in patients with end-stage cardiac insufficiency: the CardioWest (SynCardia Systems Inc.), a pulsatile-flow system.

As varied as the designs of pulsatile- or rotary-flow systems are, so also are their output requirements. In the case of rotary-flow pumps, any back-flow of blood from the aorta through the pump into the ventricle must be prevented. On the other hand, if the pumping speed is too high, the pump may empty the ventricle, thus causing tissue damage. When rotary pumps are used, the natural pumping of the heart should always be assisted as much as required to unload the heart. As the mechanical innovations are still in the initial stages of development, the majority of rotary-flow pumps in clinical use are operated at a constant rotational speed. In the case of pulsatile VADs, the system must pump synchronously with the rhythm of the heart in order to provide the heart with optimal relief. Artificial hearts are different: They have a fixed pumping frequency. The pump chambers are always emptied completely and are filled according to the amount of available venous blood.

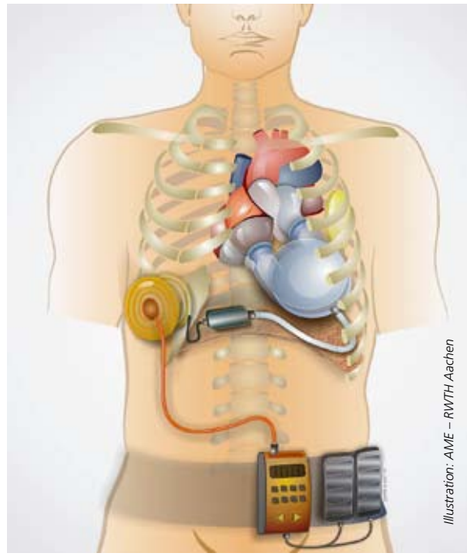

Illustration: AME – RWTH Aachen

Even if important research questions have not yet been answered, the use of mechanical support systems is even now increasing the life expectancy of patients. However, heart replacement systems have reached their limits since they cannot adequately adapt to the changing needs of patients. Consequently, their capabilities under various day-to-day stress situations like climbing stairs or high temperatures must be improved. An automatic adjustment of the pump output is necessary.

The interdisciplinary research team of the Helmholtz Institute at RWTH in Aachen is working on these individualised pump systems. Studies can be carried out directly on the ReinVAD and TAH ReinHeart systems developed here. The ReinVAD is a rotary-flow blood pump to assist the left

ventricle. It is a miniature device that is less expensive than existing systems. The ReinHeart artificial heart developed in Aachen functions as a pulsatile blood pump. The main components are the two pump chambers with inlet and outlet valves and an electromagnetic drive. Both the ReinVAD and the ReinHeart have already been successfully used in animal experiments.

Illustration: AME – RWTH Aachen

The aim of the research work is to be able to control the blood flow volume in the ReinHeart and ReinVAD systems depending on the respective physiological needs. Both heart assist devices have their own challenges: With the ReinHeart artificial heart system, the flow volume balance between the right and left side must also be taken into account. Currently this takes place only passively and is, therefore, dependent on the design parameters of the pump. In contrast, in the ReinVAD system the rotational speed of the pump determines the pump output. Here, changing physiological conditions cannot be taken into account. This can result in an oversupply or undersupply of blood, at worst the ventricle may even be sucked in. Another important aspect in the individualisation of the ReinVAD system is to foster a recovery of the heart. Current studies show that optimal relief of the heart can lead to a recovery of the compromised ventricle. In this case it might be possible to gradually withdraw the support of the heart system until the heart is again strong enough to do its work by itself.

Below: Only when we understand the body's own control mechanisms can technical heart systems adapt them. Right: Effective assistance is provided by computer-aided simulations and models.

However, the mechanical feasibility of artificial heart systems is just one aspect of the research project. In healthy organisms there are numerous control mechanisms to adapt the heart's pumping output to the actual physiological need. If, through disease, the heart stops functioning as the drive in the control loop, a technical system must also take over its adaptive abilities. To achieve this, it is necessary to collect the relevant control variables by means of sensors. A control model is being developed to ensure adequate blood flow through the pump system that adapts automatically to the physiological needs.


Illustration: AME – RWTH Aachen

In order to evaluate the control concepts, they are tested and optimised in software simulations (numeric models), hardware simulations (mechanical/hydraulic models) or in a combination of both (hardware in the loop). This requires a precise model of the human circulatory system, including the relevant control mechanisms of the body itself and the technical "pump" system. The control concepts thus developed are then tested in animal experiments.

The software-based numeric model uses mathematical language to simulate the function and behaviour of the circulatory system. To that end, the Institute of Control Engineering of the University of Aachen has developed a software library that can model the circulatory system. This library of components is based on the organ structure and can therefore also be used to analyse the body's control system and to design technical assistance devices.

The hardware simulators (circulatory system simulators) go one step further: They are electro-hydraulic circuits that reproduce the characteristics of the bloodstream and vascular system as precisely as possible. This allows the adjustment of individual physiological parameters. In the meantime, a hydraulic circulation simulator has been developed which can be set entirely by electronic means, thus allowing a physiological transition between different states of the circulatory system while in use. The value added: The circulation simulator allows continuous monitoring of the artificial heart and heart assist functions.

In order to improve the flexibility and precision of the simulations, the hardware circulation simulator was combined with the virtual software simulation to create a hybrid hardware in-the-loop simulator. This is only possible if the hardware circulation simulator has an electro-hydraulic interface. This now makes it possible to evaluate VAD and TAH systems in the laboratory under realistic physiological conditions. All control systems can now be designed, adjusted and tested in the virtual and then in the hardware-in-the-loop simulation prior to actual use.

All this shows: This combination and use of the latest developments in the field of measurement, simulation and control of physiological variables advanced by the Helmholtz Institute is opening up promising new possibilities. The road to satisfactory and effective heart assist and heart replacement systems is long. But it is worth it, because it is not just a matter of technical solutions and applications, but of improving the life expectancy and quality of life of people who are seriously ill.




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Rating: Excellent!

Decisions on the Second Phase of the Excellence Initiative / Grants Committee Selects 45 Graduate Schools, 43 Clusters of Excellence and 11 Institutional Strategies / 2.4 Billion Euros for Top-Level Academic Research

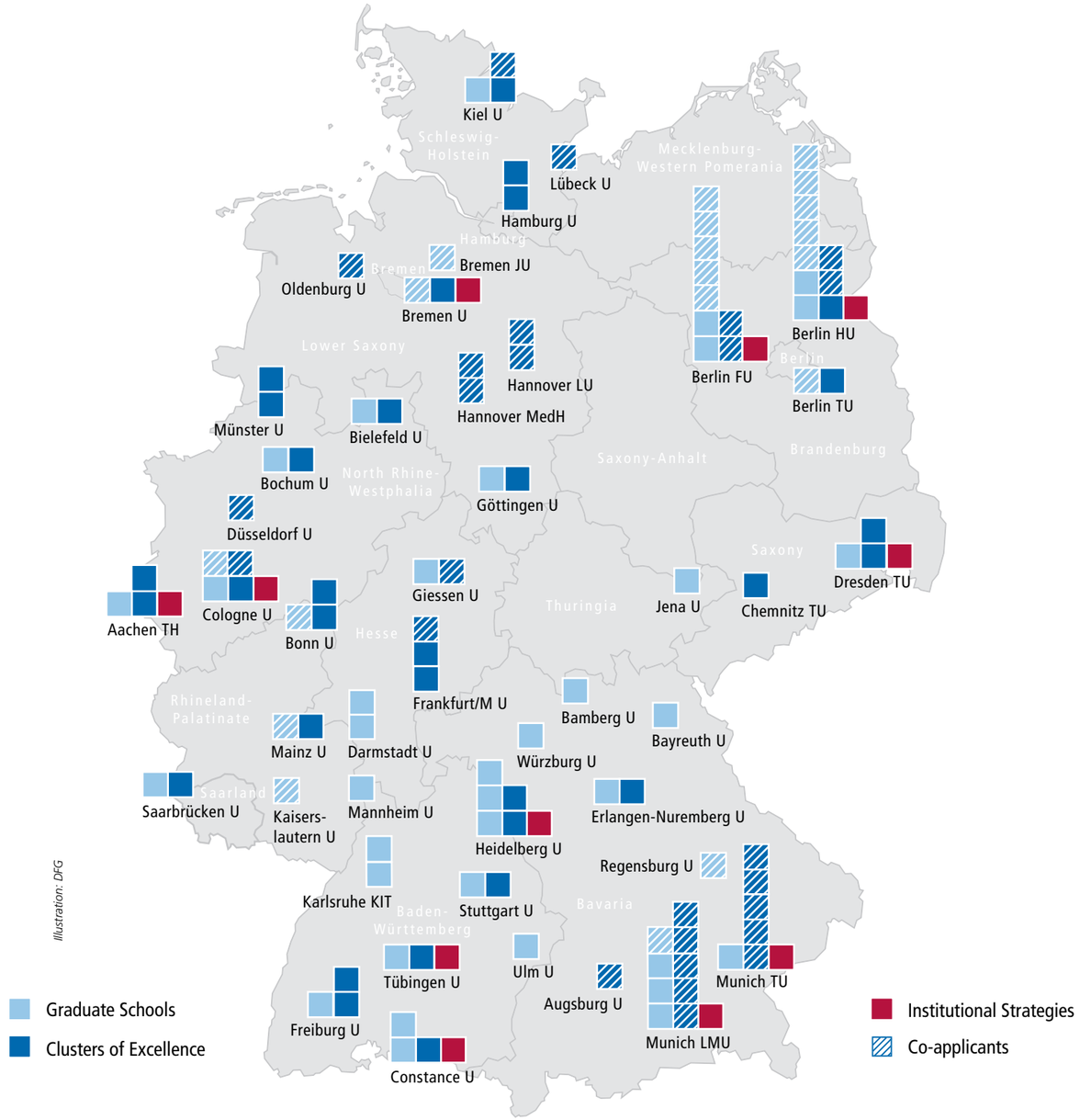


Illustration: DFG

Funding decisions for the second programme phase of the Excellence Initiative have been made. Following evaluation and discussion of a total of 143 proposals from 46 universities, the Excellence Initiative Grants Committee decided on Friday, 15 June 2012, in Bonn to support 45 graduate schools, 43 clusters of excellence, and 11 institutional strategies. In total, 39 universities will receive 2.4 billion euros.

> "This contest has strengthened our research considerably within the international arena." Matthias Kleiner

The decisions were announced by Germany's Federal Minister of Education and Research Annette Schavan, and, representing the state governments, by Ministers of Research Doris Ahnen, Rhineland-Palatinate, and Johanna Wanka, Lower Saxony. Matthias Kleiner, President of the German Research Foundation, and Wolfgang Marquardt, Chairman of the German Council of Science and Humanities, explained the results and the process from the perspective of science and academia.

"This second phase of the Excellence Initiative makes it clear once again: this contest has triggered lasting changes in the German university system and strengthened our research considerably within the international arena, and it will continue to do so – with cutting-edge research topics and innovative models for organising research and training young researchers, which would not exist otherwise", said the DFG President. "The approved projects were proposed by more than one-third of all German universities. This shows that top-level research in Germany is broad-based and diverse", added Kleiner.

Participation by almost two-thirds of all public universities in this second phase of the programme demonstrates continuing strong interest in the Excellence Initiative. There were far more submissions than could be approved. About 70 percent of all proposals were granted funding.

"We were impressed by the high quality of the submissions in all three funding lines. The continuers had set the bar very high, but the new applicants are definitely able to keep up with them", explained the Chairman of the Council of Science and Humanities, Wolfgang Marquardt.

> "We were impressed by the high quality of the submissions in all three funding lines." Wolfgang Marquardt

A novelty in this second phase is that first-time proposals were competing with renewal proposals from the first phase. 84 previously funded institutions and 59 first-time applicants participated in the contest.

For graduate schools, 63 proposals had to be considered, including 38 from previously funded institutions and 25 first-time entries. Of the total of 45 approved graduate schools, 33 are continuations of projects funded since 2006 or 2007, and 12 are projects approved for the first time. Overall, 71 percent of all proposed graduate schools were approved (87 percent of renewal proposals and 48 percent of first-time applications).

For clusters of excellence, the Grants Committee had to decide on 64 proposals, including 37 renewals and 27 first-timers. Of the total of 43 approved clusters of excellence, 31 are continuations of projects funded since 2006 or 2007, and 12 are projects approved for the first time. Overall, 67 percent of all proposed clusters of excellence were approved (84 percent of renewal proposals and 44 percent of first-time applications).

For institutional strategies to promote top-level research, a total of 16 proposals were up for decision. Of the nine strategies already funded since 2006 or 2007, six were able to secure continued support, while five of the seven new applications were approved as well. Overall, 69 percent of all proposed institutional strategies were approved (67 percent of renewal proposals and 71 percent of first-time applications).

Funded Graduate Schools and Clusters of Excellence
(newly approved institutions are shown in blue; institutions proposed jointly by several universities are shown in *italics*)

University	Name of Graduate School	Name of Cluster of Excellence
RWTH Aachen University	Aachen Institute for Advanced Study in Computational Engineering Science (AICES)	Integrative Production Technology for High-Wage Countries / Tailor-Made Fuels from Biomass
University of Augsburg	–	*Nanosystems Initiative Munich (NIM)*
University of Bamberg	Bamberg Graduate School of Social Sciences (BAGSS)	–
University of Bayreuth	Bayreuth International Graduate School of African Studies (BIGSAS)	–
Free University of Berlin	Graduate School of North American Studies / Graduate School of East Asian Studies (GEAS)	–
Free University of Berlin and Humboldt University of Berlin	*Berlin-Brandenburg School for Regenerative Therapies (BSRT) / Berlin School of Integrative Oncology (BSIO) / Berlin Mathematical School (BMS) / Berlin Graduate School Muslim Cultures and Societies (BGSMCS) / Friedrich Schlegel Graduate School of Literary Sciences (FSGS)*	*NeuroCure: Towards a Better Outcome of Neurological Disorders / Topoi: The Formation and Transformation of Space and Knowledge in Ancient Civilizations*
Humboldt University of Berlin	Berlin School of Mind and Brain / School of Analytical Sciences (SALSA)	Image Knowledge Gestaltung: An Interdisciplinary Laboratory
TU Berlin	*Berlin Mathematical School (BMS)*	Unifying Concepts in Catalysis (UniCat)
Bielefeld University	Bielefeld Graduate School in History and Sociology (BGHS)	Cognitive Interaction Technology
Ruhr University Bochum	Ruhr University Research School Plus	RESOLV (Ruhr Explores Solvation): Understanding and Design of Solvent Controlled Processes
University of Bonn	*Bonn-Cologne Graduate School of Physics and Astronomy (BCGS)*	Mathematics: Foundations, Models, Applications / ImmunoSensation: The Immune Sensory System
University of Bremen	*Bremen International Graduate School of Social Sciences (BIGSSS)*	The Ocean in the Earth System – MARUM – Center for Marine Environmental Sciences
Jacobs University Bremen	*Bremen International Graduate School of Social Sciences (BIGSSS)*	–
Chemnitz University of Technology	–	Merge Technologies for Multifunctional Lightweight Structures – MERGE
University of Cologne	*Bonn-Cologne Graduate School of Physics and Astronomy (BCGS)* / a.r.t.e.s. Graduate School for the Humanities Cologne (AGSHC)	Cellular Stress Responses in Aging-Associated Diseases (CECAD) / *Cluster of Excellence on Plant Sciences: From Complex Traits Towards Synthetic Modules (CEPLAS)*
University of Constance	Constance Research School Chemical Biology (KoRS-CB) / Graduate School of Decision Sciences	Cultural Foundations of Social Integration
Darmstadt University of Technology	Graduate School of Computational Engineering (CE) / Darmstadt Graduate School of Energy Science and Engineering	–
Dresden University of Technology	Dresden International Graduate School for Biomedicine and Bioengineering (DIGS-BB)	Center for Regenerative Therapies Dresden (CRTD) / Center for Advancing Electronics Dresden (cfAED)
University of Düsseldorf	–	*Cluster of Excellence on Plant Sciences: From Complex Traits Towards Synthetic Modules (CEPLAS)*
University of Erlangen-Nuremberg	Erlangen Graduate School in Advanced Optical Technologies (SAOT)	Engineering of Advanced Materials: Hierarchical Structure Formation for Functional Devices (EAM)
Goethe University Frankfurt / M.	–	Macromolecular Complexes in Action / The Formation of Normative Orders / *Cardiopulmonary System (ECCPS)*
University of Freiburg	Spemann Graduate School of Biology and Medicine (SGBM)	BIOSS Centre for Biological Signalling Studies: From Analysis to Synthesis / BrainLinks – BrainTools
University of Giessen	International Graduate Centre for the Study of Culture (GCSC)	*Cardiopulmonary System (ECCPS)*
University of Göttingen	Göttingen Graduate School for Neurosciences, Biophysics, and Molecular Biosciences (GGNB)	Nanoscale Microscopy and Molecular Physiology of the Brain (CNMPB)
University of Hamburg	–	Integrated Climate System Analysis and Prediction (CliSAP) / Hamburg Centre for Ultrafast Imaging: Structure, Dynamics and Control of Matter at the Atomic Scale (CUI)
University of Hannover	–	*REBIRTH: From Regenerative Biology to Reconstructive Therapy / Hearing4all: Models, Technology and Solutions for Diagnostics, Restoration and Support of Hearing*
Hannover Medical School	–	*REBIRTH: From Regenerative Biology to Reconstructive Therapy / Hearing4all: Models, Technology and Solutions for Diagnostics, Restoration and Support of Hearing*
Heidelberg University	Heidelberg Graduate School of Fundamental Physics / Heidelberg Graduate School of Mathematical and Computational Methods for the Sciences (HGS MathComp) / Hartmut Hoffmann-Berling International Graduate School of Molecular and Cellular Biology (HBIGS)	Cellular Networks: From Molecular Mechanisms to Quantitative Understanding of Complex Functions / Asia and Europe in a Global Context: The Dynamics of Transculturality
University of Jena	Jena School for Microbial Communication (JSMC)	–
Kaiserslautern University of Technology	*MAterials Science IN MainZ (MAINZ)*	–
Karlsruhe Institute of Technology (KIT)	Karlsruhe School of Optics & Photonics / Karlsruhe School of Elementary Particle and Astroparticle Physics: Science and Technology (KSETA)	–
University of Kiel	Graduate School for Integrated Studies of Human Development in Landscapes	The Future Ocean / *Inflammation at Interfaces*
University of Lübeck	–	*Inflammation at Interfaces*
University of Mainz	*MAterials Science IN MainZ (MAINZ)*	Precision Physics, Fundamental Interactions and Structure of Matter (PRISMA)
University of Mannheim	Graduate School of Economic and Social Sciences (GESS): Empirical and Quantitative Methods	–
University of Münster	–	Religion and Politics in Pre-Modern and Modern Cultures / Cells in Motion: Imaging and Understanding Cellular Behaviour in Organisms (CiM)
Ludwig Maximilian University of Munich	Graduate School of Systemic Neurosciences (GSN) / Graduate School for Quantitative Biosciences Munich (QBM)/ Distant Worlds: Munich Graduate School for Ancient Studies / *Graduate School for East and Southeast European Studies*	–
Ludwig Maximilian University of Munich and TUM Munich	–	*Nanosystems Initiative Munich (NIM) / Center for Integrated Protein Science Munich (CIPSM) / Origin and Structure of the Universe / Munich Centre for Advanced Photonics (MAP) / Munich Cluster for Systems Neurology (SyNergy)*
TUM Munich	International Graduate School of Science and Engineering (IGSSE)	–
University of Oldenburg	–	*Hearing4all: Models, Technology and Solutions for Diagnostics, Restoration and Support of Hearing*
University of Regensburg	*Graduate School for East and Southeast European Studies*	–
Saarland University	Saarbrücken Graduate School of Computer Science	Multimodal Computing and Interaction: Robust, Efficient and Intelligent Processing of Text, Speech, Visual Data and High Dimensional Representations
University of Stuttgart	Graduate School of Excellence advanced Manufacturing Engineering (GSaME)	Simulation Technology
University of Tübingen	Learning, Educational Achievement, and Life Course Development: An Integrated Research and Training Program	Werner Reichardt Centre for Integrative Neuroscience (CIN)
Ulm University	International Graduate School in Molecular Medicine Ulm (IGradU)	–
University of Würzburg	Graduate School of Life Sciences (GSLS)	–

Institutional Strategies to Promote Top-Level Research
(newly approved institutions are shown in blue)

- RWTH Aachen University
- Free University of Berlin
- Humboldt University of Berlin
- University of Bremen
- University of Cologne
- University of Constance
- Dresden University of Technology
- Heidelberg University
- Ludwig Maximilian University of Munich
- TUM Munich
- University of Tübingen

Illustration: bildschön / Schumacher

At the press conference for the announcement of the results: Federal Minister of Research Annette Schavan (centre), flanked by DFG President Matthias Kleiner (left), Chairman of the Council of Science and Humanities Wolfgang Marquardt (right) and State Ministers Doris Ahnen (left of Kleiner) and Johanna Wanka (right of Marquardt).

After a preliminary selection of draft proposals in March 2011, a total of 63 official proposals for graduate schools and 64 official proposals for clusters of excellence were received. These were assigned to 37 specialised panels, reviewed by international scientists and scholars, and discussed by a DFG-appointed Expert Commission. Of about 457 reviewers, 87 percent were based outside of Germany. Proposals were evaluated for research quality, the reputation of the participating researchers, support for early career researchers, and research structures.

Responsible for the 16 proposals on institutional strategies was the Strategy Commission appointed by the Council of Science and Humanities. Initially, proposals were assessed by review panels on the sites of the applicant universities. Of the 119 reviewers, 84 percent were based outside of Germany, about two-thirds in Europe, and the rest in North America and Asia. Reviewers evaluated the status quo of a university – and, in the case of renewal proposals, the current implementation status – as well as the institutional strategy and its potential. To qualify for an institutional-strategy grant, a university had to be approved for at least one cluster of excellence and one graduate school.

The Expert and Strategy Commissions combined formed the Joint Commission, which discussed the proposals and the results of the reviews. Its recommendations provided the basis for the Grants Committee's funding decisions.

The Excellence Initiative to promote top-level research at German universities was launched in June 2005 by the heads of the federal and state governments, initially for five years. The first funding decisions were made in October 2006 and October 2007. In mid-2009, the programme was extended for a second phase from 2012 to 2017 and endowed with another 2.724 billion euros in grant money (including overhead, transitional and expiration funding). 75 percent of these funds are provided by the federal government and 25 percent by the states.

The first programme phase of the Excellence Initiative will end on 31 October 2012. In it, 39 graduate schools, 37 clusters of excellence, and nine institutional strategies were awarded a total of 1.9 billion euros in grants. Projects that were not approved for continued support will receive expiration funding for a period of two years, granted on a staggered basis: for the first year up to 70 percent and for the second year up to 40 percent of the amount received in the final year of the funding period.

www.dfg.de/en/excellence-initiative

www.wissenschaftsrat.de/1/fields-of-activity/excellence-initiative

Rembert Unterstell

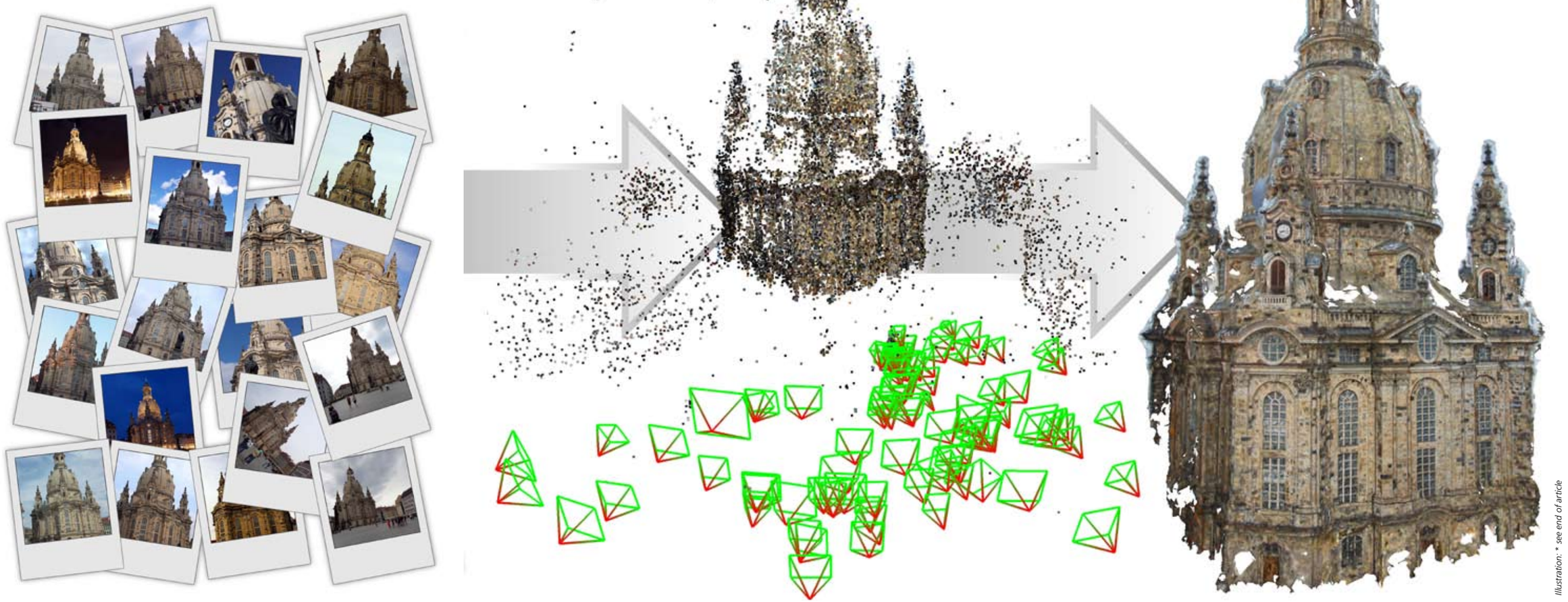


Illustration: * see end of article

“Thou shalt make thee an image”

Millions of snapshots are floating through the Internet – computer graphics experts are now using them to compute three-dimensional views of buildings and places.

As a holidaymaker, the motifs are impossible to escape: be it Dresden’s Frauenkirche under a cloudless, springtime sky, the Golden Gate Bridge in the billowing morning fog over San Francisco Bay or New York’s Statue of Liberty in the waning evening light. What tourist doesn’t quickly reach for the digital camera or camera-equipped cell phone to take a photo?

Today, holiday photos are rarely spread out on the living-room table, but are instead uploaded to free online photo sharing websites such as Panoramio, Fotocommunity and Flickr where they can be viewed, commented on and, not least of all, downloaded. The photo-sharing portal Flickr (www.flickr.com) today offers more than 7.5 billion snapshots from around the world; under the keyword “Statue of Liberty New York” alone are more than 100,000 pictures. A gigantic data Eldorado, but one that often has a flaw: the snapshots – sometimes with waving tourists in the foreground, sometimes with diving flocks of pigeons – are of widely varying quality.

“For us, this is a huge and very productive treasure”, says Michael Goesele. Since June 2011, the 39-year-old has been professor (previously junior professor) for interactive graphics systems at TU Darmstadt. He uses the amateur photos (“actually, the worst case for a computer graphics expert”), to compute three-dimensional views of buildings, places and city landscapes. Computer scientists call this “scene reconstruction”.

For three years, Goesele, an expert for visual computing, has been working with his five-person Emmy Noether independent junior research group of the DFG on “exact scene reconstruction from extremely large numbers of images”.

For Michael Goesele, himself a passionate black and white photographer, the Internet photos are the data material and, to a certain extent, the playground for the central question of his research work: how can one extract the depth information from two-dimensional digital images to spatially represent scenes? This problem has long challenged computer scientists.

Up to now, controlled data have been used. These are often photos taken indoors with a calibrated camera – with defined object distance, specified focus, optimum lighting conditions. From such laboratory views, which are time- and cost-intensive, models can be generated. “But how can this be accomplished with uncontrolled data?”, asks Goesele. The motivation: not until the step from predefined laboratory data to complex reality data is made will

an everyday, i.e., robust, solution have been found.

Experts have high expectations on such software. It could, for example, help in the documentation of archaeological excavation sites or museum collections, support the conceptual design phase in automobile manufacturing or simplify visualisations in land-use and urban planning. An alternative to the expensive laser scanning of three-dimensional objects and for stereophotography – the methods commonly used for this purpose up to now for "directly generating three dimensional content" – may thereby also be found.

The earth and its hotspots at a glance: computer graphics expert Michael Goesele and his colleague Simon Fuhrmann.

Illustration: Emmy Noether Group Goesele

Starting point of all studies is the stereo principle – the basis for spatial perception. With their eyes, humans view their surroundings from two perspectives. The brain is thereby able to associate a distance to all objects and produce a spatial image. "Colloquially, stereoscopy is incorrectly equated to 3D", emphasises Goesele, "even though, strictly speaking, these are only two-dimensional images that convey a spatial impression."

Computer graphics make use of the principle of stereoscopic vision. Goesele's Internet photos were taken under all possible and impossible conditions: the distance of the camera to the object, the perspective, the light conditions, the image detail, the depth of focus – they are all different. To extract the depth information from these digital images, they first undergo a "registration process": with the "structure from motion" method, the location of the photographer, his or her perspective and other important camera parameters (zoom, distortion, etc.) are ascertained for each image. This is performed with a software programme called "Bundler", developed several years ago at the University of Washington in Seattle. The programme also produces a rough model of the scene.

To obtain a detailed model, Goesele then uses a "multi-view stereo" algorithm, which he was able to develop together with colleagues at the University of Washington and Microsoft Research. This innovation helped him win the "Eurographics Young Researcher Award" in 2008. Starting with a picture element in a photo, a crossbar in a window, for example, the software searches pixel by pixel for corresponding points that are suitable for creating a stereo image. Even the layperson can appreciate what a gigantic puzzle this must be to solve in an automated process.

Illustration: Emmy Noether Group Goesele

Using the ascertained camera position, the depth assignment can be calculated from the geometry. In the end, one has a three dimensional geometric model with the appearance of a "plasticine creation", which impresses experts as well as laypeople in its level of detail. Nevertheless – and here Goesele places great importance – he is performing basic research. "In addition to the collaborating colleagues at Microsoft, other companies, such as Google, would certainly be interested in the technology", says Goesele, "but it will take some time before it is ready for the market."

"Make a picture for yourself": up to now, the pixel makers in Darmstadt have made use primarily of the geometry, disregarding other information. As a result, the number of input photos has not exceeded a few hundred. And characteristic data on optical effects such as shadows, colours and reflections can only be considered on a test basis. The models therefore look like plasticine objects to the viewer. To advance the contour and surface modelling, "photometric techniques" could be tried. One thing is certain: to obtain realistic results, the models must incorporate additional information. The Emmy Noether independent junior research group is working on this mammoth task.

The two research assistants in the working group, Jens Ackermann and Simon Fuhrmann, share an office in the Fraunhofer Institute for Computer Graphics Research, with whose researchers the group works together closely. The two young researchers have submission deadlines for conference papers to work on – and still find time to present their own projects.

Left: Simon Fuhrmann (standing) and Jens Ackermann simulating a ceramic tree frog. Bottom: "Exploded Views – Remapping Firenze". The viewers "walk" through the virtual cityscape.

Illustration: de Nijs

Mathematician Jens Ackermann is studying how the reflection property of objects could be better represented – a question that is as fundamental as it is difficult. Because an object often has both diffuse and glossy surfaces that reflect light differently. During the course of his work on this challenging simulation, Ackermann has acquired numerous objects, such as a big-bellied, ceramic tree frog; in his work, he combines "multi-view stereo" with a photometric method. In this way he was able to collect data that reveal the spatial orientation of the surface being considered, which help to more precisely reconstruct the surfaces.

Computer scientist Simon Fuhrmann is working on advancements in surface reconstruction, which he combines with the question of how to more productively use image data of different resolution (scale). Here, the combination of depth maps – images that store the distance to the camera at each pixel – play a decisive role. "3D is our computer world", says Fuhrmann, "the fourth dimension is the resolution." Benefiting from this fourth dimension – stated in simplified terms – are his reconstruction experiments, for example, on the façade of the Notre Dame. At the SIGGRAPH Asia conference of the Association for Computing Machinery in Hong Kong in December 2011, Fuhrmann was able to present his new method.

It is an appealing desire to be able to wander through three-dimensional visualisations of touristic hotspots, which Goesele also has his sights on, as in a computer game. What that might look like from an artistic and game-like perspective is seen in the multimedia installation "Exploded Views – Remapping Firenze" by the Dutch artist Marnix de Nijs (www.marnixdenijs.nl/exploded-views.htm). What's special: the visitor, who stands on a oversized treadmill, literally passes through the cityscape of Florence by approaching the projection screen. The three-dimensional Florentine worlds for this extraordinary experience machine were created by Goesele and his colleagues.

Whether for artistic or for technical tasks – realistic, three-dimensional reconstructions could be improved step-by step through computer-graphic basic research. This may open the way to new and promising applications. The limits of this approach are still to be determined. But the fact that Internet photos serve as a powerful trove of data for visual computing and to help advance studies on 3D mapping alone says a great deal.

Dr. Rembert Unterstell
is Publishing Executive Editor of "german research".

** The lead photo is a collage from Goesele's Emmy Noether group; the photos are from Flickr users John Bailey, Holger Baschleben, Raymond Chan, DHausBT (2x), Bert Kaufmann, Frank Kovalchek, Angela Marie, Will Palmer, Francois Philipp, Christian Prade, Paul Sableman (2x), Ralf Schulze (2x), Frank Steiner (2x), Ruben Vique (2x) and yeowatzup.*

Barbara Bramanti

Ancient Epidemic Diseases in a New Light

Plague and cholera: Infectious pandemics of earlier centuries have left deep marks in our evolutionary history. Researchers are now recovering ancient DNA from the skeletons of the victims. The analysis of this DNA provides insights on the impact of these epidemics and the possible mechanisms of resistance against infections.

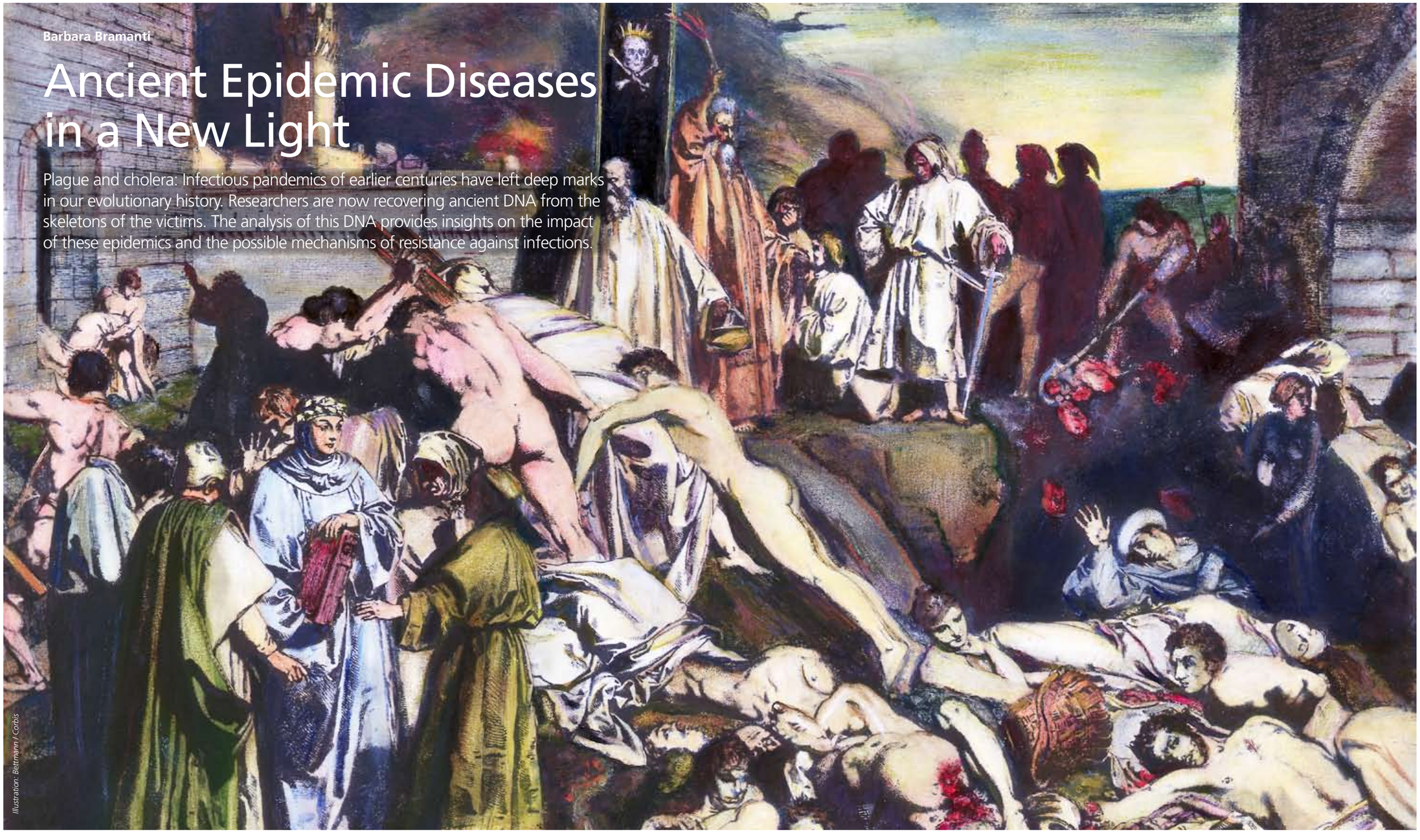


Illustration: Bettmann / Corbis

Ach, du lieber Augustin!" (Oh, you dear Augustin) – what seems to be a merry nursery rhyme is in fact a folk song with a bitter and at the same time legendary background. "Ach, du lieber Augustin!" is about the plague that was raging through Vienna in 1679. It was composed by the minstrel and bagpiper Marx Augustin (Vienna, 1643–1685). This legend has inspired several artists, who sang of how Augustin was able to escape safe and sound from a plague pit. The AustroHungarian poet Franz Karl Ginzkey (1871–1963) even wrote a ballad telling of how Augustin, after one of his frequent visits to a tavern, accidentally fell into a plague pit where he slept off his drunken stupor among dead plague victims. The music of his bagpipes brought him back to life the next day. "Funkelnder Wein und der rechte Humor / Treibt selbst die Pest und den Tod aus dem Tor" (Sparkling wine and the right humour / Will drive even plague and death out the door). According to legend, Augustin was one of the few people who was not infected by or survived the "Black Death".

Extracting a sample from an ancient human skeleton for a precise molecular analysis in the laboratory to determine the aDNA.

At the beginning of the last pandemic, which originated in Hong Kong in 1894 and spread to every continent except Europe and Australia, it was discovered that plague is a typical animal infectious disease that is transmitted via blood. It infects rodents and other mammals often without killing them, but when transmitted to humans it can quickly turn into an epidemic. During the acute phase of an epidemic the bacterium can also be passed on by inhalation of infectious droplets (pneumonic plague), but usually the pathogen, *Yersinia pestis* (a rod-shaped bacterium of the Enterobacteriaceae family) needs a vector for transmission. This is generally a flea, which transfers the dangerous bacteria into the bloodstream of its host. Once inoculated, the pathogens migrate to the nearest lymph node where they cause a painful lymphadenitis, a "bubo" (bubonic plague). Without antibiotic treatment, the infection is deadly because the pathogens can trigger blood poisoning within just a few days. There must still have been plenty of hungry fleas in the mass grave filled with plague victims into which Augustin fell, so that it is hardly possible that he did not contract the illness. Nevertheless, could this really have been possible?

Interestingly, the chroniclers of various centuries have reported that not all those infected during an epidemic died. Furthermore, a subsequent second wave of infections is generally less virulent or

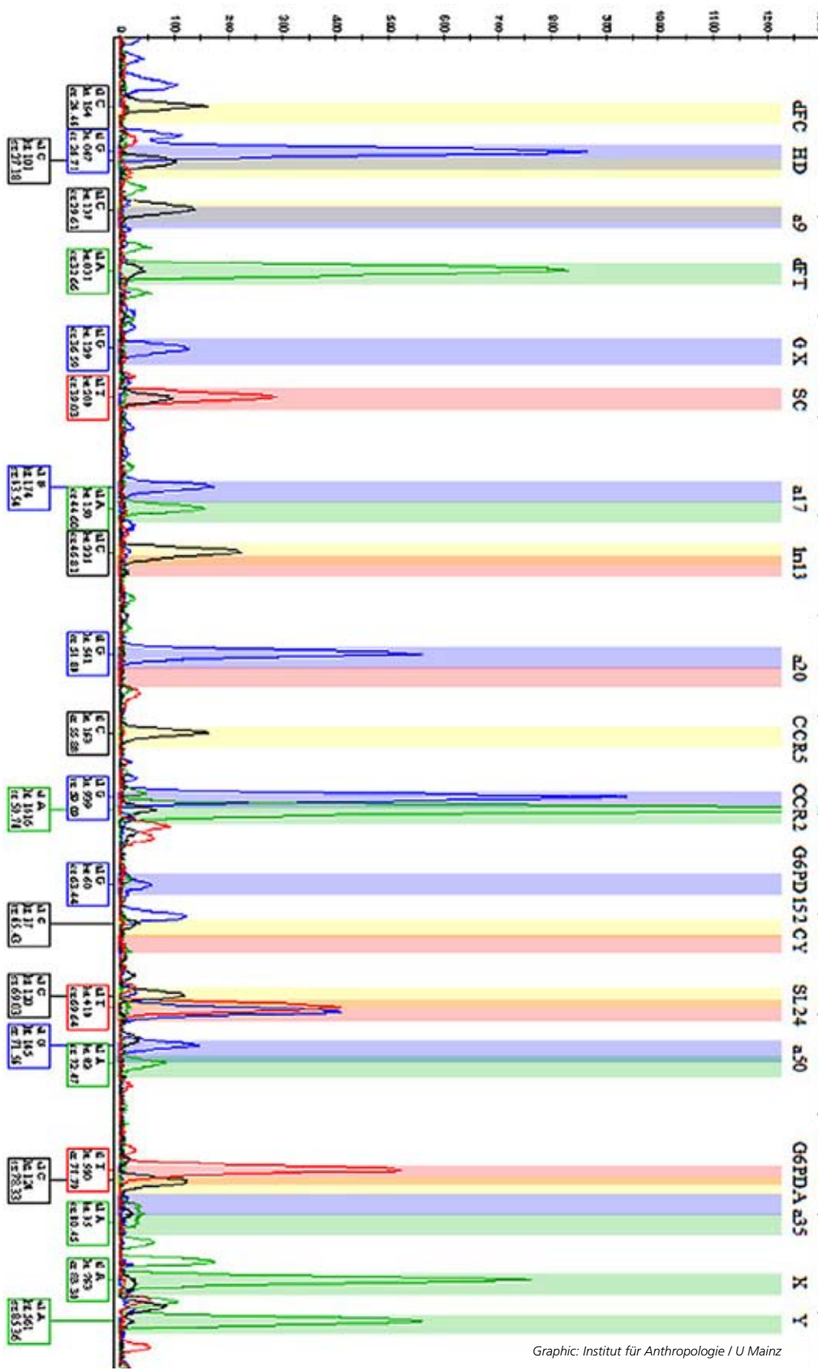
In the "trace laboratory" (above), ancient DNA is extracted. Each sample is dissolved in the aqueous phase and has its own colour.

dangerous than the first one. Some or even many people appear to have been immune to the disease. What could have caused such an immunity?

From a genetic perspective, immunity towards an infectious disease can be caused by one or more variants in the genome. These must represent an advantage for the organism when combating the pathogen. In a population, individuals carrying these variants must be positively selected during the epidemic, thus the frequency of these alleles increases in following generations. An example of such an interplay between pathogen and human is the relationship between malaria and sickle-cell anaemia. The same hereditary mutation in the haemoglobin gene, which produces red blood cells with a characteristic sickle shape also stops the life cycle of the malaria pathogen *Plasmodium falciparum* in the blood stream, because of a defective mechanism in taking up or releasing oxygen. Individuals who have only one copy of the mutated gene (i.e. heterozygotes) appear to be protected against the highly contagious pathogen, whereas two copies of the mutations (i.e. homozygotes individuals) can be fatal.

Resistance to the plague is suggested to be linked to the CC chemokine receptor 5 (CCR5) gene by means of a similar mechanism. Nowadays, people with two copies of the CCR5 mutation in their genome are immune to an HIV1 infection. This CCR5 gene is used by some pathogens to gain entrance to lymph cells. A loss of genetic material ("deletion") produces a shortened protein that no longer acts like a door. One percent of the European population has two copies of this variant and is thus protected against being infected with HIV1. In recent years, researchers have discovered that the CCR5 gene is exposed to a very strong selection pressure. HIV infection, however, has only developed into a pandemic in the last 25 years and cannot thus have led to the high mutation frequency in Europe. In this case, other infectious blood diseases – e.g. the plague? – may have played a decisive role in selection.

These and other hypotheses on plague resistance cannot be tested directly on living patients. People infected with the plague – this disease is still present in parts of Africa, Asia and South America – are now fortunately treated with effective antibiotics and generally survive the illness, irrespective of their genome constellation. Experiments with mouse models could be affected by the evolutionary distance of this species. In-vitro studies on isolated cells do not allow any definitive statements on this resistance hypothesis because they do not take account of the complex reactions of the body during an infection. For these reasons, the analysis of ancient DNA (aDNA) from historical plague skeletons offers a unique opportunity to find evidence for susceptibility and to



Graphic: Institut für Anthropologie / U Mainz

thus model evolutionary mechanisms of resistance to pathogens of the bloodstream.

But how can we tell whether people in a historic mass grave are indeed plague victims? In contrast to many other infectious diseases, such as tuberculosis or leprosy, plague does not leave any visible traces on the bones. The most reliable way of verifying a plague infection is a molecular genetics test that can detect specific DNA fragments of the ancient plague pathogen.

In our aDNA laboratory in Mainz, we were able to identify Y. pestis DNA in three of our collections of plague skeletons from the 14th century. Surprisingly, these people had been infected by different strains of Y. pestis and a comparison with modern strains showed that one of these lines no longer exists. Further analyses are necessary to fully determine the other line. It was previously assumed that the pandemic waves were caused by three different biological variants (biovars): The Y. pestis biovar Antiqua was thought to have caused the Plague of Justinian (6th to 8th century), biovar Medievalis the "Black Death" (1346–1750), whereas Y. pestis Orientalis is known to have caused the third pandemic (1894 until the present). However, our ancient strains do not belong to the Orientalis or Medievalis biovars nor to other such simply defined sub-groups. It therefore remains

Results of ancient DNA analysis from a prehistoric human specimen. Peaks matching coloured bars represent the allelic variants of the individual.

Illustration: Stephanie Hänsch

Laboratory instruments are exposed to UV light to destroy foreign DNA molecules.

an important goal to identify these and other ancient Y. pestis lines more accurately, to define their geographic origin and to thus elucidate the history of the plague at the molecular level.

In addition to plague there are many infections that could have played a major role in the history of human evolution, included gastrointestinal infections. In the 1990s, a 19th century grave site in a cave in Sicily containing around 300 cholera victims was opened and evaluated. The discovery was unique because there are very few other skeletons of cholera victims to be found in Europe. Cholera is a gastrointestinal disease caused by the bacterium *Vibrio cholerae*. The victims of the infection can die within 24 hours as a result of extremely severe diarrhoea.

In the 1980s, it was hypothesised that the carriers of a mutation in the CFTR gene are protected against fatal diarrhoeal diseases. Individuals who have two copies of mutated CFTR genes, manifest cystic fibrosis (CF or mucoviscidosis), a severe hereditary disease. Until the 1950s, most patients with CF died during infancy and had no chance of reaching sexual maturity. For this reason, the mutation should have disappeared by now. Instead, mucoviscidosis is one of the most frequent genetic hereditary diseases in Europe: one person in 25 is potentially a carrier of this serious illness.

More than 1000 mutations can cause CF; the various mutations influence the formation of the CFTR protein, which acts as a chloride channel in the gut and thus controls the releasing of water from the blood stream into the intestinal lumen. CF heterozygotes, which produce 50 percent of faulty CFTR protein, should have a greater chance of surviving the devastating diarrhoeas induced by cholera and other intestinal infections, thus an evolutionary advantage. This could explain the persistence of these otherwise deleterious mutations in the European population. The hypothesis of the possible protective resistance of CF carriers is also being studied in our laboratories using aDNA analysis on the Sicilian cholera victims.

According to reports of the World Health Organization (WHO), infectious diseases are still one of the most frequent causes of death. The majority of these infections are originally transferred from animals to humans and spread with great virulence, particularly in areas with a high population density. These basic conditions for the outbreak of epidemics probably started with sedentism of humans and domestication of livestock. Both events occurred in Europe with the introduction of farming culture during the so-called Neolithic Transition (7000–5000 B.C.). This is why it is particularly interesting to detect such mutations in prehistoric skeletons. Our genetic susceptibility to infections could have begun with the start of our culture.

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www.uni-mainz.de/FB/Biologie/Anthropologie/MolA/Deutsch/Mitarbeiter/Bramanti.html

Johannes Müller and Constanze Bickelmann

Genes and Fossils

Even though they have many things in common, palaeontologists and molecular biologists traditionally went separate ways. Palaeobiology, which combines the methods of both fields, is now producing new insight, as shown by studies on egg-laying terrestrial vertebrates.

In 1859, Charles Darwin presented his theory of evolution, which not only revolutionised 19th century biology but also paved the way for future work. Palaeontology provided important evidence. Its fossils documented and proved that life on Earth did indeed evolve in small steps. Or in other words, present-day species did not always inhabit our planet over its entire history. Spectacular fossil discoveries, such as Archaeopteryx, referred to by its German name "Urvogel" and meaning "ancient bird", which was found near the Bavarian town of Solnhofen, are eloquent testimonials that Darwin's predictions were correct.

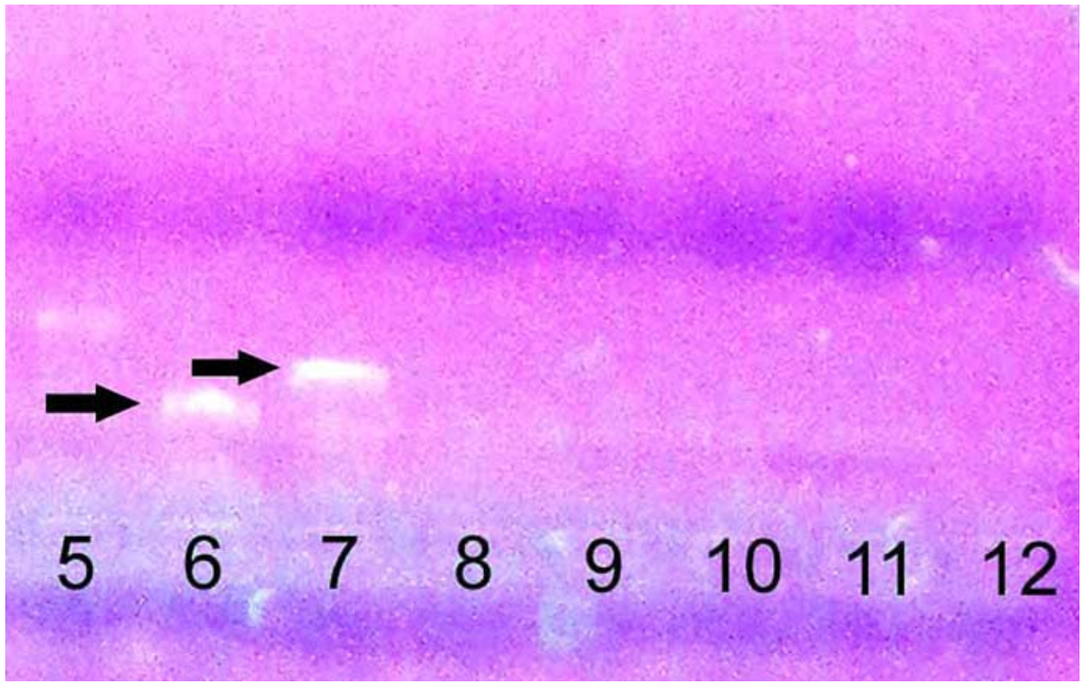
Until the middle of the 20th century, palaeontology provided corroborative support for evolutionary researchers; however, by 1950 at the latest when James D. Watson and Francis Crick discovered that DNA is the carrier of genetic information, the importance of fossils for understanding evolution lost significance in favour of genes. For over half a century, molecular biological research and palaeontology have been co-existing separately, even though they both deal with life on Earth. Only a few years ago, researchers of both disciplines began to realise that working together can sometimes be more productive than working in parallel – particularly when the research topics are similar or even the same.

An independent junior research group at the Museum für Naturkunde in Berlin, funded by the DFG as part of the Emmy Noether Programme, is working with a combination of these two research fields. The main topic of this research group is the origin and palaeobiology of egg-laying terrestrial vertebrates, or "amniotes", whose present-day representatives are mammals, reptiles and birds. In contrast to amphibians such as frogs and newts, amniotes are no longer reliant on water for reproduction because they pass through the tadpole stage inside the terrestrial egg.

This evolutionary innovation was probably crucial for the success of the amniotes during the Earth's history. Favoured by their new method of reproduction, they were able to conquer the most remote mainland areas and even the air. The first unambiguously identified amniote fossils originated in Canada and were found in fossilised tree stumps from the Upper Carboniferous that are around 315 million years old.

By this point, the amniotes had already split up into two main lines: the "sauropsids", which includes all modern reptiles as well as birds, dinosaurs and other fossil relatives, and the "synapsids", which includes mammals and their ancestors. Whereas these fundamental phylogenetic relationships are generally accepted, other aspects in the history of early amniotes are still not understood. Hence one of the issues addressed by the research group concerns reconstructing the ecological context in which mammals originated. Were the first mammals indeed nocturnal, as is often proposed in modern textbooks? Or is this simply speculation?

A major problem in traditional palaeontology is that only hard body parts such as bones, exoskeletons or shells have survived, whereas fossilised soft tissues are extremely rare. Ultimately, this means that only very indirect conclusions on the biology of extinct species can be inferred. Although dietary adaptations or locomotion strategies can be now recon-



Above: A 290 million-year-old egg-laying terrestrial vertebrate. Right: Sequencing to reconstruct a mammalian visual pigment. An agarose gel under UV light. The arrows indicate the location of the rhodopsin DNA of the echidna.

Illustrations: Emmy Noether Group Müller

structed relatively unambiguously by comparisons with present-day animals, most of the other ecological and physiological aspects are still obscure.

For example, arguments for a nocturnal lifestyle of the first mammals are primarily based on the comparatively small size of the earliest known representatives, which was roughly between a hedgehog and a shrew. In addition to this evidence, studies of their dentition lead to the conclusion that these fossil mammals were active at night, similar to shrews and hedgehogs, and only emerged from their hiding places after dusk. If this is indeed the case, then the cooler night temperatures could have prompted the evolution of fur and a self-regulated constant body temperature, thus paving the way for today's success of this group.

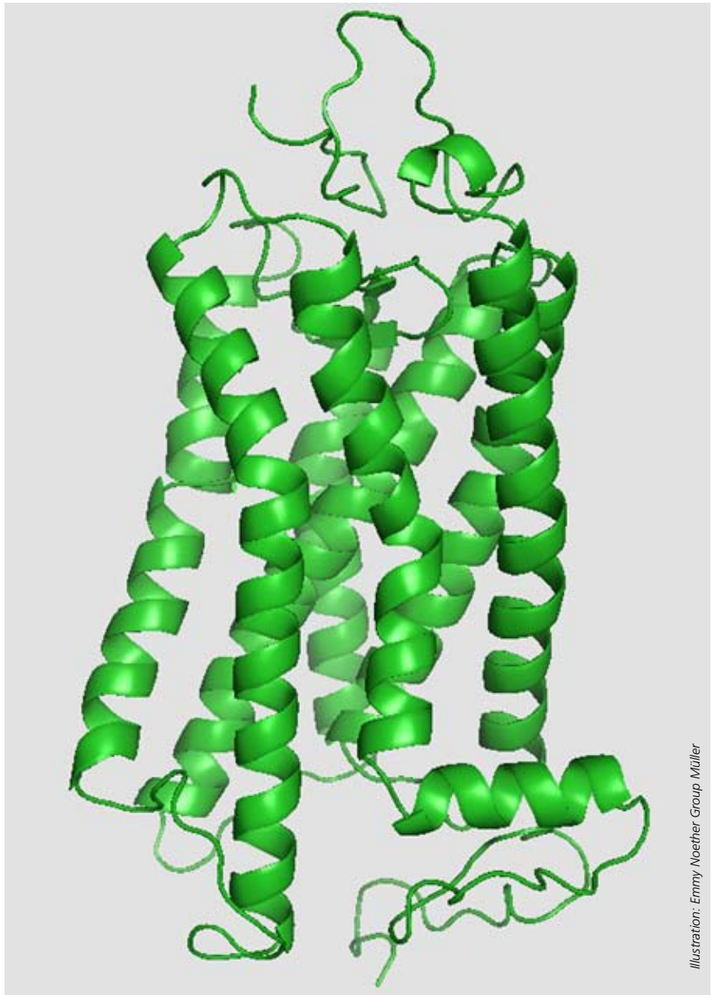


Illustration: Emmy Noether Group Müller

From the molecular laboratory: computer-generated three-dimensional structure of the visual pigment rhodopsin.

For a long time these issues could not be intensively investigated owing to problems associated with fossil preservation. However, recent advancements in molecular biology have opened new perspectives. Already in the 1960s, the eminent Austro-American molecular biologist Emile Zuckerkandl and his equally renowned colleague, the American chemist and Nobel laureate Linus Pauling, postulated that knowledge of the structure of a protein, respectively its gene sequence, in two related organisms could be used by future scientists to reconstruct "molecular ancestors" of the specific protein. And indeed, using theoretical and experimental methods along with the ever-expanding knowledge of molecular evolution, it is now possible to reconstruct ancestral sequences of proteins from present-day living organisms with a computer. These proteins can even be synthesised in the laboratory. Researchers familiar with the function of the respective protein in the organism can thus obtain completely new insights into fossil physiology. This was previously only a matter of speculation.

The question as to whether the first mammals were nocturnal is an ideal topic for this methodological approach. To address this issue, the members of the junior research group are focussing on a particular group of proteins: the visual pigments. These represent the first step in the chain of visual perception in the eye. When a photon of visible light is captured by the respective visual pigment in the "rods" and "cones" – the photoreceptors – in the retina, this triggers a neuronal signalling cascade that eventually ends with information processing in the brain. Special attention was paid to rhodopsin because it is the only visual pigment responsible for night vision.

In cooperation with colleagues from the work group of Professor Belinda Chang, University of Toronto, it was possible to reconstruct the rhodopsin sequence for the ancestors of the mammals and amniotes as well as the common ancestors of placental mammals and marsupials. Transcription to the actual existing protein was carried out with the help of a modern protein synthesis method in human tissue cultures. At the end of the labour-intensive procedure in a completely blacked-out room, the scientists obtained a solution containing many microscopic rhodopsin molecules.

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Above: Skull of a fossil reptile from the Red Beds of Texas. Middle: A lizard-like reptile that lived 260 million years ago in present-day Russia. Right: This South African carnivore resembling a sabre-toothed cat is a distant relative of the mammals.

These molecules were then tested, for example with an optical spectrometer, to find out whether they are capable of functioning and whether the hypothetical protein could aid night vision. The initial results did indeed indicate that the function of rhodopsin changed dramatically at the beginning of mammalian evolution. However, further investigations are needed to find out whether these changes can really be regarded as a consequence of a novel nocturnal lifestyle.

It goes without saying that such studies must take into account that the applied bioinformatics techniques are associated with sources of error. In addition, the reconstructed proteins ultimately have only a hypothetical character and may not necessarily correspond to the actual situation at that time in every last detail. Nevertheless, an invaluable advantage of this method is that it can be implemented where palaeontology and its fossils are at their limits.

Under no circumstances, however, should we fall into the trap of thinking that molecular biological techniques will be able to replace traditional palaeontological research in the future. Without fossils and their intensive study, palaeobiological issues that can be investigated by molecular biological methods would be impossible from the outset, because fossils are needed to define the subject of study. Thus in the present case, without knowledge of the anatomy of the earliest fossil mammals, the hypothesised potential nocturnal activity could not have been suggested in the first place. Without doubt, an integrative approach that combines the advantages of both disciplines in a novel way will play an increasingly important role in future.

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The Deutsche Forschungsgemeinschaft

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An exhibition entitled "Archaeology in Southwest Asia", showing through mid-September at the DFG's Head Office in Bonn, presents the public with exciting research findings from the field and the lab. Showcasing ten long-term projects funded by the DFG, the exhibition offers fascinating insights into a broad spectrum of archaeological research and straddles the divide between the past and the future. The prominence of the archaeological sites is matched only by the importance of the research topics under consideration here. Early sedentary cultures are the subject of research at a temple complex in Göbekli Tepe, Turkey. At Hirbet ez-Zeraqon in Jordan, researchers are studying life in an Early Bronze Age town. A selection of original pottery works (see photo) takes centre stage at the exhibition, complemented by masterfully produced replica clay tablets and basalt sculptures.