LICHTGEDANKEN 06
The Magazine of the Friedrich Schiller University Jena

ENGLISH

SURVEY
JENA'S RESEARCHERS AND THEIR VISIONS
Scientific goals, ideas, and wishes of University staff members in a nutshell

REPORTAGE
HAECKEL'S MEDUSAE IN A NEW LIGHT
Exhibition in the Phyletisches Museum offers an insight into a fascinating underwater world

INTERVIEW
DECLARATION AGAINST BIOLOGICAL RACISM
Evolutionary biologist Martin S. Fischer talks about the special responsibility of Jena's zoology to make a stand

FEATURE

CONSTRUCTION PLANS OF LIFE

Ernst Haeckel arranged life within geneaological trees and shaped our concept of numerous animal species with his artistic drawings. The zoologist, artist, and idealist died 100 years ago in Jena.

LONG NIGHT OF THE SCIENCES 2017 IN JENA. PRESENTATION OF THE RESEARCH GROUP »TEACHING METHODOLOGY IN PHYSICS AND ASTRONOMY« | PHOTO BY: ANNE GÜNTHER

Long Night of SCIENCES

22 NOVEMBER 2019, 18:00 – 24:00

On 22 November 2019 between 6 o'clock p.m. and midnight, the Friedrich Schiller University Jena and its partners from research and economy invites you to join the 7th Long Night of Sciences in Jena. In the night, you will be able to take a look behind the scenes and let our researchers astonish you with their surprising experiments in understandable and exciting way.

Whether young or old, with or without family—if you have a thirst for knowledge, this is definitely the place to be. In addition to numerous experiments, you can attend presentations, guided tours, and a lot more to learn about the challenges of science.

Save the date now and be on site when our researchers will be presenting the diverse world of science as well as the latest discoveries and innovations »made in Jena«.

More information:
www.lndw-jena.de

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Development and responsibility

Development and responsibility: these two aspects are a common theme throughout this edition of LICHT**GEDANKEN**. The research magazine is dedicated to the zoologist, artist, and philosopher Ernst Haeckel, who died in Jena 100 years ago. He spent his life standing up for Darwin's theory of evolution and defended it against all odds. He was constantly breaking new ground—on his journeys around the globe, in his descriptions and presentations of living beings as well as while classifying the organisms in trees of life in which he placed the human species on the very top.

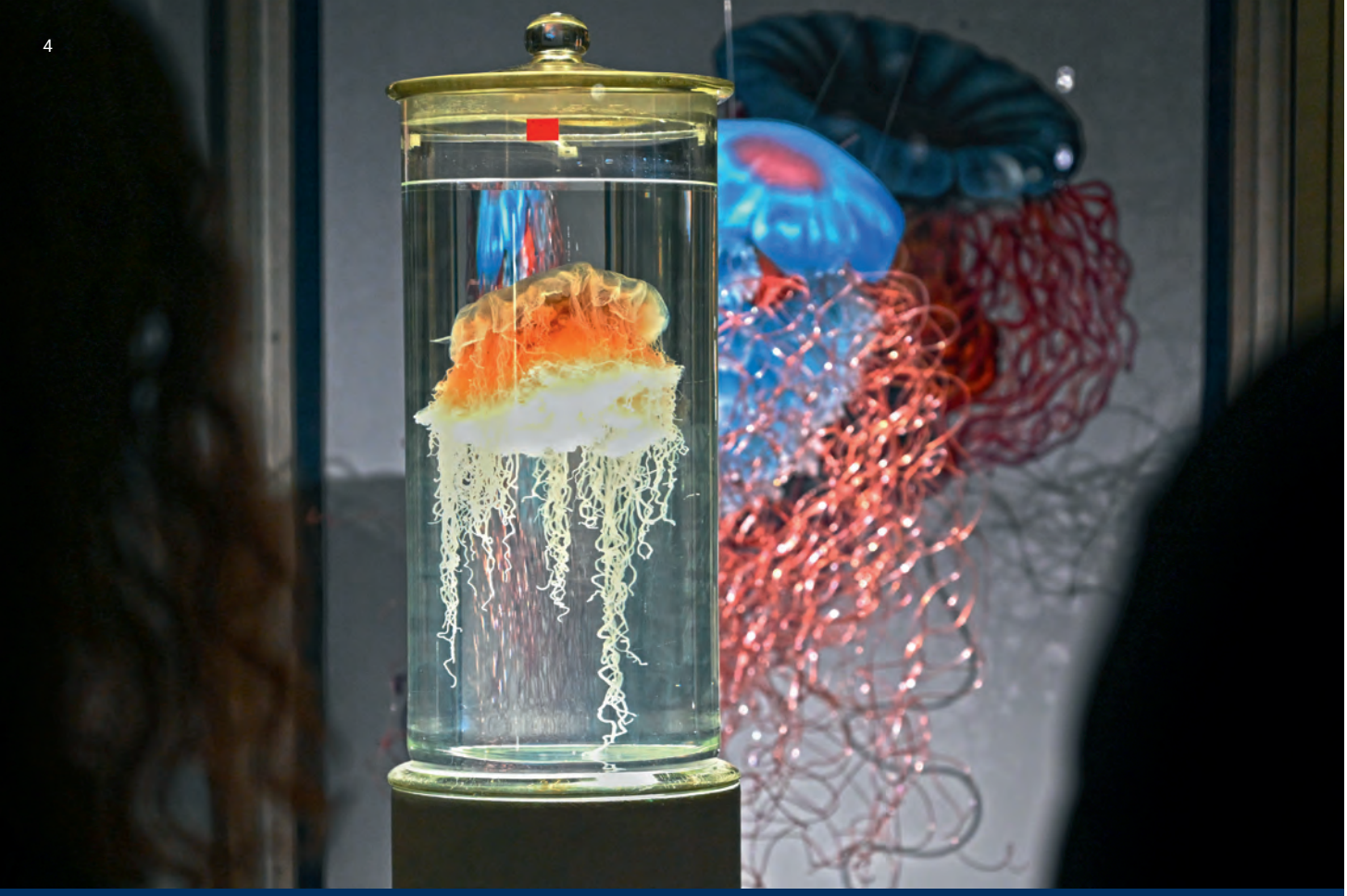
We can still witness Haeckel's varied legacy in science and in the arts, especially here in Jena, as our magazine shows (p. 14 ff). He had been researching and teaching at our University for more than four decades. Despite this fact, we do not want to glorify Haeckel. He was not a guiding light, but rather a highly ambivalent person. His enthusiasm for progress and development saw him cross ethical boundaries: Haeckel falsified, distorted the truth, and was a racist. This does not only cast doubts on the scientist Ernst Haeckel; it also eased the way for later ideologists to misappropriate his views and prepared the ground for Jena to develop into the stronghold of the race theory in the first half of the 20th century.

The University Jena and its researchers are well aware of this responsibility today. Evolutionary biologists and zoologists from the Friedrich Schiller University are working together with colleagues from across the German-speaking world to take a stand against racism. They are about to publish the »Jena Declaration against Biological Racism« before the end of this year (p. 34). Racism remains an issue and has once again come to the fore. The responsibility for taking a stand against it is an imperative of the moment, not only for zoologists. Advancements are also required beyond science: the German Constitution, which just celebrated its 70th anniversary, still contains the term »Rasse«, for example.

Moving forward, setting new objectives, looking to the future—researchers at the Friedrich Schiller University Jena reveal their plans and wishes for 2025 in our LICHT**GEDANKEN** survey (p. 10). In the interview, the new Vice-President for Research, Prof. Dr Georg Pohnert, too, is looking ahead talking about the future prospects for our University (p. 8).

I hope that you will enjoy reading this edition. Do you have any feedback on our research magazine? Please do not hesitate to contact the editorial team or myself: presse@uni-jena.de.

Jena, August 2019



FEATURE

Construction Plans of Life

Nonlinear optics research laboratory: a target chamber of the »Jena Titan: Sapphire 40-Terawatt Laser Systems« or »JETI40« for short.

Nonlinear optics collaborative research centre

The German Research Foundation (DFG) has approved the 1375 »Nonlinear Optics down to Atomic Scales« collaborative research centre for at least the next four years. The team working with the physicist Prof. Dr Ulf Peschel and the chemist Prof. Dr Stefanie Gräfe has received funding of around nine million euros.

Nonlinear optic phenomena appear whenever light hits matter. However, they are only visible and truly relevant at high intensities. The researchers want to investigate the resulting interaction processes between light and matter at an atomic resolution to model them on computers and to learn how to control them. If they succeed, numerous attractive applications will be available—from very small nanolasers, extremely compact X-ray sources, to a optical detection of fewer atoms.

The new collaborative research centre will see the Friedrich Schiller University work together with the Fraunhofer Institute of Applied Optics and Precision Engineering and the Leibniz Institute of Photonic Technology, Humboldt University in Berlin, and the Technical University of Munich. Twenty-four doctoral candidates and one postdoc will now begin their research into the nonlinear interaction between light and nanostructures or individual molecules. sl

New building for the Cluster of Excellence

The German government and the Free State of Thuringia are planning on building a new research center for the »Balance of the Microverse« Cluster of Excellence on the Beutenberg campus. German Council of Science and Humanities (WR) approved the grant proposal of the University and will recommend the project to the Joint Science Conference of the Federal Government and the Federal States (GWK) for funding.

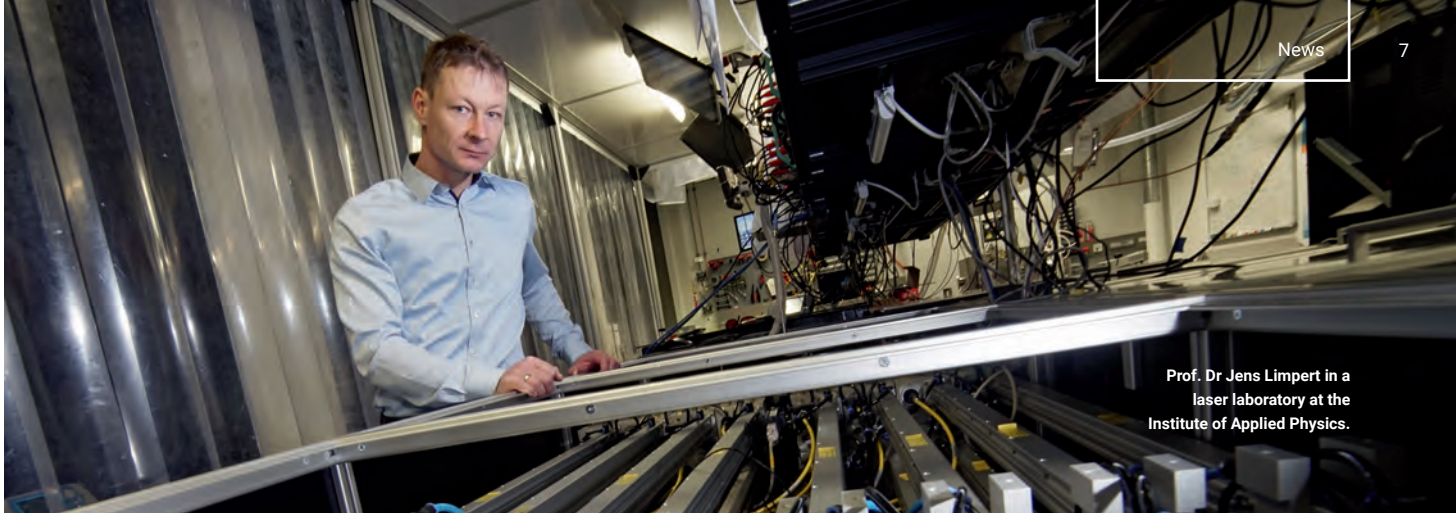
Microbiology research laboratory at the Beutenberg campus.

Being granted a final approval by the GWK, the federal government will pay half the cost of the new »Microverse Center Jena« (MCJ), which amounts to over 40 million euros. The Free State of Thuringia will pay for the other half of the building which should be ready for use in 2024.

University's consistent strategy

The Science Council stated: »The Microverse Center Jena demonstrates the success of the University's consistent profile strategy over more than 15 years. There is no university in Germany pursuing the importance of the microbiome for the human health as consistently and as comprehensively. Its focus ranges from a basic research to the transfer, which can also rely on the regional business partners. In addition to the bioscientific questions, another important goal is to further develop the imaging method, for which Jena is also an important location.«

The further research centre which will have a total area of 4,900 square metres, has been designed to accommodate 170 scientists and 30 non-academic staff members. AB



Prof. Dr Jens Limpert in a laser laboratory at the Institute of Applied Physics.

ERC Advanced Grant for Prof. Dr Jens Limpert

The European Research Council (ERC) will be funding the physicist and his team from the Institute of Applied Physics with almost 2.5 million euros over the next five years. The aim is to develop a high-powered fibre laser system to generate coherent laser pulses in the infrared, terahertz, and soft X-ray spectrum.

Limpert is one of only a few researchers in Germany and the only researcher in Thuringia to have been awarded three ERC grants. The ERC Advanced Grant is one of the most prestigious grants from the European Union. This year, the ERC has awarded 222 researchers across Europe with an Advanced Grant—there were more than 2,000 applications. With this project, Limpert and his colleagues hope to expand the range of applications for high-powered particle accelerators (synchrotrons): specifically with frequency-converted fibre lasers, which can be operated in all conventional laser laboratories.

Limpert believes that these types of lasers have an enormous range of potential applications. Powerful radiation in the terahertz range makes it possible to investigate complex materials without causing any damage, for example. Meanwhile, spectroscopic methods in the central infrared range could be used in medicinal imaging. US

Research training group in theoretical physics

The German Research Foundation (DFG) is funding the network for doctoral candidates at Jena and Leipzig universities with more than three million euros. The early-career researchers want to understand the interaction between matter and force fields.

Modern physics uses the concept of fields to describe the building blocks of nature and their interactions. The central research idea behind the new research training group 2522 »Strong Dynamics and Criticality in Quantum and Gravitational Systems« is to investigate and calculate the complex interactions between matter and force fields in gravitational and quantum field theories.

According to Prof. Dr Holger Gies, special focus will be placed on the interface between gravitational and quantum theory, which could in turn benefit the understanding of the mutual concepts and methods. The theoretical physicist is the spokesperson of the new research training group that is based at both universities. The funding will cover twelve doctoral positions.

The group is also part of an international network. In addition to the two main institution partners, two researchers from Denmark and Israel will also work on the project as Mercator fellows funded by the DFG. The 30 doctoral and postdoctoral researchers will engage in a curriculum consisting of local, joint, and international research-based teaching and qualification components. AB

»Our current understanding of nature is fundamentally based on dynamic field theories, such as Einstein's theory of relativity or quantum field theories concerning matter and its interactions. While both theoretical systems are based on the reductionist search for the components of space, time and matter, the latest theoretical research is faced with the challenge of complexity: a multitude of physical characteristics arises from the fascinating interplay between matter and fields.« Holger Gies, spokesperson of the new research training group.

»We have taken a major step forward.«

Prof. Dr Georg Pohnert took the Office of Vice-President for Research of the Friedrich Schiller University Jena at the beginning of the year. In this LICHTGEDANKEN interview, the 51-year-old chemist reveals the goals for his term of office, his own research work, and the challenges which researchers are facing in Jena and beyond.

INTERVIEW: UTE SCHÖNFELDER

You have been holding the Office of Vice-President for Research since the beginning of the year. How have you settled in?
It has been excellent, thank you. As Vice-President, I come into contact with the whole range of university research. Meeting so many open-minded and creative people working across the extremely varied disciplines has been a very positive experience.
It is a very interesting post, indeed, that much I can confirm already. I am, however, still learning and enjoying great support from my team. My predecessor Prof. Thorsten Heinzel, too, did a great job during the handover of the office.

To what extent can you influence actions as Vice-President for Research?
There is plenty of opportunity to leave my mark on various levels. On the one hand, I maintain the existing projects. Currently, I have been involved in ongoing review processes of two new collaborative research centres which started before my term of office for which I am, however, responsible now. On the other hand, part of the job involves positioning the University in terms of future projects and programmes. Supporting the next generation of researchers is of central importance here, but also bringing them into contact with each other and forging new consortia to be able to apply for funds should not be neglected.

Considering your experiences from the first few months, when you look into the future, which goals have you set for your period in office?
As a university, we have just taken a major step forward by obtaining the Cluster of Excellence. However, we cannot afford to rest on our laurels. We need to think about establishing a second or even a third pillar. My aim is to use our excellent collaborative research centres as a basis from which to create new »seeding cells« for Clusters of Excellence. We will continue to build on our strengths in the focal research areas Light, Life, and Liberty. I can see very creative initiatives—not just in the focal research area Life with its Cluster of Excellence—but also in other areas.

The »Balance of the Microverse« Cluster of Excellence, you have just mentioned, has been receiving funding since the beginning of the year. Have research activities already started?
Yes, but it is still too early for any results. At the moment, the focus is on acquiring the best minds for the projects. After all, a large programme of excellence like this depends on the people who work on it. The first contracts of employment for early-career researchers are currently being signed; other recruitment procedures are still open, we pay special attention to professorial positions which now may be filled. This will be a characteristic task of this year.
In the meanwhile, the new research building on the Beutenberg campus for the cluster has been approved, so that we can now start with the concrete planning.

You are also involved in the research within the cluster. With what questions are you and your team dealing?
We are doing research on plankton and examining the regulation mechanisms which have an important role in complex communities of marine microorganisms. We are trying to understand how such types of communities of species are organized in the open sea and how it is possible to have recurring patterns in the species structures without any spatial structuring at all.

How do you keep a balance between your research work and the position as Vice-President?
Admittedly, the new role takes up a lot of time. But it is clearly possible to continue my work as an active researcher while being a Vice-President and I take

this very seriously. I am lucky to have an excellent team within my research group and we allocated the tasks among us very quickly. Nonetheless, I had to take a step back from the daily activities in the laboratory.

You are also engaged in communicating issues from the world of science to the greater public.

Yes, I believe it is a key part of being a scientist to share our findings with the general public, rather than just publishing findings to a closed scientific community. That is why we are involved in holding organizing experiments in primary schools. For example, I took part in Jena's *SciencePub* myself; at our faculty, we regularly hold Saturday public lectures. I think that these formats are important. Admittedly, we know that people we address at such events are already interested in science. The real challenge lies in reaching out to those who are not curious about it and those who even deny scientific findings like believing in populist climage change scepticism.

This edition of LICHTGEDANKEN focuses on Ernst Haeckel. What is your link to him?

I have a very personal connection to him. As the son of a biology teacher, I came across Haeckel very early on in my life. Haeckel's drawings from the »Kunstformen der Natur« series hung on our walls at home and I now work with some of the organisms that Haeckel drew so skilfully—the diatoms. However, the aesthetic of these microorganisms is different for me than it was for Haeckel and it is not so obvious: for me, the beauty lies in identifying the chemical patterns, which can then be used to explain the cohabitation of two or more species from this group. ■

Brief portrait

Born in 1968, Georg Pohnert grew up in Gelnhausen, Hesse. Initally, he wanted to become an industrial photographer. After his school time, he first worked as a freelance reporter for a regional newspaper before taking a degree in chemistry at the University of Karlsruhe. Soon he was as captivated by his studies that he abandoned his plans of becoming a photographer and focused fully on science instead.

Following his graduation, Pohnert moved to the University of Bonn where he received his doctorate in 1997. In his doctoral thesis, Pohnert investigated the pheromone chemistry of brown algae. These creatures communicate with each other via odoriferous substances and keep predators away with chemical compounds. Following his doctorate, Pohnert moved to Cornell University in Ithaca, State of New York, as a postdoctoral researcher. There his research focused on phenylalanine receptors. These protein molecules help to regulate the build-up of specific amino acids in bacteria.

Georg Pohnert first came to Jena in 1998. He moved to the Max Planck Institute for Chemical Ecology, where he established his own research group and continued to research the chemical defence mechanisms of algae—albeit now predominantly microalgae. In 2003, he gained his habilitation at the Friedrich Schiller University in organic chemistry. Three years later, he was appointed Professor of Chemical Ecology at the Federal Institute of Technology in Lausanne, Switzerland. In 2007, he returned to the University Jena as Lichtenberg Professor of Bioorganic Analytics.

Here, he spent previous years using different chemical analytical methods to investigate signalling substances in the interaction between microbial communities of species, predominantly of marine microorganisms in plankton and in biofilms. Since 2014, he and his colleague Prof. Dr Christian Hertweck from the Hans Knöll Institute (HKI) have been spokespersons for the »ChemBioSys« collaborative research area. Pohnert is also a member of the research team in the »Balance of the Microverse« Cluster of Excellence. He became Vice-President for Research on 1 January 2019.

Georg Pohnert is married and has four children. In his free time, he likes to travel with his family and is also a passionate long distance runner. US

Prof. Dr Georg Pohnert (left) on the podium at the 2015 Jena *SciencePub*. Sharing scientific findings with the broader public is something that is close to his heart.

»Light, Life, Liberty—Connecting Visions«

With this strapline, the Friedrich Schiller University continues to develop its profile. The first Cluster of Excellence for Jena »Balance of the Microverse« has just begun its work, whereas researchers, faculties, and university committees discuss already upcoming tasks and goals. Apparently, the strategy 2025, which is to encompass the future direction of research and teaching activities as well as of promoting young researchers, already occupies the University. What personal goals and visions do scientists have for 2025?

SURVEY: TILL BAYER

My vision for 2025 is to have the analytic research into the chemical language of microorganisms completely interlinked with ecology by then. Thanks to new methods, this research will not just illustrate the chemical complexity, but will also connect it with processes in communities of species.

Prof. Dr Georg Pohnert
Faculty of Chemistry and Earth Sciences

In the age of the Anthropocene, I want to contribute to literary studies being given a greater role in making the effects of climate change more tangible. Trends like ecocriticism and nature writing can provide important impetus in that respect.

Prof. Dr Caroline Rosenthal
Faculty of Arts

I anticipate technological, methodological and scientific breakthroughs in laser-based nanoscale XUV imaging as part of a collaborative research centre which—being connected with small and big research projects—should ultimately merge into a Cluster of Excellence in the long term.

Prof. Dr Gerhard G. Paulus
Faculty of Physics and Astronomy

Each year, the state spends several billions of euros on economic policy measures. In my vision, evidence-based economic policy will be enshrined in legislation by 2025, in order to be able to analyse the cause-effect relation systematically and in a sound way.

Prof. Dr Silke Übelmesser
Faculty of Economics and Business Administration

My vision for 2025 is to have biophotonic optic tumour diagnostics implemented. In addition, I want to use new diagnosis methods, which are based on artificial intelligence, so that we will be able to better adapt treatment to the needs of individual patients.

Prof. Dr Orlando Guntinas-Lichius
Faculty of Medicine

What are the fundamental laws of nature? I hope that our theoretical research—together with our colleagues focused on experiments—can add a few lines to the answer of physics to the famous question from Goethe's Faust: »What does the world contain in its innermost heart?«

Prof. Dr Holger Gies
Faculty of Physics and Astronomy

I hope that in 2025 the priorities of the Thuringian higher education landscape will be set right again: research can be conducted without being plagued by overwhelming bureaucracy. Successful research needs an intellectually inspiring atmosphere as well as an open and unbiased politicital environment.

Prof. Dr Andreas Freytag
Faculty of Economics and Business Administration

In 2025, light will be used as a tool to understand how spatio-temporal features of the land surface connect to climate change. Local spectral observations will be connected to satellite observations. Universities flourish based on political recognition of scientific education and financial support.

Prof. Dr Christiane Schmullius
Faculty of Chemistry and Earth Sciences

Not much is lacking: stable basic financing and a new balance in teaching activities. As soon as that is re-established, I will have no concerns about the excellent research in Jena. In my wildest dreams, 2025 is also the year in which freedom of science in Eastern Europe would no longer be in danger.

Prof. Dr Joachim von Puttkamer
Faculty of Arts

In 2025, the Ernst-Haeckel-Haus will be a research location with an international reputation where history meets the future: where expertise in the history of science is dedicated to an interdisciplinary reflection on the current problems facing science, technology, and society.

Prof. Dr Christina Brandt
Faculty of Biological Sciences

Research of sports and health systems from an economic perspective has to consider especially the relevant long-term changes. Therefore, the focus will be on technical progress in sports, sport facilities in urban rooms, efficiency of sport organizations, and efficient methods to promote health prevention.

Prof. Dr Frank Daumann
Faculty of Social and Behavioural Sciences

For me, there are two main aspects for 2025: firstly, I will take part in the 500th anniversary of the German Peasants' War as a researcher of the Reformation and Luther; secondly, I want to gain funding for a larger interdisciplinary project about Christians in the GDR as part of the ›Liberty‹ focal research area.

Prof. Dr Christopher Spehr
Faculty of Theology

Digitalization and networking not only pose challenges for the legal system, but affect all aspects of life. My research vision is about helping to shape this development, accompanying it critically and excite interest for these topics among students, too.

Prof. Dr Christian Alexander
Faculty of Law

My vision is that generic methods and tools will be available for data-driven sciences. Thanks to the University's Michael Stifel Centre, they will be available to various joint projects and other research projects in which researchers will be able to apply them.

Prof. Dr Joachim Denzler
Faculty of Mathematics and Computer Science

Between politics and science

Vice-President Prof. Dr Uwe Cantner advises the German government in his role as a member of the Commission of Experts for Research and Innovation (EFI). The latest annual report was critical of German universities for their digitalization efforts. In this interview, the economics expert explains what needs to be improved and how the Friedrich Schiller University Jena stands in terms of digitalization.

INTERVIEW: AXEL BURCHARDT

As a member of the Commission of Experts for Research and Innovation, this is the fifth time that you have presented a report to the Federal Chancellor. What is the difference between a political report and a scientific publication?
The main difference is the language. Reports are written in a language that can be generally understood without any jargon. In addition, the report focuses on problem-oriented presentation and recommended actions which can be deducted from this; any comments concerning the theoretical basis and extensive empirical findings may be found in the endnotes—this helps to make the argument easy to follow and ensures good readability.

Does the Commission choose the topics itself or are these determined by the politics?
The Commission acts independently. We naturally look for interesting issues. And we choose topics that we believe to be relevant at present and that provide an opportunity to advise policy-makers to take action.

Is it possible to avoid party politics within the tension between politics and science?
There is a certain level of neutrality amongst the members of the Commission as the report is a result of our consensus. But, of course, we are also in discussion with the parties. At the end of the day, it is about ensuring an open discussion that is not swayed by political views, so that we can identify relevant topics and know how the parties perceive them. The insights that we acquire are used in the report, but they are treated objectively without any party political bias.

Do the politicans as recipients of the report really do not know its contents before it has been passed to the Chancellor?
Yes, they do not. There is usually only a brief discussion when the report is presented. Afterwards, it is about communicating the report and its content to the public and discussing it: in the Federal Press Conference, within the ministries, with friends and sponsors of our work, with research institutes and so on. The session with the Committee for Education in Research in the German Bundestag, in which we present the report and discuss it with the members of parliament—is rather political.

Do the politicians give you feedback?
What is crucial is the fact that the report is discussed in a parliamentary session which is not the case for all reports. After it, we receive feedback and statements from the ministries, professional associations, and organizations.

This year, the report deals with various topics, for example also with digitalization. You have played a leading role in compiling the corresponding part of the report. In this section, you criticize the shortcomings of the higher education institutions in terms of teaching and administration as well as the lack of governance structures. How have these institutions reacted to the criticism?
The digitalization chapter is based on a study, which was conducted by the Higher Education Information System Association HIS upon our request. It was the first time that higher education institutions across Germany had been surveyed about digitalization. They were asked about the status of digitalization and the related difficulties and expectations regarding teaching, research, and administration. The results showed us that the level of digitalization in the research sector is fairly well-established. Regarding the teaching sector, however, it is poor, and things are even worse for administration. The explanations by the higher education institutions were predictable: insufficient funds to properly finance the digitalization process. But we also ascertained that the necessary structures are not in place. There are still universities without digitalization commissioners, only a few universities have a digitalization strategy. These facts led us to the conclusion that the structures in universities need to be changed, so that digitalization can work. On the other hand, we have reminded the Federal Government and the Federal States of their duty to provide long-term funding.
All universities face tight budgets and are not well organized regarding structures required for digitalization. If politics desires a general digitalization turn, to move universities forward, it generally will not work without additional money. Otherwise, the universities will need to restructure themselves which may lead to other problems. Project-based funds are a real solution neither as these are only a

Prof. Dr Uwe Cantner (right) at the presentation of this year's annual report by the Commission of Experts for Research and Innovation to the German Chancellor Angela Merkel (4th from the right) in February 2019 in Berlin.
Cantner has been holding the Professorship of Economics/Microeconomics at the University since 2000. In 2014, he was appointed Vice-President for Young Researchers and Diversity Management. He conducts research into innovation-related economic issues, industrial dynamics and evolution as well as cooperation and networks. He has been a member of the Commission since 2015 and has been chairing it since the previous May. The commission advises the Federal Government on research, innovation, and technological performance.

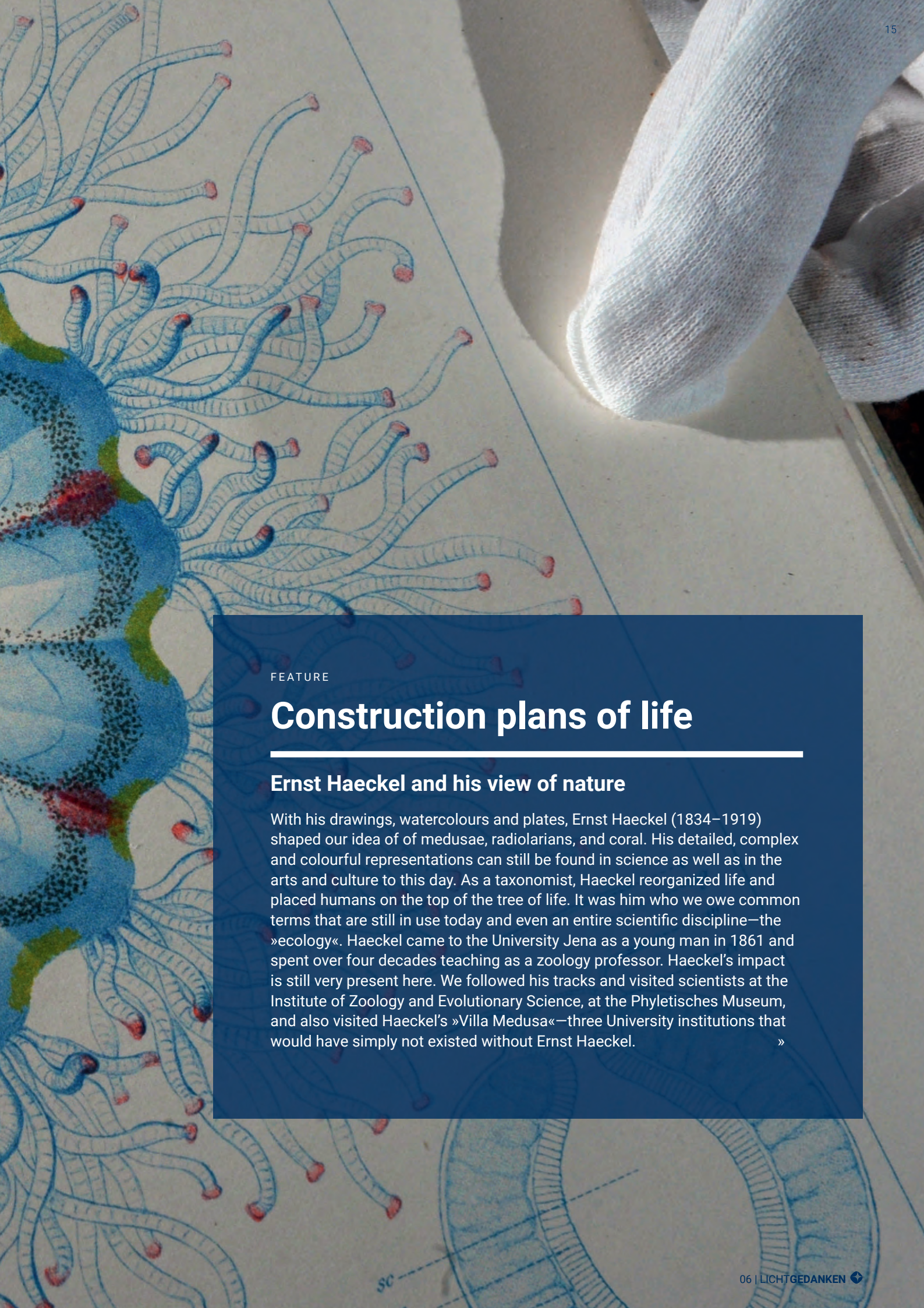
drop in the ocean. If you want to do it right, digitalization needs to be rolled out and established in one go. This is why we recommend a lump sum digitalization payment: in order to improve the digitalization, each institution of higher education should receive a particular amount of money per student.

From an expert of the Commission to the Vice-President of the University of Jena: what can you say about the digitalization of our university?
Digitalization has not been a hot topic here for a long time either and was only part of the discussions within the CIO Board. But digitalization is more than just hardware, the user perspective of it was rather neglected in the past. Project-based funding can be found here and there but this does not result in good overall development. We are now working on a strategy. With this in mind, we have set up the Digital University Office. In cooperation with the Executive Board, it is currently preparing a digitalization strategy to be implemented finally. I expect the first draft to be ready soon.

What should be the essential objectives in terms of digitalization?
Digitalization is a means to an end, it is not an end in itself. It should support the research and teaching activities as well as the administrative processes. The digitalization must be supported by the competence of staff. In other words, people need support to learn how to use the new technologies. They need to understand the benefits and why it will help their own work. Everything needs to be coordinated—there can be no individual special digital solutions. There must be a complementary structure, that excels by permanent development. It should always be possible to implement something new and to get rid of something old.

How fast may these objectives be met?
We will be able to bear fruit in five to seven years. But there is also always something that can be done to achieve a quick fix. For example, all faculties will soon be introducing software that considerably simplifies the appointment procedure. But a comprehensive system which would also encompass teaching and allow us to identify appropriate forms for particular study programmes—such a development takes time. We have already made relatively good progress in the field of research; but we can do more to raise awareness about digitalization. There are some faculties and university employees who still need to take the plunge and need to learn about the benefits of digital technology. You cannot force them, but can only recommend them to use it. The administration sector is a particular problem, and not just in terms of enterprise resource planning. We are trying to redraw the map here, too. ■

Haeckel's drawing of a deep-sea medusa from his work »Die Tiefsee-Medusen der Challenger-Reise und der Organismus der Medusen« from 1881 which is now preserved by the archive of the Ernst-Haeckel-Haus (»Villa Medusa«) in Jena.



FEATURE

Construction plans of life

Ernst Haeckel and his view of nature

With his drawings, watercolours and plates, Ernst Haeckel (1834–1919) shaped our idea of of medusae, radiolarians, and coral. His detailed, complex and colourful representations can still be found in science as well as in the arts and culture to this day. As a taxonomist, Haeckel reorganized life and placed humans on the top of the tree of life. It was him who we owe common terms that are still in use today and even an entire scientific discipline—the »ecology«. Haeckel came to the University Jena as a young man in 1861 and spent over four decades teaching as a zoology professor. Haeckel's impact is still very present here. We followed his tracks and visited scientists at the Institute of Zoology and Evolutionary Science, at the Phyletisches Museum, and also visited Haeckel's »Villa Medusa«—three University institutions that would have simply not existed without Ernst Haeckel. »

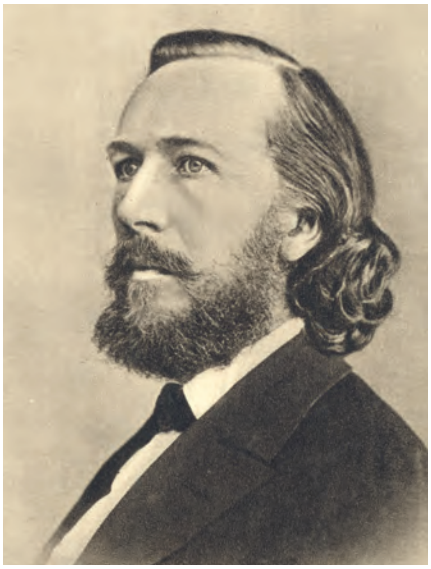
Ernst Haeckel—a phenomenon

Ernst Haeckel is often called the »German Darwin«. He was even compared to Luther. For many of his contemporaries, he was the »monkey professor« or »the pestilence of Jena«. Ernst Haeckel continues to polarize opinions some 100 years after his death. His legacy in the field of evolutionary theory remains undisputed. But his darker sides are equally indisputable: Haeckel was one of the pioneers of eugenics and, as a researcher, repeatedly embellished his scientific observations or rashly declared them as generally accepted as a result of his narcissistic craving for recognition. A portrait of the superstar of evolutionary theory, the natural scientist, artist and self-promoter—the phenomenon Ernst Haeckel.

BY UTE SCHÖNFELDER

It is easy to realize how Haeckel must have perceived himself when you pay a visit to his former home in Jena—the »Villa Medusa«. Here you see the zoologist alongside the greats of his field: Darwin, Lamarck, and Goethe. The four life-size paintings by Karl Bauer show the »fathers« of evolutionary theory. Ernst Haeckel had commissioned the paintings himself. They were originally intended for the entrance hall of the Phyletisches Museum, which he donated to the University at the end of his research career in 1908.

He first came across the theory of evolution—the focus of his life's work—almost 50 years earlier, in the summer of 1860: the 26-year-old Haeckel had just returned from a long research trip to Italy, when he was given Charles Darwin's revolutionary work »On the Origin of Species« which had been published a year earlier. Haeckel was immediately enthralled and dedicated his work to Darwin's theory of evolution. The following year, he was appointed as professor at the University Jena and, from the winter semester of 1862/63, he held blazing lectures on evolution. In September 1863, he gave a lecture about Darwin's theory at the convention of German natural scientists and and doctors in Szczecin—well aware of the fact that this was going to »split the great camps of zoologists, and botanists, palaeontologists and geologists, physiologists and philosophers into two staunchly opposing sides«. Haeckel took a clear position and staked his research field on the side of the »progressive Darwinists«.



Ernst Haeckel in 1872. The 38-year-old researcher already published several extensive publications, including »Die Radiolarien« (1862), »Generelle Morphologie der Organismen« (1866), »Natürliche Schöpfungsgeschichte« (1868). 1872 his monograph »Die Kalkschwämme« was published. Haeckel wrote more than two dozen scientific works, some of them comprising hundreds of pages and panels.

A circuitous path to a natural scientist

Haeckel's career as a zoologist was by no means a straightforward one. Born in Potsdam in 1834, Ernst Heinrich Philipp August Haeckel grew up in Merseburg and was interested in the beauty of nature from a young age. His tutor that his parents had hired before Haeckel began attending the Domgymnasium in Merseburg initially sparked his interest in botany. Haeckel set up an herbarium, which included thousands of plants. As an adolescent, he studied the writings of Charles Darwin, Alexander von Humboldt, and Matthias Jacob Schleiden on nature and travelling, dreaming of undertaking his own expeditions to the tropical rainforests. After having completed his *Abitur*, Haeckel wanted to study botany with Schleiden in Jena, however, he followed his father's advice and opted for a degree with better career prospects: medicine. He was increasingly interested in anatomy and physiology, but the thought of working as a practitioner disuaded him from becoming one. He was scared of illnesses and toiled through his degree. His interests lay elsewhere. Even during his studies, he undertook research trips to the sea: to Helgoland and Nice. In the end, he only worked as a doctor for a few months. He fled the medical practice in early 1859 and began a 15-month study trip in Italy. In the Gulf of Messina, he investigated tiny radiolarians, discovered and depicted one hundred previously unknown varieties of these microscopically small organisms. Back in Germany, he began to search for a

»Stammbaum des Menschen« (1874). This ink drawing by Ernst Haeckel (format 21.5 x 13.5 cm) is partly painted in grey watercolours and includes additions, written with a blue pen.

lectureship and was offered one in 1861 in Jena where his friend and benefactor Carl Gegenbaur was in charge of the Institute of Zoology. Just one year later he became associate professor and director of the University's Zoological Museum. It was with the monography of radiolarians, published in 1862, that Haeckel first caught the attention of those in specialist circles. While his first lecture in Jena had a total of nine attendees, by the winter semester of 1867/68, his lectures were attracting over 200 students—around a third of all students enrolles. Haeckel's name was on everyone's lips.

The mother of all questions

In 1866, Ernst Haeckel published a fundamental scientific work: the two-volume »Generelle Morphologie der Organismen« (General Morphology of Organisms) comprised over 1,000 pages and formed the foundation for all of his later works. In this book, he named ecology as a new discipline and introduced terms like phylogeny and ontogeny, which are still used to this day (see the box on p. 19). In addition, Haeckel also reorganized life; he classified all of the systematic groups of living organisms by ancestry and presented them in phylogenetic trees.

Unlike Darwin, Haeckel was quick to focus his work on the mother of all questions: the status of human beings within the natural world. While Darwin initially remained vague on the subject, Haeckel believed it self-evident to classify humans in the genealogical tree of living beings.

Haeckel the racist

Once Haeckel had set out his stall among expert circles with his »General Morphology«, he spent the following years increasingly addressing his findings and ideas to the general public. In 1868, he had his Darwin lectures stenographed and published them under the title »Natürliche Schöpfungsgeschichte« (The History of Creation, Or, The Development of the Earth and Its Inhabitants by the Action of Natural Causes). Eleven editions of this book were published before his death, and this in turn played a key role in popularizing Darwin's theory of evolution. However, it was in this book that Haeckel first formulated racist observations which saw a clear classification of inferior and superior species of humans. The conscious classification of »human races« by Haeckel provided the basic argument for social darwinism and racist responses until well into the 20th century, for example, by the National Socialists. In 1904, Haeckel considered eugenics in his work »Die Lebenswunder« (The Wonders of Life): whether it would be possible to give the »poor and and miserable« (»arme Elenden«) the chance to end their suffering with a painless death—a question of »eminent importance, both for practical philosophy and for legal and medical practice.« He described the life of a hopelessly ill person—on the presumption that they only suffer and cause troubles their relatives—as »worthless«.

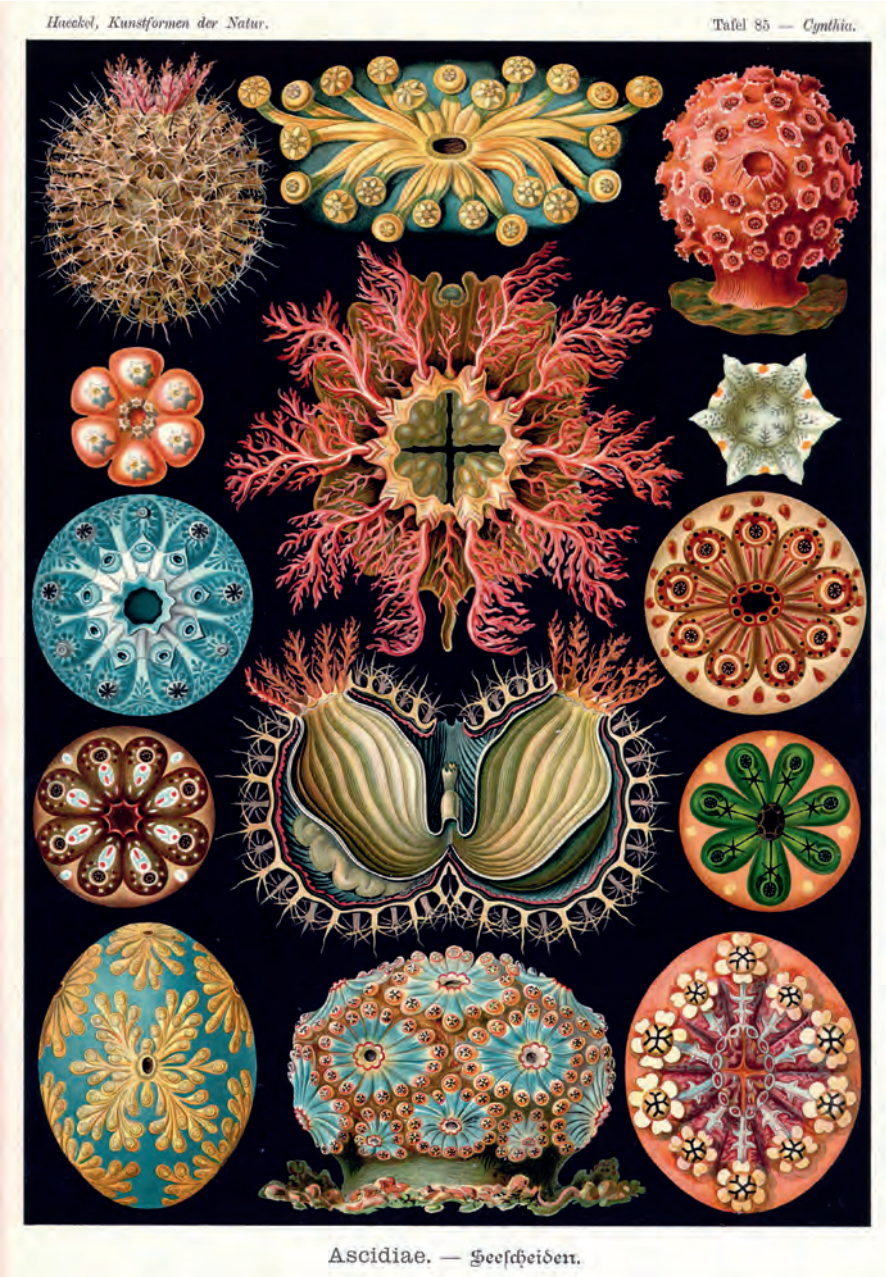


Plate from the »Kunstformen der Natur« (1899–1904) showing sea squirts (Ascidiacea). These sedentary marine organisms are very species-rich and varied.

Decorative science

Throughout his life, Haeckel was an extraordinarily talented artist. His illustrations of single-celled organisms, plants, and animals are distinguishable by their excellent level of detail and artistic prowess thus having inspired numerous artists and architects, in particular in the art nouveau style. Haeckel always considered science and art to be closely linked. In his depictions of radiolarians, jellyfish, and sponges, he seeked for universal principles of nature and found them, particularly in symmetrical systems which are typical of his drawings, watercolours, and lithographs.

His magnum opus in terms of his aesthetic observations of nature is considered to be his work »Kunstformen der Natur« (Art Forms of Nature), published between 1899 and 1904. Some of the illustrations in these works are now common iconographic resources: his *Desmonema annasethe*—named after his first wife, who died young, does not just adorn a plate in the »Kunstformen der Natur«; it is also featured on millions of T-shirts, mugs, and mouse pads.

The fact that this colourful depiction of the jellyfish, which was discovered near Cape Town in South Africa, actually has nothing to do with Haeckel's original specimen does not seem to affect its popularity. With his work, Haeckel wanted to »make the wonderful treasures of beauty which are hidden in the depths of the ocean [...] accessible to broad educated circles.« There is no disputing that he achieved this aim. However, in many cases his depictions do not stand up well to scientific review. It is not just the *Desmonema annasethe* (see the report on p. 22), which Haeckel was the first to describe, that is now considered to be a falsely described species. Regarding the ten species of jellyfish which adorn the ceiling painting in the Medusa Hall of the Phyletisches Museum—all of Haeckel's first species descriptions from the »Kunstformen der Natur«—only three are considered to be valid today.

The antipope in Jena's St Peter's Basilica

Even though Haeckel, who did not shy away from confrontation, had made Darwin's teachings popular in Germany, the two scientists represented very differing views. While for Darwin the evolution of life was a mere coincidence, higher development was considered as crucial for Haeckel; for him, the emergence of humans was the logical result of an inevitable development, which could be traced back to organic matter and which concluded with humans taking their place at the top of the genealogy tree of organisms.

Thus, for Haeckel, evolutionary theory formed the basis for a monistic belief turning the natural scientist increasingly into a kind of a religious leader. From the mid-1890s, when Haeckel was older than 60 years old, he worked less and less as a zoologist in spite of his ongoing teaching activities at the University until 1909. For Haeckel, monism represented a connection between science and religion. He believed that no spirit could exist without matter, and no matter without spirit. To him, both were linked to each other. He saw an almighty god as the »creator of all things« and the »sum of all forces« and he claimed that this god »revealed itself in all natural phenomena.« For Haeckel, nature was itself god: »All substances

Ernst Haeckel, drawing on the beach in Rapallo, 1903/1904.

possess life, whether inorganic or organic; all things have souls—crystals as much as organisms.«
Haeckel would not have been Haeckel if he had kept his beliefs to himself. In 1906, he founded the German Monist League (»Deutscher Monistenbund«) which missionized through its own newspapers, flyers, and presentations, with the aim of spreading »a unified, natural ideology« across the population. Two years prior to this, he was proclaimed the »antipope« at an international congress of freethinkers in Rome. The Phyletisches Museum, which he founded, served not just as a museum about evolutionary theory; instead, it was also a monist »temple«—like »Jena's own St Peter's Basilica«.

Congratulations on the Nobel Prize!

1908 was a key year in the life of Ernst Haeckel. To mark the 350th anniversary of the University Jena, he published his work »Unsere Ahnenreihe (Progonotaxis Hominis). Kritische Studien über Phyletische Anthropologie« (Our line of ancestors [Progonotaxis hominis]. Critical studies on phyletic anthropology). In this work, he once again summarized the key points of his research. 1908 was also the year in which the Phyletisches Museum opened and Haeckel was given many gratulations for having received the Nobel Prize. The latter was, however, appeared to be a canard; at the beginning of December 1908, various reports of several Italian and French newspapers stated that Haeckel had been awarded the prize. Some German papers, too, wrote the prize would be heading to Jena—yet without having provided any names.
Ultimately, it was not Haeckel who was awarded the prize, but the Jena-based philosopher Rudolph Eucken. Haeckel's disappointment must have been extreme when he realized the mistake. He speculated that there was a—quasi ideological—dispute in the Nobel Prize Commission about the decision between Eucken, a representative of idealism and a follower of Kant, and him »the materialist«. There is no evidence to back up this assertion. Besides Eucken, there were further 15 names on the list of nominations for the Nobel Prize in Literature in 1908, including prominent figures like Selma Lagerlöf, Adolf Harnack, and Algernon Charles Swinburne. Ernst Haeckel's name was not listed.

His final years

On 1 April 1909, at the age of 75, Ernst Haeckel completed his teaching career at the University—after almost 50 years. He faced a number of forgery claims in the final years of his life. Critics accused him of knowingly falsifying representations, including in his embryo plates. Haeckel fought back with a document entitled »Sandalion. Eine offene Antwort auf die Fälschungsanklagen der Jesuiten.« (Sandalion. An open answer to the forgery claims by the Jesuits). One year later, Haeckel left the Church. As, to mark his 80th birthday in February 1914, the Dukes of Saxony (Meiningen, Altenburg, Coburg) wanted to award him the noble rank, which would turn him to Ernst von Haeckel, he declined it »with thanks«. Ernst Haeckel died on 9 August 1919 in his »Villa Medusa«. His ashes were scattered in the garden of the house. ■

This text is largely based on: »absolute Ernst Haeckel« published in 2010 by Orange Press, edited by Uwe Hoßfeld.

Biological terms

Haeckel's enduring scientific legacy includes numerous terms he introduced into the biology terminology in his monumental work »Generelle Morphologie der Organismen« (General Morphology of Organisms, 1866). Many of those have remained in use for over 150 years. Here are some of them:

- **Ontogeny**
  »development history of organic individuals«
- **Phylogeny**
  »development history of organic strains«
- **Ecology**
  »the entire study of relations between the organism and the surrounding outer world«
- **Promorphology**
  »basic morphology of organisms«
- **Chorology**
  »study of spatial distribution of organisms«
- **Species**
  »the entirety of all cycles of conception which have the same form under the same circumstances«

Lateral thinker and polemical mind

In this interview, science historian and biology education expert Uwe Hoßfeld talks about Ernst Haeckel—the scientist, the artist and the person—someone whom he is connected to through more than 30 years of research.

INTERVIEW: UTE SCHÖNFELDER

What is Haeckel's most important achievement to science?
One of his lasting legacies is the introduction of numerous terms into biological terminology back in 1866—terms that are still in use to this day, some 150 years later. These include ontogeny, phylogeny, ecology and the term phylum. We also have Haeckel to thank for compiling the first phylogenetic trees—which incorporate humans—as well as the Gastraea theory and the biogenetic law.

Haeckel is often referred to as the »German Darwin«. What role did Darwin play in Haeckel's life?
Besides Lamarck and Goethe, Darwin was one of Haeckel's champions. Haeckel visited Darwin three times (in 1866, 1876 and 1879) and the two men were in regular written contact over a period of twenty years. In these letters they not only exchanged professional musings, but also personal information.

How did he distinguish from Darwin?
Unlike Darwin, Haeckel was more spontaneous and decisive, but in many areas his science was also less accurate. Thus, for example, he integrated humans into his phylogenetic construct back in 1866, whereas Darwin spent a decade from 1859 onwards considering doing the same. Furthermore, he didn't consider Darwin's teachings to be the definitive, comprehensive solution to the mystery of creation. He developed Darwin's ideas and added to them and immediately recognized the ideological consequences that they had.

As a taxonomist, what role did Haeckel play?
Haeckel described around 4,000 new species of primitive marine creatures—that is without doubt a pioneering feat. He attempted to use this comprehensive systematic work on smaller groups of organisms to reinforce the theory of common descent by proving their genealogical descent. Or, consider the analysis of the materials from the Challenger Expedition (1872 to 1876), which was undertaken by 76 academics over a period of twelve years. In this work, Haeckel processed the radiolarians, medusae, siphonophores and dictyoceratida. A total of 50 quarto volumes were published; Haeckel was responsible for 2,763 pages of text and 230 illustration plates. The names that he chose for new species paid tribute to family members, friends and colleagues, including Darwin, Virchow and Huxley. However, as a taxonomist, he was not so open to advancements within biology and he barely acknowledged the prospering field of genetics at the turn of the 20th century.

What was he wrong about?
I think it is too easy to attest retrospective mistakes and errors to him from our perspective several generations later. I would rather talk about what needs to be revised from a modern-day standpoint. This would include, for example, his views regarding the deep-sea dictyoceratida, medusae, and calcareous sponges; the biogenetic law, his Gastraea theory and genealogical trees are all interpreted differently, at least in part, nowadays. The same applies to his declarations about human phylogenics. In his defence, it must be stated that only two human fossils had been discovered when Haeckel was working: the Neanderthal Man, which was discovered in 1856, and the Java Man from 1890. In addition, there were hardly any human embryo specimens. He was only able to work deductively. Despite this, even these mistaken interpretations were heuristically valuable!

When you think of Ernst Haeckel, you immediately remember his numerous detailed illustrations. In your opinion, is this scientific or artistic work?
I am no art historian, but I think they combine both fields. Haeckel was an incredibly diligent artist: this can be seen in his two dozen sketchbooks and 1,000 watercolours. They represent his popularization and visualization of biology and his interest in landscape painting, for switching from the micro-level (microscope) to the macro-level. Haeckel was a visual person—a *homo opticus*. For him, pictures were not just illustrations; they were central to knowledge.

How would you characterize Haeckel as a person?
Haeckel was certainly a polemical mind, and someone who mutated from a zoologist to an »educator of the people«. On the one hand he was sophisticated, sensually realistic and interested in politics; on the other hand, he was at times wry, sarcastic and obstinate. He was a good university lecturer who always insisted on the veracity of his scientific findings and defended them against all criticism. But he was also a man of pleasure and enjoyed eating Thuringian-style barbecue roast pork or turkey with a jug of Lichtenhainer wine in the restaurants of Thuringia. Haeckel also enjoyed sports—he hiked long distances, was a climber, a swimmer and a rower.

Why has Haeckel polarized people to such a degree?
As a result of his close and constant linking of science and ideology, reli-

gion and artistry, Haeckel positively invited different kinds of controversies throughout almost his entire life. And then later, especially in the 20th century, his materialistic, Lamarckian, eugenic and monistic opinions led to politicians, scientists or the general public interpreting and exploiting these ideas in various societal systems. Here are a few examples: his lifelong fight for Darwinian theories and for the establishment of the subject of biology being taught in schools; his battle against the Church; the establishment of his substitute religion monism; his soft spot for Bismarck, eugenic thinking and social-darwinism.

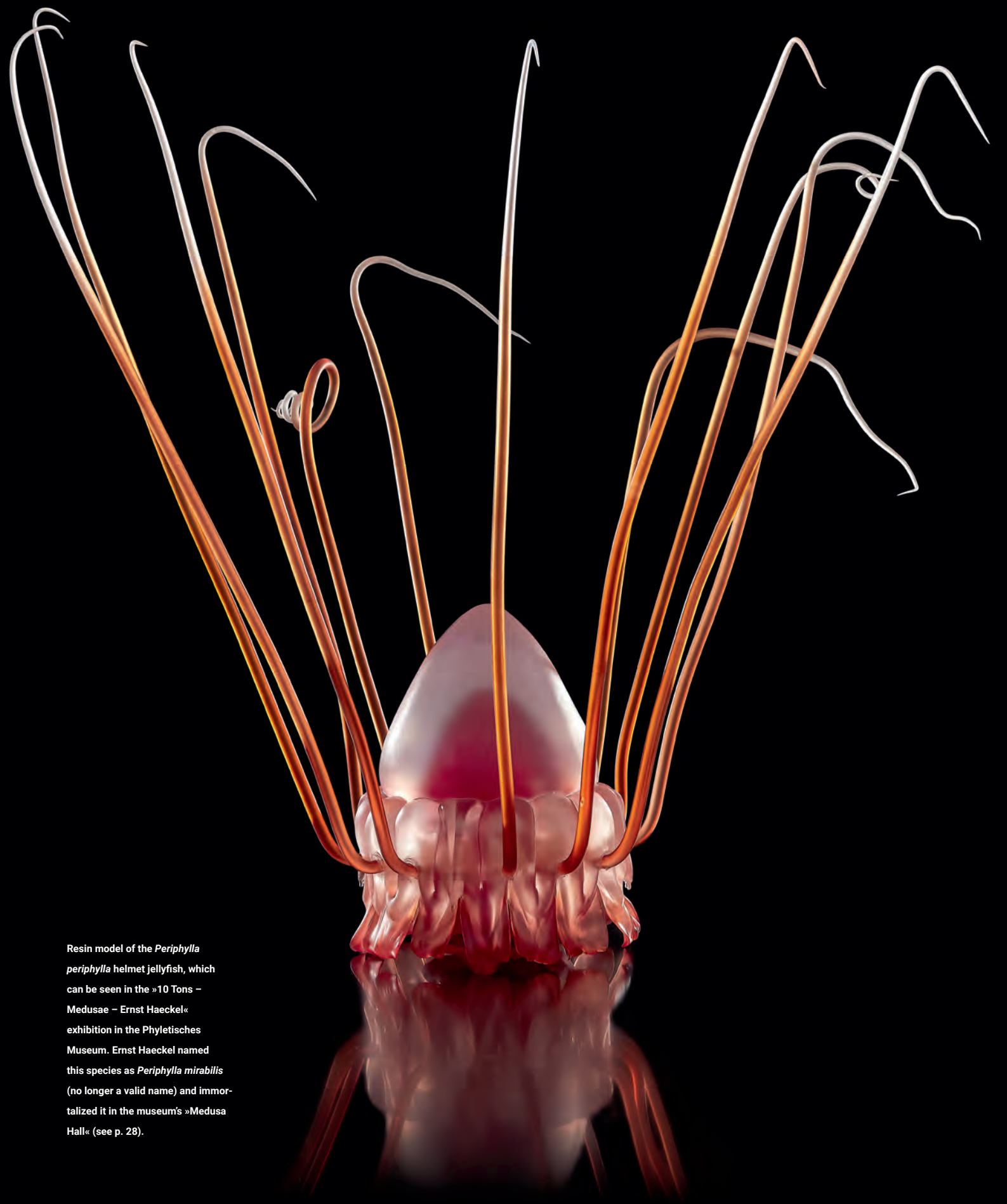
How do you think Haeckel would get along in today's scientific system, in the age of the internet and new media?

I think he would have loved the internet: »public enlightenment« and popularization were always a key part of his research and teaching. Then there is the fact that Haeckel was prone to a certain level of self-presentation and self-staging and that he also had the required portion of narcissism. During his lifetime, he reached wide circles of the population and not just within the »scientific community« but also in society as a whole, from housewives to politicians, with his letters, numerous photographs and works. The plethora of data and images available now and the rapid exchange of information is sure to have inspired him. He may have had an issue with the transience of emails compared to the letter-writing culture of his own era. After all, Haeckel wrote and received around 46,000 letters.

If you were to meet him today, what would you like to discuss with him?

Oh, there is lots that springs to mind. For example, I would like to ask why he did not trust the field of genetics that was becoming established from the year 1900 onwards. Or what caused him to pronounce himself the antipope. Did he really consider the ties between religion and science to have been broken? How does he view the placement of his research within evolution and developmental biology, and why did he not follow the approach of combining language and evolution? But, above all, I would be interested to know what he would say about the misuse of parts of his work by the National Socialists and Communists. I don't think he would mince his words. ■

Prof. Dr Uwe Hoßfeld manages the Research Group for Biology Education in the Institute for Zoology and Evolutionary Research at the Friedrich Schiller University Jena. He first came across Haeckel at the end of the 1980s thanks to a series of articles in the GDR weekly magazine »Wochenpost« and was fascinated by his personality and creativity. In addition, the August Schleicher memorial in his home town of Sonneberg is part of the national culture of remembrance for Haeckel. Evolutionary research and Ernst Haeckel have had a grip on him ever since. Hoßfeld is the author of numerous research studies and popular science publications on evolutionary history and has an extensive private archive about Haeckel. However, there is no portrait of Ernst Haeckel to be found in his office in the »Bienenhaus« at the University Jena—there is one of Charles Darwin, however (see above).



Resin model of the *Periphylla periphylla* helmet jellyfish, which can be seen in the »10 Tons – Medusae – Ernst Haeckel« exhibition in the Phyletisches Museum. Ernst Haeckel named this species as *Periphylla mirabilis* (no longer a valid name) and immortalized it in the museum's »Medusa Hall« (see p. 28).

Museum employees Bernhard Bock (l.) and Kenny Jandausch with jellyfish models.

Haeckel's fantastic sea creatures

To mark the 100th anniversary of the death of its founder, the Phyletisches Museum is dedicating the special exhibition »10 Tons – Medusae – Ernst Haeckel« to the most well-known organisms depicted by him: the medusae. The exhibition does not just provide an insight into a fascinating underwater world, but also into Haeckel's universe, in which visionary science and art combined in a truly unique way. In this reportage, we take a look at the organization and preparation behind the scenes of this exhibition.

BY UTE SCHÖNFELDER

It is Wednesday morning—a fresh spring day at the beginning of May. In front of a former harbour building in the south-east of the Danish capital Copenhagen, two young men are loading their van with about a dozen crates—containing items shimmering in white, blue and pink. At first glance, you could easily mistake the contents for fish—after all, the fishing port is just a stone's throw away. But, when you look closely, you can see that the crates are actually full of jellyfish: more than 200 deceptively real-looking plastic models; all delicate individual pieces. The two men carefully stack the crates onto the loading area. Around 700 kilometres of highway and two hours of ferry crossing await them today. Their destination: the Phyletisches Museum in Jena.

When I meet Bernhard Bock and Kenny Jandausch one day later as they unload the crates in the museum courtyard, there is a real hectic feel to proceedings: we cannot get through the museum's entrance hall, as the floor is currently being tiled with tiles that have been especially produced in Marrakesh based on a historical pattern. As such, Bock and Jandausch carry the jellyfish through the side entrance—the »Kubus«—cutting through a school group who are standing around, chatting. Despite the construction work, the museum remains open.

Chaos awaits in the exhibition room; well, at least that's what it looks like to me: tools, equipment and power cables lie around; some of the large glass display cabinets are open; it smells of fresh paint. The curtains from the previous exhibition still hang in front of the windows. »Oh, it is always like this,« says Bernhard Bock, calmly. After all, there are still two weeks to go.

Original specimens and lifelike models

Bock is referring to the deadline for the opening of the new special exhibition. The taxidermist handcrafted the jellyfish models in cooperation with the company »10 Tons« in Denmark especially for this exhibition. 100 years after the death of its founder Ernst Haeckel, the Phyletisches Museum is dedicating a special exhibition to the most well-known group of organisms that he de-

Almost impossible to distinguish from genuine jellyfish: models of common jellyfish during their transportation from Copenhagen to Jena (top image) and in production (central image). The image below shows a historic glass model of a siphonophora (*Physophora myzonema*) made by the glass artists Leopold and Rudolph Blaschka, which is on display in the current exhibition as a loan piece.

picted: the medusae or jellyfish. The exhibition room in which we are currently standing, is as good as predestined for a medusae exhibition. Ernst Haeckel had the ceiling of the twelve-by-twelve-metre room decorated with ten huge medusae. »Haeckel depicted the jellyfish in a highly idealized way, however, and with unrealistic symmetries,« says Dr Gunnar Brehm, who briefly stops by, looking upwards. »In our exhibition we want to compare and contrast this Haeckel art with scientific reality, in the form of original specimens and lifelike models,« explains Brehm, placing a pile of flyers on the counter. »10 Tons – Medusae – Ernst Haeckel« is the straightforward, unconventional title of the exhibition written on the flyers. Brehm has to get back on with his work. We arrange to meet later.

A lifelike underwater world made of resin

Bernhard Bock and Kenny Jandausch have now brought in all the crates. They want to prepare at least one of the eight large display cabinets for the exhibition today and fill it with a swarm of common jellyfish. »These are typical jellyfish, like those you see on the Baltic coast and on many beaches around the world,« states Kenny Jandausch. When everything is finished, the aim is to give visitors the impression that they are standing in front of a huge sea aquarium. In order to achieve this effect, around 200 lifelike models will be suspended from razor-thin threads. Jandausch shows me a whitewashed metal grid, which has been welded by the University's metalworkers. »This will be installed in the top of the display cabinet and each individual jellyfish will be positioned using a magnet.« Once

Chief taxidermist Matthias Krüger between shelves in the wet storeroom of the Phyletisches Museum. Numerous original specimens by Ernst Haeckel are stored and preserved here.

all the animals are in position, the cabinet will be immersed in soft lighting to create a truly lifelike illusion. Thanks to a mirrored rear panel, visitors will also form part of this underwater world. The model jellyfish are made of resin and are all made by hand. Bernhard Bock spent around two months in spring of this year working on these in Copenhagen at the company »10 Tons«. Each jellyfish is made up of numerous individual parts—the hood, the tentacles and the gonad piece—a clover-shaped blue-purple pattern in the hood, which forms the gonads of the jellyfish. »For each individual piece we used a 3D printer to create a prototype. This was used to pour a silicon mould, which was then filled with resin,« says Bernhard Bock, giving a rough overview of the manufacturing process. Once hard, the resin was processed by hand until the jellyfish's typical »ghost look« had been perfected. He is not willing to reveal anything else about the process, however. »Trade secret,« he says, grinning.

The »vibrancy« of the swarm is owed to the fact that none of the animals are the same, and each appears to have been caught in a different movement. Each of the 800-plus tentacles look different. How did he manage that? Bock grabs a huge hair dryer and a single tentacle. After blasting the tentacle with the hair dryer for a few seconds, he hands me the piece of plastic—it is now warm and malleable. I can twist it and move it without distorting the original shape. As soon as the resin cools again, it solidifies into the new shape.

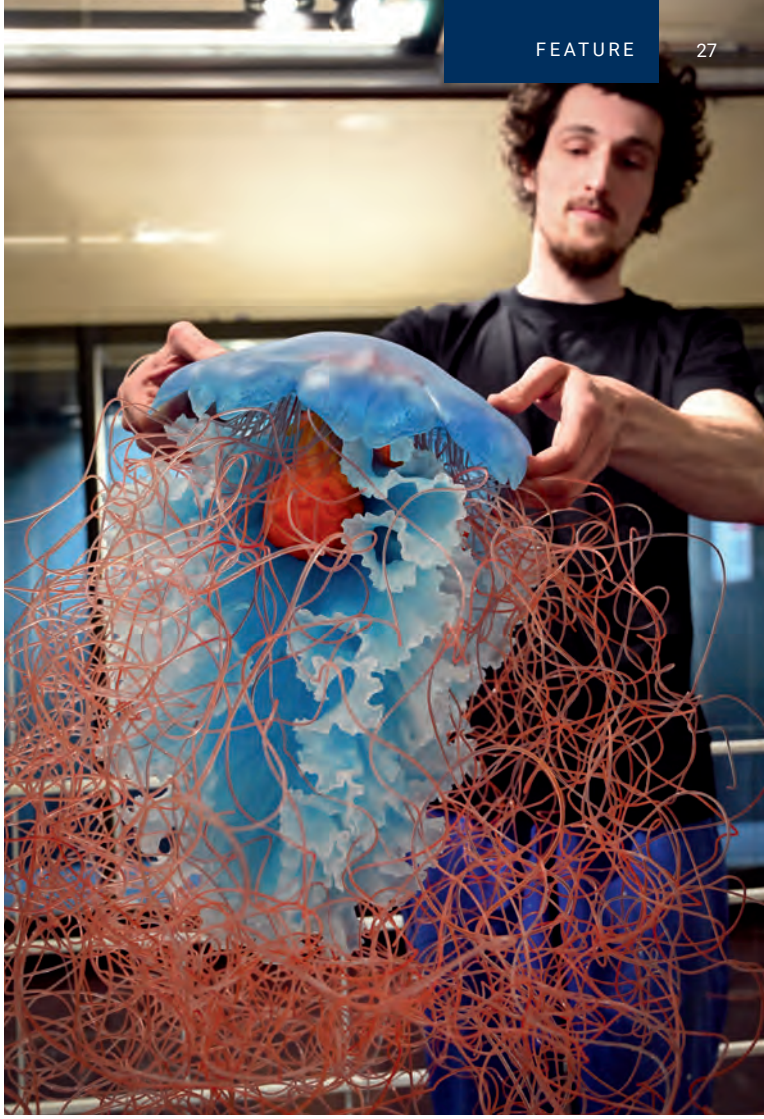
Colourful *Discomedusa* as a proof of love

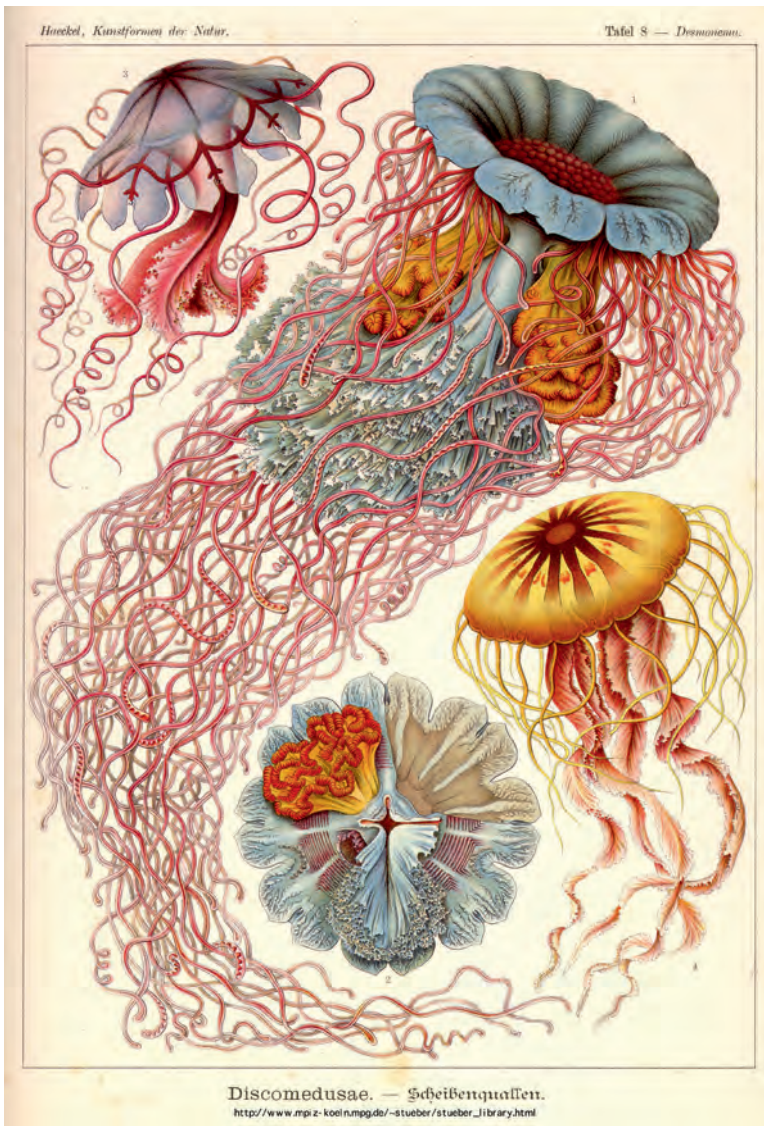
While the common jellyfish are modelled true-to-life in terms of size and appearance, the exhibition organizers have made a clear reference to Ernst Haeckel in another item within the exhibition. The display cabinet opposite is home to the most famous jellyfish that Haeckel named and depicted: *Desmonema annasethe*; now known as *Cyanea annasethe*. The oversized, half-metre-long and around eight-kilogram-heavy model stands as the magnificent Discomedusa that Haeckel drew in his »Kunstformen der Natur«—and not as a reflection of the original specimen. It was caught by Wilhelm Bleek—a researcher who was related to Haeckel—near the coast of South Africa, preserved and passed on to Haeckel. Haeckel named this previously unknown type of jellyfish after his first wife who died prematurely: her maiden name was Anna Sethe. And he neatly decorated his illustration: the colourful animal shines in powder blue and reddish-orange, and is surrounded by a lush veil of tentacles, which is said to have reminded Haeckel of Anna Sethe's magnificent head of hair. In this exhibition, Haeckel's model will stand side-by-side with the original type specimen of the *Cyanea annasethe*. The almost 150-year-old specimen is still stored in the so-called wet storeroom in the museum's cellar.

Natural treasures in alcohol and formaldehyde

Back outside, across the courtyard, to the right and down a steep staircase. At the end of a narrow corridor, I meet chief taxidermist Matthias Krüger and follow him into the storeroom, in which fish, amphibians and reptiles from across the world are preserved in glass tanks filled with alcohol and formaldehyde.

The vaulted cellar is almost completely full of store cupboards; the narrow corridor in the middle offers little room for movement. Krüger uses a lever to move





Fantasy meets reality: the original type specimen for the *Desmonema annasethe* (left) and the representation by Ernst Haeckel in the »Kunstformen der Natur« (bottom right). Museum taxidermist Bernhard Bock shows how the model has been produced for the exhibition based on Haeckel's template (top right).

One of ten medusae in the »Medusa Hall« in the Phyletisches Museum depicts *Periphylla mirabilis*, as named by Haeckel. However, this name was not valid—the species had in fact been named *Periphylla periphylla* by the French researchers François Péron and Charles Alexandre Lesueur back in 1809; i.e. some 70 years prior to Haeckel's naming.
The exhibition includes a plastic model of this unusual helmet jellyfish (see p. 22), which swims upwards with its tentacles. *Periphylla periphylla* is a deep-sea jellyfish, which can be found in the Norwegian Fjords, amongst other places.

one of the wall cabinets on the left-hand side, which creaks as it opens. He briefly disappears into the dimly lit space between receptacles full of yellowy-green and browny-grey scales, eyes and skins. Krüger sticks out his arm between the cabinets—he is holding one of these receptacles in his hand. The medusa? No, no, a python from Java, which Haeckel brought back from his expedition to Indonesia in 1891. Krüger looks amused at my shocked face and once again disappears between the shelves.

There are between 17,000 and 20,000 specimens stored here, I hear him explain out of the darkness. He is familiar with almost all of them and has a story or two to tell. Matthias Krüger has worked at the Phyletisches Museum since 1980 and has thus experienced a considerable part of the 111-year museum history at first hand.

Here it is now for real: the »annasethe«. It looks small and pale compared with its oversized, idealized, resin big sister. Its body measures around 20 centimetres in diameter. It shimmers in white and a delicate reddish colour and floats in a large glass of formaldehyde. The tentacles—Anna Sethe's »hair«—are reminiscent of a ball of overcooked spaghetti. Magnificent is definitely not the word that springs to mind. Despite this, the gelatinous organism is a touching sight: largely made of nothing but water, it has survived more than a century. And it inspired an enthusiastic scientist to create an extraordinary work of art during a difficult time in his life. A work of art that, since the copyright for the »Kunstformen« has expired, has been reproduced millions of times on posters and books, as well as on everyday objects like mugs, T-shirts and wallpaper. This *Desmonema annasethe* is truly unique, even if in a different way to how it was for Haeckel himself. »The medusa that we have here in this glass is seemingly the only example of this species that has ever been found,« Dr Brehm later tells me, when I visit his office on the second floor above the exhibition room. »It is not certain that it is actually a unique species.« After all, no one has seen a medusa like this since Haeckel. It is likely that *Desmonema annasethe* is

simply a juvenile stage of another species. It would mean that Haeckel had produced a synonym, »what happened to him considerably often,« as Brehm reveals in another display cabinet in the exhibition.

Together with museum educator Sabrina Hug, he has looked closely at Haeckel's monography »Das System der Medusen« (The System of Medusae), which was published in 1879/1880 and is a heavy, two-volume work in true Haeckel style. It contains descriptions of 580 medusae. According to Haeckel, 400 of these are new descriptions in line with Haeckel's own depictions. »From today's perspective, this is not even remotely true,« states Brehm, showing me a pie chart on his computer screen, which illustrates Haeckel's systematic work. »From these 400 species, Haeckel just assigned 142 of them to a different genus and wrote his name as the author after them. These are just new combinations, not new species«. As such, one third of the pie chart has been coloured red.

And it gets worse. Of the remaining 258 types of medusae which were actually newly described by Haeckel, over half remain unclear cases to this day: these organisms have simply not been found since—as is the case with the *Desmonema annasethe*. Another third of the pie chart turns red. »If you take out the section with invalid scientific descriptions, from his 258 species, there remain just 55 as valid newly described species,« continues Brehm. A truly small slice of the pie—just 21 percent—remains green. And, apart from »annasethe«, there are only a few other type specimens in the museum that are needed to be able to conduct further research.

Was Haeckel a sloppy scientist? Brehm takes a deep breath before answering. »He was inconsistent.« On the one hand, he was incredibly talented, hard-working and productive. But, on the other hand, he often overshot the mark. »I think he would have achieved more with less.« At the end of the day, Haeckel didn't need to exaggerate his work. »Even 258 newly described species is a large number.« Brehm is himself a taxonomist and knows the effort and care required to distinguish one organism from another, to describe new species and to classify them in the correct families.

Brilliance and contradictions

Haeckel's rather disillusioning accuracy in terms of describing species can be clearly seen in the ceiling fresco in the Medusa Hall, which I return to look at before concluding my visit. It shows ten medusae; all of Haeckel's first-described species. Seven of these are now invalid. But this doesn't change anything about the fascination that they evoke. The decorative, ornamental medusae are and remain simply eye-catching. And they provide the perfect backdrop to an exhibition through which Bernhard Bock, Kenny Jandausch, Gunnar Brehm, Sabrina Hug, Matthias Krüger and the other museum employees present Haeckel's legacy in all its brilliance and contradictions. ■

Like Haeckel, Dr Gunnar Brehm is a taxonomist—although he works with butterflies rather than sea creatures. He views Haeckel's art concept and method of working in describing medusa species in a critical light.

Further information:
The exhibition »10 Tons – Medusae – Ernst Haeckel« is being held at the Phyletisches Museum at Friedrich Schiller University Jena until November 2020.

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»With kindest regards from your loyal Ernst«

These days, we tend to email each other on a regular basis; Ernst Haeckel used to write letters day in, day out. And a large proportion of his correspondence has been retained to this day. Science historians are now giving the public access to this hoard. They intend to make all of the letters written by and addressed to Haeckel accessible via an online database by 2037.

BY SEBASTIAN HOLLSTEIN

My dearest grandfather! What are you up to? We were in Leipzig on the 15th May. My mother and I went to an animal stall, we saw: 1. 4 pelicans, 2. 1 tiger, 3. monkeys, 4. 1 raccoon, 5. 1 wolf and 1 bear together in 1 cage, 6. 1 bear, 7. 1 lion 8. 1 badger, 9. 1 cockatoo 10. parrot 11. 1 giant snake
Yours, Ernst

Even as a school boy, Ernst Haeckel seemingly had a special enthusiasm for two things, as his first letter from 22nd May 1840 reveals: animals and systematics. It comes as no great surprise then that this six-year-old went on to become a famous natural scientist and evolutionary biologist. He was an avid letter-writer throughout his life: thousands of letters followed this first postal greeting to his grandfather before his death in 1919. Through this medium, Haeckel was in regular contact with his family and friends, as well as with colleagues and those interested in his work. And the truly special thing: the orderly Haeckel didn't throw anything away; instead he kept almost his entire correspondence. He was partly saving them for reasons of private interest—thus, for example, he asked his parents to save his letters to serve as a kind of replacement diary. But he was well aware of his importance as a scientist and this led him to archive all of his correspondence for posterity. As a result, we have a paper legacy comprising around 46,000 letters.

Staff at the Ernst Haeckel Briefedition in the Ernst-Haeckel-Haus at the Friedrich Schiller University Jena have been working since 2013 so that we can follow the life and work of the renowned thinker into his old age via his correspondence. The project, which is part of the National Academy of Sciences—Leopoldina—and funded by the Union of German Academies, aims to make all of Haeckel's correspondence available online by 2037 and to publish selected letters in a 25-volume print edition.

At the level of characters

In their work, they are reaping the benefits of Haeckel's own preparations. »In the years prior to his death, Haeckel had already started to get his legacy in order with the help of his assistant Heinrich Schmidt,« says Dr Thomas Bach, head of the letter publishing project. »He prioritized the sorting of his correspondence in his estate.« At least two thirds of the papers come from this archive; the others have been collated as a result of extensive research. One of the members of staff, Dr Claudia Taszus, wrote to archives across the world to ask if they had any Haeckel letters in their collections. Institutions are still getting in touch to report new finds, as some of the estates from Haeckel's correspondents have only just been made accessible.

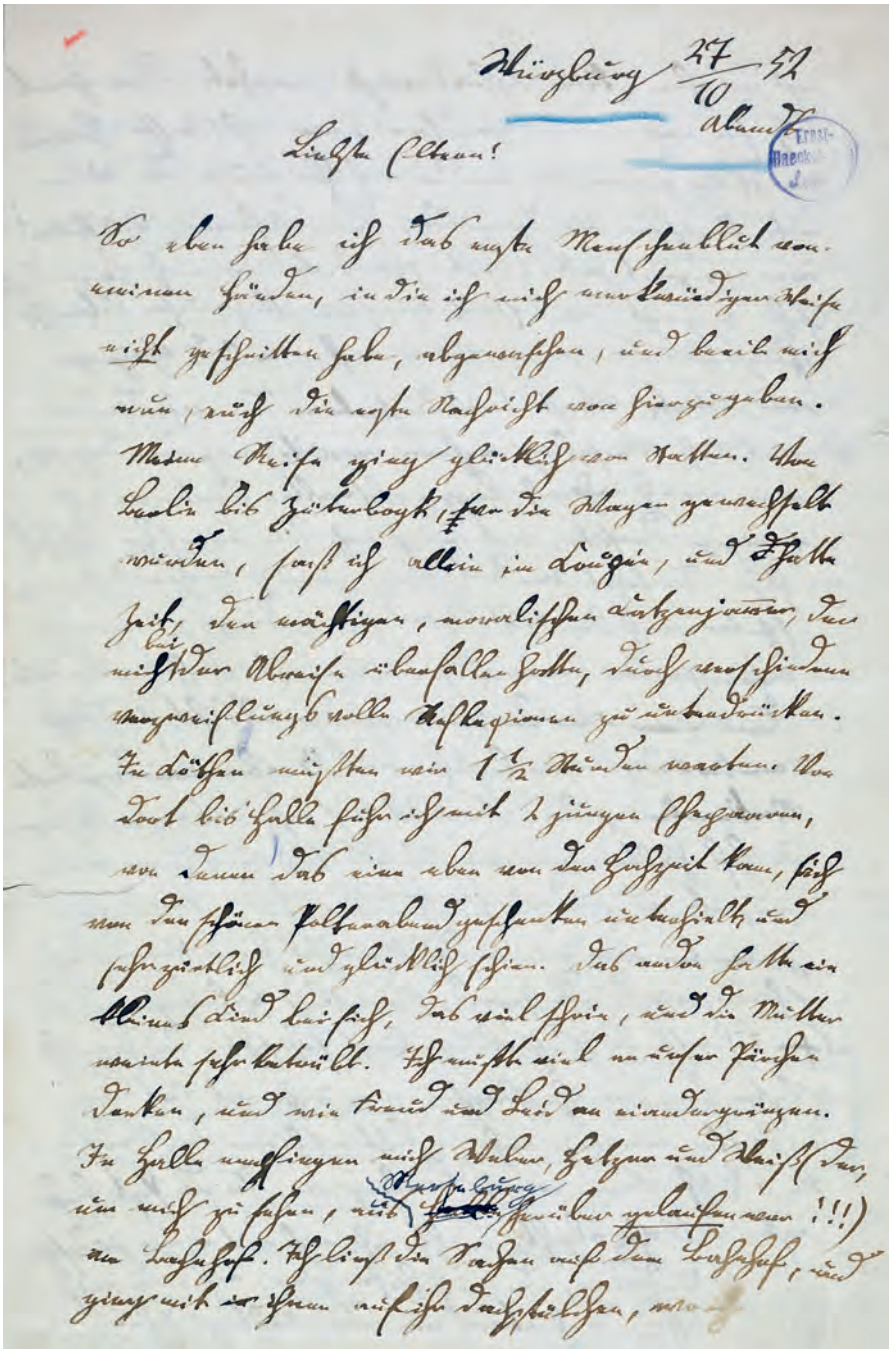
The meta data for the letters is now fully recorded in the online edition. The researchers inspect each letter by hand and record information, such as the date, the location, the author and the recipient. They are now working on one letter at a time in three steps: first, they compare the recorded meta data with the original letters or copies. Then they transcribe and collate the text. This means that one member of staff types the letter into a text file and a colleague then compares this transcription with the original. Once all of these processes have been completed, the text of the letter is immediately published to the online edition and can be accessed via internet. It is largely the size and quality of the handwriting that determines how much time it takes to process an individual letter. »We have both, short postcards and letters spanning several pages,« Bach says. »Then there is the fact that admirers of the biologist generally wrote in clearer handwriting than Haeckel's Aunt Bertha, for example, whose writing is harder to read.«

During their everyday work, the academic staff working on the project focus mainly on the level of characters. »When we transcribe and collate the letters, we focus on language, grammar and the characters used,« says Bach. »The more you consider the content itself, the longer it takes to process each letter.« Despite this, it is impossible for the researchers to fully ignore the contents of the letters. »We are, of course, accompanying Haeckel through his life, over many years and we are not machines. It is the sheer quantity of the work that keeps us on the straight and narrow.«

Death threats by mail

It is, for example, touching to follow the exchange between Haeckel and his first wife Anna Sethe, in which they plan their life together and their wedding. Anna died shortly after the wedding at an age of 28 years. »It is like reading a thriller with a spoiler,« the humanities scholar says about reading these letters. The hostility which Haeckel was faced with as an advocate of evolutionary theory also landed in his letter box. There were even death threats. Occasionally, the content of the letters themselves is required to provide important information for classifying the letters. For example, Haeckel often only addressed letters to »Mein lieber Freund« (My dear friend) and,

Letter from Ernst Haeckel to his parents from 27 October 1852. The 18-year-old had just begun his degree in medicine in Würzburg. The letter begins as follows: »Dearest parents! I have just washed the first human blood that was, strangely enough, not caused by me cutting myself from my hands and I am now rushing to send you this first message. ....« The full transcript (in German) can be read in the online collection of letters.



if there is no envelope, the recipient of the letter has to be determined by the content that follows. »Sometimes it is real detective work,« says Bach.

A master of small talk

Generally, Haeckel was very close to his correspondents. »He was very good at small talk—the transitions between private and professional are often fluid as a result,« says the head of the publishing project. Thus, for example, he discussed matters of science with his closest friend and teacher Carl Gegenbaur, before reminding him to water his plants. It is also possible to deduce the effect of Haeckel's popularization of science from his correspondence. The natural scientist tried to share science in a way that it could be understood, by addressing large audiences. And this readership often got in touch by post. Admirers expressed their appreciation, requested an autograph or asked for recommended reading. The biologist was eager to grant these wishes.

The Jena-based research team is also following this tradition. All of the edited letters are freely accessible online. In mid-May, 6,537 letters were already available, and 2,000 more are due to fol-low each year. In addition, the second volume of the print edition containing family letters from 1854 to 1857 (see p. 36) was published this spring. ■

Further information:
The online edition of the letters sent by and to Haeckel can be found at:
haeckel-briefwechsel-projekt.uni-jena.de

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The moon man

He was a natural scientist, anthropologist and ethnologist—and the first anti-racist. Nikolai Miklucho-Maclay studied with Ernst Haeckel in Jena for only a few years. Then he fell out with his mentor. Yet it was this dispute of all things that appears to have driven him on throughout his entire life.

BY SEBASTIAN HOLLSTEIN

Nikolai Miklucho-Maclay (left) and Ernst Haeckel. The photograph shows the two natural scientists in 1866 on a trip to the Canary Islands.

Nikolai Miklucho-Maclay must have looked like an alien to the people of Papua when they saw him for the first time: a small, slight man, rowing to their island from a large ship. He was probably the first white person they ever saw. It is September 1871. The Russian natural scientist had come to live on New Guinea. He built a hut in one of their villages and spent around 14 months living with the indigenous people. During this time, he researched both the flora and fauna on the island and the lifestyles—the social structures, the language and the customs—of his hosts. He wanted to use his research—especially in the field of comparative anatomy—to unequivocally prove that all humans belong to the same species. For, what is now seen to be self-evident, was still an ongoing scientific dispute in the second half of the 19th century—including between Miklucho-Maclay and his former mentor Ernst Haeckel. He studied with him for three years in Jena.

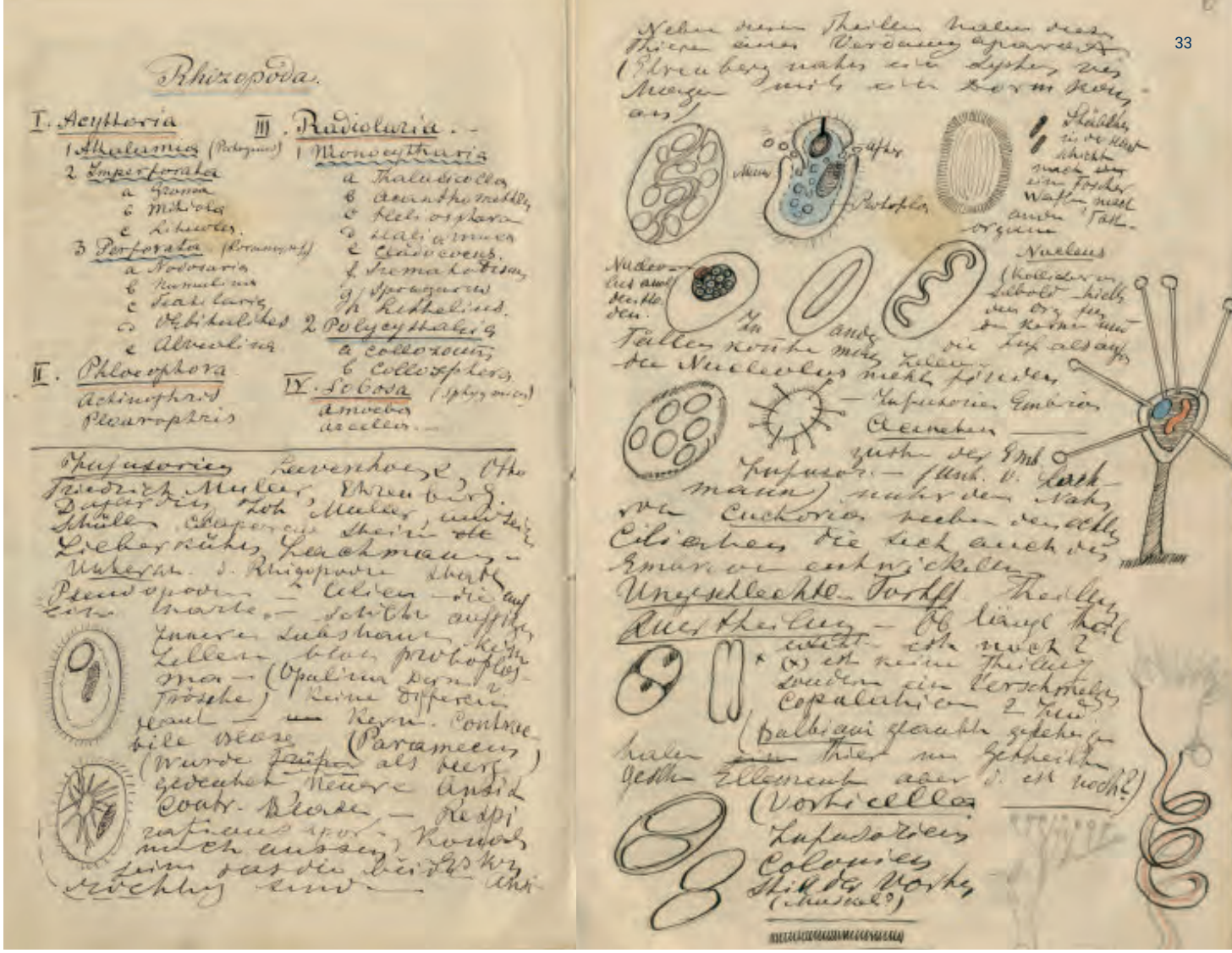
Prof. Dr Uwe Hoßfeld and PD Dr Georgy Levit from the Research Group for Biology Education at the Friedrich Schiller University Jena are now tracing the history of this special relationship. It all began with a sensational finding: in the archive of the Russian Geographical Society in St Petersburg, where the complete estate of Miklucho-Maclay is held, the two scientists reviewed documents from his time as a student in Jena—and discovered complete lecture notes from Ernst Haeckel's lectures. »We found comprehensive drawings from one of Haeckel's zoology and palaeontology lectures, as well as from a further lecture by Carl Gegenbaur, Haeckel's mentor,« says Uwe Hoßfeld. »In other words, we have an unbiased and unique insight into Haeckel's teaching methods. It is especially valuable, because, as a university professor, he tended to speak without any notes.« In addition, Miklucho-Maclay even copied the panel painting in full and integrated it into his notes. Thus, for example, there are illustrations of horseshoe crabs, seahorses and even of the »Collegium Jenense« in the papers. It could have been this meticulousness that sparked Haeckel's interest in his Russian student and led him to appoint him as his assistant in 1866.

Less than half a year later, Ernst Haeckel described him as »one of his favourite students« in a letter to his parents, even worrying that he was ill. Furthermore, in 1866 and 1867, he took him on expeditions to Madeira and the Canary Islands. Haeckel inspired the young biologist to research sponges and this led to his first publication.

But Miklucho-Maclay led an erratic student life, got into debt and occasionally disappeared, although always came back. But, in 1868, he finally cancelled his studies without academic degree. He subsequently undertook a number of research trips, including to Sicily and to the Red Sea. It is likely that he was last in Jena in 1870, as he wrote a comparative monograph on the neurology of vertebrates; but he dedicated it to Carl Gegenbaur rather than Ernst Haeckel. »He had broken off all contact with his former mentor and promotor by 1871 at the latest—presumably, because he did not share Haeckel's classification of humans into hierarchically structured races,« says Georgy Levit.

Notes on Haeckel's lectures published in a book

Hoßfeld and Levit now want to look more closely at how intense the ties and the disagreements between Haeckel and Miklucho-Maclay were. The discovered notes on the zoology lecture will be published this year (autumn 2019) in a book, in cooperation with the Stadtmuseum Jena (Jena City Museum). The two science historians also want to find out more about Miklucho-Maclay's research work and his associated reputation. Thus, for example, he founded the first marine biology research station in Oceania in Sydney, where he settled in 1878 and married the daughter of the Prime Minister of New South Wales.



Excerpt from Miklucho-Maclay's notes from Haeckel's zoology lecture from the 1865/66 winter semester.

Yet, he was denied a great research career: in 1887, on a trip to St Petersburg, during which he wanted to report on his work to the Russian Geographical Society, he suddenly fell ill. He died one year later at the age of 41. His widow returned to her home with their children. »Unfortunately, he didn't ever publicize his work in a systematic way. Matters are worsened by the fact that his wife burnt many of his papers after his death; as a result, there are huge gaps in his legacy. His research efforts are thus difficult to get a handle on,« says Levit. »There is still no agreement on whether he was more a outstanding scientist or a outstanding humanist. Both sides of the coin can even be combined when it comes to the dispute with Haeckel.« His humanistic attitude is undisputed. Even the Russian author Leo Tolstoi wrote to him: »You were the first person to demonstrate from their own experience that a human is always a human; a friendly, social being that we can and should communicate kindly and truthfully to—and not with weapons and an evil spirit.« In the later Soviet Union, memorials were erected in honour of the »first anti-racist«, as Hoßfeld calls him, and he was immortalized on stamps. Some statues of him can also be found in Australia and Indonesia. In Papua New Guinea, Nikolai Miklucho-Maclay is still considered a folk hero for his work against slavery and colonialism, as well as for championing the rights of the indigenous population. He visited the island several times between 1876 and 1877, staying for long periods. The memory of their first meeting with him led the Papuans to immortalize their guest with a name. They called him »Kaaram tamo«, the moon man. ■

Further information:
In the »HAECKEL on stage« exhibition in the »Stadtmuseum Jena« and in the exhibition catalogue (ISBN 978-3-942176-50-7)

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There is no biological foundation for racism

In this interview, evolutionary biologist Prof. Dr Dr h. c. Martin S. Fischer talks about the ambivalent scientist Ernst Haeckel and the particular responsibility of the Friedrich Schiller University Jena to stand up against racism. He is due to announce a Jena declaration against biologically justified racism at the upcoming annual meeting of the German Zoology Society, which is to be held in Jena in September.

INTERVIEW: AXEL BURCHARDT

Jubilee ceremonies pose the risk of putting the jubilarian on a pedestal. Does Ernst Haeckel, who died 100 years ago on 9 August, belong on a pedestal?

That depends on the height of the pedestal. Haeckel is the most famous German-speaking zoologist of all time—and he was based in Jena. But the taxonomist Haeckel named 500 medusae; half of which had already been discovered and were simply renamed by him. Only around 20 percent of the names have stood the test of time; a very small number compared to other taxonomists. In his specialist field of taxonomy and systematics, he is only below average. Thus, the question remains: What height should a pedestal have for a taxonomist whose work was sloppy? Just two years after the publication of his »Das System der Medusen« (The System of Medusae), it was roundly criticised by other zoologists. As such, it was no coincidence that Haeckel soon withdrew from zoology. At the age of 50, he stopped being a zoologist.

What did he become instead?

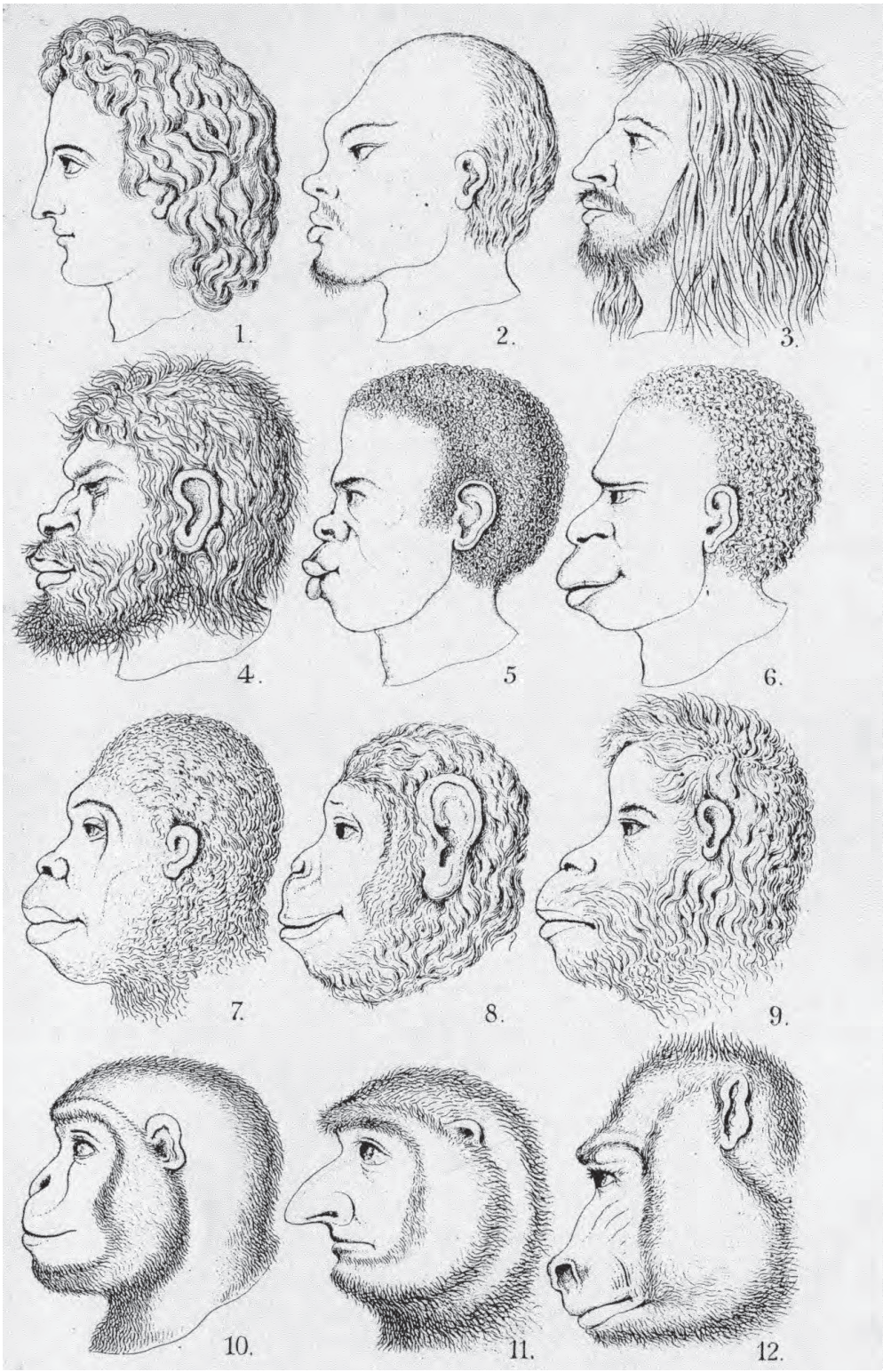
A self-proclaimed philosopher, founder of a religion and world teacher. In his book »Welträtsel« (The Riddle of the Universe), he explained the world in relatively few pages. His claim of being a world teacher for all matters is actually quite impudent. The great scientists never attempted anything like that. The scientist Haeckel turned into someone convinced of a divine mission to improve the world; a know-it-all. »His reading and reasoning […] is so superficial that he never records any complicated trains of thought […],« wrote the initially loyal and later critical student Hans Driesch about Haeckel. It is also irritating to find that Haeckel quoted relatively few other scientists; his work is teeming with self-quotations. And this was seen as disreputable in his time, too.

It is still about the scientist. What is going on with the author of »Die Lebenswunder« (The Wonders of Life), a work in which Haeckel claims that killing disabled newborns would not be murder, but rather a »useful measure«?

In principle, ethical judgements can only be made at the time and not retrospectively. Haeckel was not out of the ordinary with these thoughts back then. It was also part of his thinking to order things: if I am classifying single-celled organisms, jellyfish, the world of flora and fauna, then I will classify everything—including humans. Even with humans, he looked for characteristics to differentiate between different entities. Thus, for example, Haeckel classified humans by hair structure: there are the smooth-haired, the curly-haired, the woolly-haired etc. He then derived differences from one single characteristic—it is completely absurd. He always posed the same question: which are the highly developed snails, worms and humans? In terms of humans, he lacked the insight that he needed to curb his own thoughts. But it is the racism that has existed since the mid-19th century, which made this classification by different characteristics.

So, Haeckel was just someone who did classification and not a racist?

Racism does not need a scientific foundation. The racists of today have moral, ethical or other motivations. Biologically justified racism is especially dangerous, because it purports to be based



Ernst Haeckel differentiated between »lower« and »higher« humans. This illustration »Die Familiengruppe der Katarrhinen« (catarrhine monkeys) was taken from his »Natürliche Schöpfungsgeschichte« (The History of Creation, Or, The Development of the Earth and Its Inhabitants by the Action of Natural Causes). By way of explanation, Haeckel wrote: »The lowest humans (Fig. 4, 5, 6) are clearly far closer to the highest primates (Fig. 7, 8, 9) than the highest humans (Fig. 1).«

on scientific findings. In science at that time, the aim of differentiation was always to strive towards superiority. Thus, for example, woolly hair was the original trait, which then led to smooth hair and, so the thinking went, smooth hair must be superior. We now know that it is often not like this.

Haeckel and racism are topics on the agenda for discussion at the annual meeting of the German Zoology Society, which will take place in Jena in September. What role does Jena play when it comes to racism?

Out of all the universities in Germany, here at Jena we have the greatest obligation to speak out against biologically justified racism. As Uwe Hoßfeld from our University has established, during the time of the National Socialists, the greatest number of professors of biological racism was found at the University Jena—the so-called »Race Quadriga«. This was due to the fact that the ground in Jena was fertile for racist thinking—from the time of Haeckel to the end of the Second World War. And, because Jena had this position, we came up with the idea of discussing biologically justified racism at the conference. Also because this line of thought is once again finding fertile ground and is getting louder—and that makes me angry.

What can you and other scientists do to counteract this?

We are going to publish a »Jena Declaration against Biological Racism«. By doing so, we want to make it clear that there is no biological foundation for racism. It is important, because the German Constitution still states that there must be no discrimination on the grounds of someone's »race«. The fact that this law speaks of »race« implies that human races do exist. This is politically fatal and a disaster for science. The mothers and fathers of the German Constitution meant well; they didn't want to experience racism again in Germany. But the term »race« is misleading; it needs to be removed. It is completely sufficient to write: »No human is to be discriminated against.«

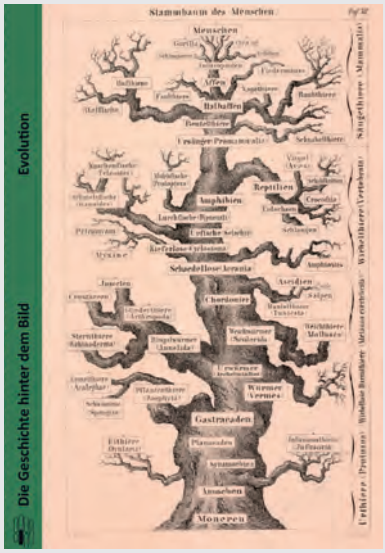
Will this issue be discussed at the conference?

We will start by looking at the history of the German Zoology Society to consider our own responsibility and will review our own history. With this public event, we want to look at biological, historical and genetic reasons for human »races« and to have an open discussion about these. This discussion will then conclude with the Jena Declaration—with the agreement and support of the expert society. Jena's zoology department and the University definitely stand behind the »Jena Declaration against Biological Racism«. ■

The latest publications on Ernst Haeckel and evolution

Roman Göbel, Gerhard Müller, Claudia Taszus (eds): Familienkorrespondenz August 1854 bis März 1857, Volume 2 from the series: »Ernst Haeckel: Ausgewählte Briefwechsel«, Stuttgart 2019, ISBN 978-3-515-11655-8

Uwe Hoßfeld: »Evolution«, published by the Thuringia Centre for Political Education, Erfurt 2019, ISBN 978-3-946939-56-6



Ulrich Kutschera, Georgy S. Levit, Uwe Hoßfeld: »Ernst Haeckel (1834 – 1919): The German Darwin and his impact on modern biology«, Theory in Biosciences (2019) 138: 1, DOI: 10.1007/s12064-019-00276-4

Elizabeth Watts, Uwe Hoßfeld, Georgy S. Levit: »Ecology and Evolution – Haeckel's Darwinian paradigm«, Trends in Ecology & Evolution (2019), DOI: 10.1016/j.tree.2019.04.003

How was Haeckel received abroad?

The natural scientist Haeckel undertook numerous research trips, which led him to Egypt, Greece and the Canary Islands, amongst other places. He also toured Europe as a lecturer, predominantly in the period when his scientific career was nearing its end. »When Ernst Haeckel was in Sweden in 1907, he received a rapturous applause from the audience,« says Prof. Dr Lennart Olsson, who teaches zoology in Jena. Haeckel was apparently well-known in Sweden; almost like a popstar. Books that later became global bestsellers such as »Die Welträtsel« (The Riddle of the Universe) from 1899 played a key part in this. Furthermore, Haeckel corresponded with leading Swedish scientists, like Sven Lovén and Gustaf Retzius. The explorer Sven Hedin was another correspondent of Haeckel. He wrote to him to tell that Germany may necessarily win the war. He was referring to the First World War. Lennart Olsson points to the fact that it was Ernst Haeckel rather than Charles Darwin who brought

Prof. Dr Lennart Olsson, professor of special zoology at the University Jena, has researched how Haeckel was received in his homeland of Sweden.

evolutionary theory to the Scandinavians. This is likely to be due to the strong cultural influence that Germany had on Scandinavia. »German was the first foreign language; if you wanted to go abroad to conduct research, you went to Leipzig, Berlin or Basel,« explains Olsson. Sweden's enthusiasm for Germany ended with the defeat of Germany in the Second World War. From that point onwards, Scandinavians looked towards the USA. sl

Where can you see Haeckel's art now?

Haeckel's depictions of nature—in particular the illustration panels from the »Kunstformen der Natur«—are not just limited to books, magazines and posters nowadays. The Haeckel designs can be found on practically all everyday objects that can be printed: mugs, T-shirts, bibs and sneakers. Haeckel's drawings and engravings had inspired other artists and creative types during Haeckel's own lifetime. The French painter and art nouveau architect René Binet, for example, designed the entrance gate for the Paris World Exhibition in 1900 based on Haeckel's drawing of a radiolarian (picture right). Examples of modern adaptations of Haeckel's art are provided by people including the Icelandic singer Björk, who used Haeckel's illustrations of marine animals as part of the stage design for her »Vespertine« world tour

at the beginning of the 2000s, and the English fashion designer Vivienne Westwood, who printed Haeckel images on jeans. The special exhibition »10 Tons – Medusae – Ernst Haeckel« in the Phyletisches Museum at the University Jena looks at where Haeckel's medusae feature in art and commerce in the present day (see p. 22 ff.). US

Mr Haeckel, in one word!

There has been plenty written and said about Ernst Haeckel. Not least in this edition of the LICHTGEDANKEN. Supposedly, he was a maverick and a visionary, a workaholic and an ingenious artist. But he was also a sloppy taxonomist, a dreamer who overestimated himself, and a racist. How would have Haeckel found his work and the past controversies over it today? We dialed the monist heaven and someone actually put us through to him! Our author grabbed a chance to talk to Ernst Haeckel.

INTERVIEW: TILL BAYER

Mr Haeckel, you have now been dead for 100 years. Does it rankle you that we talk about Darwinism today, yet »Haeckelism« has never come up?
Haeckelism? I must confess that would have pleased me and, when you consider my achievements, it would not be undeserved. Perhaps it was because of the word itself which—unlike the term »Darwinism«—the most could not get their tongue around it. As for Darwinism, it was understandable, that everyone was talking about it back then. Did you know that I met the peerless Darwin several times myself and that he was even an admirer of my research? My work did bear fruit, you see.

Being in your service of Darwinism, your contemporaries strongly attacked you. How did you deal with the hostility?
After Darwin's »On the Origin of Species« had been published, a veritable confrontation arose in the world of science. It was only natural that people were at each other's throats—there was so much at stake. I dished it out quite nicely myself. Once I wrote that the professors who had protested most against man's descent from apes were the least distant from them in terms of their brain development. That really hammered home!

You explained evolutionary theory in a way that everyone could understand. Why did you find it as crucial to educate the public about it?
Darwin's enlightening idea of evolution turned the human conception of the world upside down. Above all, he disproved the Christian story of creation in which I had mistakenly believed for a long time. Now there were suddenly arguments against the idea of humans leaping from Jupiter's head as armed Minervas or emerging from the Creator's hand as adult, innocent Adams. Instead, it turned out that they are part of an ancient, widely branched tree of life and had worked their way from a primitive state of animal rawness to the very first simple beginnings of culture rather slowly. What a great finding! I saw the need to convince all thinking persons of this and thus free them from the chains of ignorance and superstition.

You were not just a zoologist, but a philosopher, too. Are these disciplines not contradictory?
Quite the opposite! We recognized that the human beings formed just the latest branch on the vertebrate strain, with apes as their closest relatives. It was only a matter of time before further secrets of the great riddle of the universe were uncovered. I therefore assumed that mind and matter formed one single unit and that no creation could thus exist outside of nature. God did not disappear, God suddenly popped up everywhere. When three atoms of oxygen combine with one atom of sulphur to make sulphuric acid, these phenomena are as much a part of the direct impact of God as blossoms of plants, the movement of animals or human thoughts.

Being part of your posterity, we owe you a wide range of biological drawings. How do you face the accusations that these drawings were not always scientifically correct?
What a nerve! I suppose you are alluding to the pamphlet by Arnold Braß, a member of the nasty *Keplerbund*. This despicable sophist claimed that in my pictures I had depicted the ape embryos with human heads and vice versa. It was one of the most wretched pieces of libel that had ever been written about me! Please excuse my anger, but I have a fiery temper and I have been haunted by this matter even in the monist heaven. After the allegations, I initially followed the tried and tested tactics of Master Darwin, and just kept quiet. Later I had to admit that I had to adjust some of the drawings. But it was purely for didactic reasons!

You had been a professor of zoology in Jena for 44 years and always turned down offers from other universities. Why did you remain loyal to Jena?
Let's just say that I was rather settled in here to be able to move away from here while alive. During my journeys to three parts of the world and all European countries, I always longed to return there. I had the »Villa Medusa« built in Jena, started a family and met faithful companions. Well, I may have fallen out with some of them. My friendship with my colleague Carl Gegenbaur was of particular importance to me. He was the one who motivated me to start my academic career in that lovely university village. We used to go for walks across the beautiful Thuringia landscape, following the tracks of my intellectual hero—Goethe. And, last but not least, it is thanks to the University of Jena that I always remained loyal to that town. It always gave me freedom in my research, teaching and my thoughts.

All of the answers in this interview combine fiction with actual statements by Haeckel, which have been taken from the following sources: »absolute Ernst Haeckel« published in 2010 by Orange Press, edited by Uwe Hoßfeld; Ernst Haeckel Online Briefedition: haeckel-briefwechsel-projekt.uni-jena.de

The »Villa Medusa«

Ernst Haeckel's former home in an Italian country-house style was built in 1882/83—just when Haeckel was working on his monograph about medusae. Nowadays, the »Villa Medusa« is part of the Institute of Zoology and Evolutionary Science of the Friedrich Schiller University Jena. It is both a research institute and a museum, and is home to numerous original manuscripts, letters, drawings, paintings, photographs, and books formerly belonging to Haeckel. The researcher's study has been preserved in its original state. The »Villa Medusa« is currently undergoing extensive refurbishment and is due to re-open in the upcoming year. The LICHTGEDANKEN photogallery gives a first insight into the building and presents selected items from its archives.

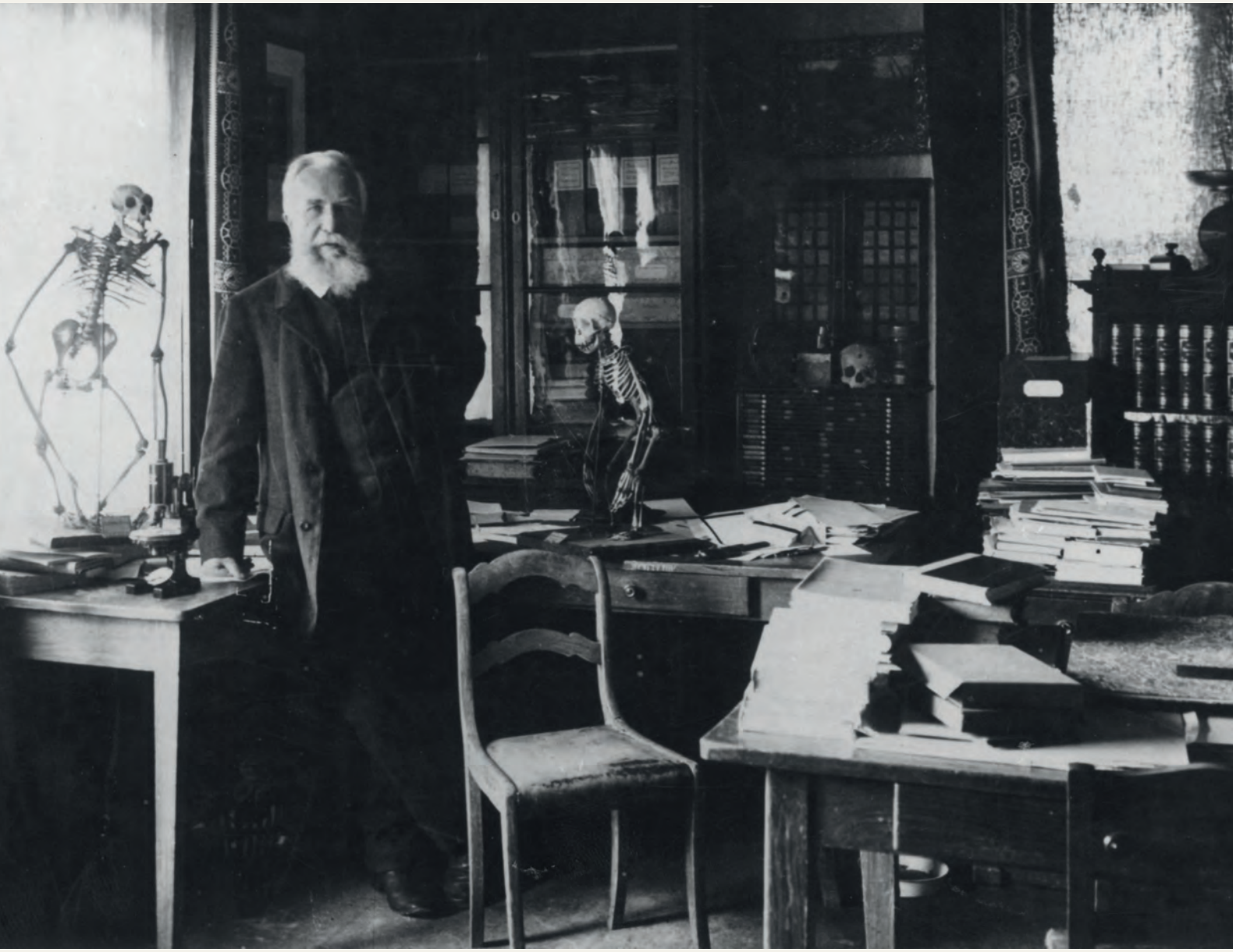
Top left image: Ernst Haeckel had the »Villa Medusa« (nowadays at Berggasse 7) built close to the new Zoology Institute. The location was not a coincidence. Back in 1810, Goethe, who was greatly esteemed by Haeckel, had made a sepia drawing of Schiller's summer house, which is located diagonally opposite, from this standpoint.

Bottom left image: Lianas from the Javanese rainforest and spines of a porcupine. Haeckel brought these trophies back from his second trip to the tropics to Ceylon, Singapore, Java, and Sumatra (August 1900 to April 1901).

Watercolour »Jena, von der Westseite«. Considering the fact that Haeckel painted over 1,000 landscape watercolours during his lifetime, there are only a few that feature his Thuringian home. In Haeckel's house, 49 works like this are stored.

Top image: View of Ernst Haeckel's study in its original state in the »Villa Medusa«. After his death in 1920, a Haeckel museum was established here. After extensive renovations, the room will be open to visitors from 2020 again.

Image right: Excerpt from a letter by Victor Weber to Ernst Haeckel from 6 July 1852: Ernst Haeckel (right) and Victor Weber wading through a »salty lake« during a botanical excursion on 27 June 1852. Both men are carrying a vasculum on their backs.



Top image: Ernst Haeckel in his office at the Zoology Institute in 1907.

Image left: Haeckel's laurel wreath from the 2nd Leipzig Gymnastics Festival in 1863, which he received for his six-metre long jump.

The watercolour »Jenzig bei Jena« from 1917 is one of Haeckel's later pieces. Following the death of his wife Agnes in 1915, he increasingly retreated to his »monastic cell« in the »Villa Medusa« to paint. Most of the paintings deal with the hills around Jena. He lovingly referred to the Jenzig Hill as »Jena's Matterhorn«.

The large black floppy hat was one of Ernst Haeckel's trademark looks. There are numerous photos of him wearing one of those hats. It was called the »creation hat« as a hatmaker in Austria and an enthusiastic admirer of the »story of creation« sent him one each year.

Haeckel's original lecture manuscript from 1862/63. Ernst Haeckel taught at the University of Jena from 1861. A year later, he became an associate professor in 1862. Even then he was an ardent supporter of Darwin's »Theory of Development«.

SOCIAL PSYCHOLOGY

Integration in Thuringia

Around 30,000 refugees currently live in Thuringia; most have come from Syria, Afghanistan and Iraq. An interdisciplinary research team of psychologists and sociologists has documented the refugees' willingness to integrate and their experiences of discrimination in the »Thüringen-Monitor Integration«.

BY AXEL BURCHARDT

Democracy is the best form of government for the vast majority of Germans and for the refugees who have fled to Germany. German nationals and refugees agree on a lot of other things too; but they do differ on some issues.

This has been proven—at least for Thuringia—in a recent study conducted by the Center for Research on Right-Wing Extremism, Civic Education and Social Integration (KomRex), which was published at the end of April and contained numerous facts, data and differentiated results. A total of 906 men and women over the age of 18 who had fled to Germany between 2013 and 2018 from various countries were surveyed between March and October 2018 about their attitudes and experiences concerning various areas of life that are connected with the integration process. Almost 80 percent of those surveyed were less than 40 years old. According to the study, which was compiled by Jena psychologist Prof. Dr Andreas Beelmann and his team, one of the objectives was to »create an empirical basis for political planning and decision-making processes in view of the integration of asylum seekers and refugees into German society«.

Only around 30,000 refugees live in Thuringia. Of these, the largest groups are from Syria, Afghanistan and Iraq—as such, it is a markedly heterogeneous group, as the Jena study shows with its various special analyses based on gender, age and education.

Fleeing due to fear of war, persecution and violence

Yet, despite the individual differences, the subjects of the survey displayed many fundamental similarities. The main reason for fleeing was fear of war, persecution and violence. This results in an increased likelihood of psychological stress. »This also underlines the lower levels of life satisfaction in comparison with the German population,«

Researchers at the Centre for Research on Right-Wing Extremism, Civic Education and Social Integration (KomRex) surveyed over 900 refugees in Thuringia on their experiences and attitudes concerning integration.

writes the KomRex team of researchers, which also publishes the annual »Thüringen Monitor«. And this is also a reason why—despite the difficult situation in their homeland—one in every two refugees suffers from homesickness. Refugees are highly trusting in institutions, such as the police and the Federal Government, and they support democratic values and principles. »The approval ratings are even higher than those of the German population in many cases,« the authors say.

Over half of those surveyed had experienced discrimination

The democratic orientation of most refugees is even more astounding given that many of them report having been discriminated against. This was stated by over half of those surveyed, particularly when looking for somewhere to live and a job. Furthermore, over ten percent reported physical attacks.
»This data is backed up by analyses from previous editions of the ›Thüringen-Monitor‹ in which a considerable number of xenophobic and anti-immigrant attitudes were identified. Apparently, they are also partly reflected in concrete anti-social and criminal behaviour,« write the scientists. On the other hand, the refugees have a very positive view of the German population, as two thirds of refugees living in Thuringia have formed close friendships with Germans. Despite this, they would like more and closer contact with the locals. In order to deepen this, a pronounced majority of the male and female refugees (96.3 percent) want to get involved in at least one area of civic activities. The willingness to become involved is at its greatest for social organisations and charities, as well as organisations working on protecting human rights.
Nine out of every tenth persons surveyed want to adopt aspects of German culture and the German way of life. Most also want to retain elements of their own culture, yet it is recognized that this is not welcomed by around half of the Thuringia population. Refugees appear to believe it very important to learn the German language: 90 percent are in favour of compulsory language courses. This is no doubt partly due to experiencing how hard it is to find a training role or job. Integration into the labour market is of pressing importance for the refugees surveyed. But only around 20 percent of those surveyed have succeeded—the higher the level of education and language skills, the more successful they are.

Refugee women face particular challenges

When it comes to questions of equality, around half of those surveyed displayed patriarchal attitudes differing from the societal norm of a liberal democracy. Against this background, refugee women are faced with particular challenges regarding integration. »Compared to men, they were less involved in civil society, participated less in language development and integration measures, visited advisory services less often and exhibited lower participation in the labour market,« identified the study.

In many respects, opportunities for successful integration are good

The KomRex study shows that integrating a large number of refugees into society is a challenging task and one requiring effort and a willingness to adapt from both the refugees and the receiving society. If, for humanitarian reasons, you are willing to help people in need and are interested in achieving successful and positive integration, you shouldn't leave it up to those—on both sides—who do not believe in the principles of a free, democratic constitution and humanitarian values. In this regard, the study offers hope: In many respects, the chances of successful integration for the people—at least the group that was surveyed—are good.
The study was funded by the Federal Chancellery of the Free State of Thuringia and the Saxony-Anhalt-Thuringia region office of the German Federal Employment Agency. ■

Original publication:
Thüringen Monitor Integration. Lebenslagen, Einstellungen und Perspektiven von Geflüchteten (2019)

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PREHISTORY

A big Ice Age hunt

A team from the University Jena and the Senckenberg Research Station of Quaternary Palaeontology in Weimar has conducted the first detailed comparisons of the mechanical properties of mammoth ivory from Siberian permafrost soil with ivory from present-day African elephants. Mammoth ivory was used during the Ice Age as a raw material for hunting weapons.

BY JUDITH JÖRDENS

In their study, the team has shown that mammoth ivory was ideally suited to producing tips for Ice Age weapons due to its extraordinary material properties—something that Palaeolithic big game hunters in Central Europe also utilized.

Tusks—status symbols and weapons

Spiralling tusks of various sizes are probably the most impressive and most visible characteristic of mammoths. Proboscidea, which became extinct with the end of the Ice Age mammoth steppe, used their tusks—which grew throughout their lives to lengths of up to 3.5 metres and could weigh over 100 kilograms—as status symbols and weapons, but also as a tool; to break open frozen watering holes, for example. Nicks and facets on the surface of the tusks of the Ice Age giants are evidence of forceful use; which often led to splits, although rarely led to them breaking altogether.
»There must have been special mechanical properties, which made it possible to form long tusks like that. After all, around two thirds of the tusk stuck out from the upper jaw and thus were directly subjected to the highly dynamic movement of the animals. We wanted to understand precisely how this worked,« explained Prof. Dr Ralf-Dietrich Kahlk from the Senckenberg Research Station of Quaternary Palaeontology in Weimar, talking about the interdisciplinary joint project.
Humans from the last Ice Age used mammoth ivory to produce tools and jewellery, as well as magnificent works of art—an example of the latter can be found in the recently named UNESCO World Heritage Site »Caves and Ice Age Art in the Swabian Jura«. »It occurred to us that, at different

Image left: Discs of ivory from mammoths (right) and from African elephants (left).
Image right: Projectile points made from mammoth ivory (long tip) and reindeer antlers from the Upper Palaeolithic cave site Garsitz-Bärenkeller (Thuringia).

times and in different parts of the world, even weapons, in particular perfectly made spearheads, have been made from mammoth tusks. We asked ourselves why Ice Age hunters used this raw material of all things. The material is not easy to work with and antlers, horns or bones from other Ice Age animals would have been far easier to get hold of,« explains Dr Sebastian Pfeifer, archaeologist at the Friedrich Schiller University Jena and initiator of the study. Pfeifer continues: »Together with the material scientists working with Prof. Dr Frank Müller at the University Jena, we have measured numerous structural and mechanical parameters for unweathered mammoth ivory and compared the data with measurements for ivory from African elephants.«

The perfect combination of rigidity and toughness

The result: the composition and mechanical properties of Ice Age mammoth ivory from the permafrost and ivory from African elephant tusks are almost identical. The exceptional ivory is distinguished by its perfect combination of rigidity and toughness. During the Ice Age cold spells, the ivory was the perfect raw material for producing hunting weapons, in particular for effective spearheads. Compared with other Ice Age materials, such as reindeer antlers, the shiny white mammoth ivory is also far more attractive-looking. »Perhaps the Ice Age wearers of ivory weapons were especially proud of their equipment. The material could also have become a status symbol for them,« speculate the researchers.

Original publication:
Mammoth ivory was the most suitable osseous raw material for the production of Late Pleistocene big game projectile points. Scientific Reports (2019), DOI: 10.1038/s41598-019-38779-1

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ZOOLOGY

Salamanders do chew!

A team of researchers from the Universities of Jena and Massachusetts have discovered chewing behaviour in salamanders, which is presumably primordial. Thus, they disproved the previous theory that salamanders swallow their prey without chewing.

BY STEPHAN LAUDIEN

Triturus carnifex eats anything and everything it can overpower. Eearthworms, mosquito larvae, and water fleas are on its menu, as well as snails, small fish, and even its own offspring. *Triturus carnifex*—or the Italian crested newt—is an amphibian of the order Caudata and is a true salamander. A research team led by Dr Egon Heiss from the Jena Institute of Zoology and Evolutionary Science has studied the chewing behaviour of the newt and has made an astounding discovery.

»According to the textbooks, amphibians swallow their prey whole, but we have been able to refute this,« says Dr Heiss. Together with his doctoral student Daniel Schwarz and Dr Nicolai Konow from the University of Massachusetts, Heiss has succeeded in proving that the crested newts actually chew their prey, but in a way that is different from that of most other land-based vertebrates.

Palatal teeth kill the prey

»These salamanders use their so-called palatal teeth to kill their prey and to break it up,« says Heiss. This means that the jaw teeth are mainly used to catch or hold the prey. With the help of the tongue, the prey is then rubbed rhythmically against the palate. The palate is equipped with very sharp teeth, around 0.5 to one millimetre long, which are constantly replaced by new teeth. These teeth can, for example, tear open the extremely tough cuticula of fly maggots. »This kills the prey and, at the same time, helps the digestive secretions to take effect,« says Dr Heiss. For the newt, this is also a form of life insurance: some insect larvae have such a strong bite that they would be able to bore through the predator's body. The first impetus for the surprising research result came on a research visit to Antwerp, when Nicolai Konow and Egon Heiss observed a newt feeding. The biologists were intrigued by the amphibian's head, jaw and tongue movements after it had seized its prey. »The newt

actually appeared to be chewing,« says Heiss. The researchers were able to obtain a clear idea of what was happening with the help of the X-ray video unit at the Institute of Zoology and Evolutionary Research.

Salamanders chew like primeval land-based vertebrates

The newt's chewing behaviour prompts the question of how it can be explained in the context of evolution. »We can assume that real palatal teeth were present in early land vertebrates, and we suspect that the ›tongue against palate‹ chewing mechanism, as seen in newts, is something that goes back to the early days of land-based vertebrates,« says Heiss. Very similar chewing mechanisms can indeed be found in ancient mammals, such as the echidna and the duck-billed platypus, but also in the manatee. Although in these animals the palatal teeth have been replaced by rough keratin structures, the creatures still rub their food against the palate.

The tongue originated when vertebrates came onto land

From the point of view of evolution, the move from water to land brought about change in animals' chewing apparatus. A key role is played by the tongue, which only developed after vertebrates left the water. It is crucial for enabling chewing, as it moves food to the right place in the mouth. »With fish, the water current helps to do this,« explains Egon Heiss. A similar change occurs in amphibian larvae; during metamorphosis, the gills of amphibians transform into a tongue when the larvae leave the water. These new findings are the first results from the research project »Form, Function and Evolution of Food Manipulation in Urodela,« which is being funded by the German Research Foundation. The project runs until the end of 2019 and maybe during that time, *Triturus carnifex* will be persuaded to reveal more secrets. ■

Dr Egon Heiss and doctoral student Daniel Schwarz (left) place a specimen of the Italian crested newt *Triturus carnifex* in the high-speed X-ray unit to analyse its chewing movements.

Original publikation:
Chewing or not? Intraoral food processing in a salamandrid newt.
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SPORTS PSYCHOLOGY

Loud Grunting when playing tennis is not unfair

The former number one female tennis player Martina Navratilova always used to make the complaint: it is unfair when opponents make loud grunting noises as they hit the ball. In a recent study, sports scientists have actually come to a different conclusion. According to their analysis, the flight of the tennis ball can be accurately anticipated, even with background noise.

BY TILL BAYER

Exceeding noise levels of 100 decibels, the grunting sounds produced by some tennis players when hitting the ball are on a par with motorbikes or chainsaws. While fans react to these impressive exhalations with either annoyance or amusement, the habit has also been a source of intense debate among professionals.

For instance, Serena Williams has said that she is not bothered by opponents grunting in the heat of the competition. In contrast, former world number one Martina Navratilova has complained that grunting masks the sound of the racket striking the ball, making it—unfairly—harder to predict the ball's trajectory. The question of whether this common complaint is justified has now been examined in a new study by a team of sport psychologists from Friedrich Schiller University Jena, led by Dr Florian Müller and Prof. Rouwen Cañal-Bruland.

Experiment with manipulated grunting noises

For this study, the research team conducted a series of experiments in which experienced players were shown video clips of rallies from a professional tennis match. After observing players hitting the ball, they had to work out the ball's trajectory and indicate where it would land. Largely unnoticed by participants, though, the intensity of the grunting noises was manipulated. Results indicate that grunting does have an effect—but not the one claimed by Navratilova.

Grunting biases anticipation of ball flight

There was no evidence that grunting caused a distraction effect. In spite of the supposed irritation, participants' level of error in predicting where the

In tennis, grunting noises influence the prediction of the ball's trajectory.

ball would land was the same—regardless of the intensity of the grunts. Instead, it was shown that the louder the grunting, the further the participants assumed the ball would fly. This reaction was observed even when the noises could only be heard after the racket had made contact with the ball, as is usual in many professional matches. »We assume that players account for the physiological benefits provided by grunting,« explains Müller. Other researchers have demonstrated that forcefully exhaling air activates the abdominal muscles, providing additional strength that enables players to hit harder, making the ball fly faster. »This possibly explains why an effect can be observed as a result of the grunting, but the ability to anticipate the ball's trajectory remains unaffected.«

Perception in sport as the interplay of multiple sensory impressions

According to Müller and his colleagues, the results of the study suggest that Navratilova's claim needs to be reconsidered. For the sport psychologists, it is also evidence that sensory impressions other than sight are of importance in sport as well, and that scientists should look at these more closely in future. For this reason, too, they want to stay »on the ball« and investigate the phenomenon further. To get closer to real-world conditions, in the next step participants will have to catch a tennis ball on the touchscreen in real time. Ultimately, the experiment could even be conducted during a real match on a tennis court—as long as no one nearby is disturbed by excessively loud grunting. ■

Original publication:
The sound of speed: How grunting affects opponents' anticipation in tennis.
PLoS ONE (2019),
DOI: 10.1371/journal.pone.0214819

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Fungus paralyses the immune system

The fungus *Aspergillus fumigatus* is found in practically all habitats on earth. An international team of researchers led by Prof. Dr Oliver Werz from the Institute of Pharmacy has now discovered how the mycotoxin »gliotoxin« overcomes immune responses and can thus trigger life-threatening invasive fungal infections (DOI: 10.1016/j.chembiol.2019.01.001).

Order in nature's construction set

The periodic table is celebrating its 150th anniversary. In 1869, the chemists Dmitri Mendeleev and Lothar Meyer, independently of each another, ordered the chemical elements systematically by atomic mass and properties. In order to make this fundamental discovery, the two scientists lent on the equally significant preliminary work done by Johann Wolfgang Döbereiner from Jena. Years before, he had realized that elements might be ordered into groups based on their chemical properties.

BY STEPHAN LAUDIEN

The periodic table of elements remains an essential tool for every chemist to this day. It is found in almost every chemistry classroom and textbook. Even the United Nations took the opportunity to mark the anniversary by naming 2019 the »International Year of the Periodic Table of Chemical Elements«.

Long before the periodic table provided order and an insight into the elementary framework of nature, alchemists from the Middle Ages had sought to find ways to produce gold or to find the mysterious philosophers' stone. This stone was said to be able to turn base metals into precious ones—to find it would have been like hitting the jackpot. Later, Goethe's quote »to explain what the world contains in its innermost heart« described the craft of chemists well. A decisive contribution towards this was made by Johann Wolfgang Döbereiner (1780–1849), who taught at the University of Jena from 1810 as an associate professor of chemistry, pharmacy, and technology. He investigated the chemical properties of stones and ordered the elements known at this time into three groups based on similarities—the so-called »triads«: The alkali metals lithium, sodium, and potassium, for instance, formed one triad whereas the halogens chlorine, bromine, and iodine another.

Döbereiner also noticed that the atomic mass of the second element in a triad was equivalent to the average atomic mass of the first and third elements. With his »Versuch zur Gruppierung der elementaren Stoffe nach ihrer Analogie« (attempt to group the elementary materials by their analogy), which was published in 1862, he created an important foundation for the periodic table proposed in 1869. Initially by the Russian Dmitri Mendeleev (1834–1907), who taught and conducted research as a chemist in St Petersburg, and a little later by Lothar Meyer (1830–1895), a German doctor and chemist. All of the elements, from the first element hydrogen (atomic number 1) to the latest currently known oganesson (atomic number 118), had been discovered or created as well as described by 2016. Discovering itself appeared to be as fascinating as the gaps in the table made it possible to postulate about the missing elements. The final elements in the periodic table were synthetically produced and disintegrated in fractions of a second. All of the elements—coloured in for clarity—show the »building blocks of nature«. They depict a system that appears almost unreal in the light of the chaotic world in which we live.

Prof. Dr Philipp Adelhelm (left) and the Indian visiting scientist Dr Palaniselvam Thangavelu putting the new coating plant into operation.

Stopping the ageing of batteries

Jena chemists are participating in the »TRANSITION« research project on new energy storage systems. The environmentally friendly sodium-ion batteries are to be used in e-mobility and stationery energy storage in the future.

The next generation of sodium-ion batteries are to be environmentally friendly, cost-effective and powerful—to stand as an alternative to lithium-ion batteries. Researchers are developing suitable active materials and electrolytes as part of the project funded with 1.15 million euros by the German Federal Ministry of Education and Research. The project involves the Helmholtz Institute in Ulm, which was founded by the Karlsruhe Institute of Technology, the Center for Solar Energy and Hydrogen Research Baden-Württemberg, and Friedrich Schiller University Jena.

The Jena team led by Prof. Dr Philipp Adelhelm coordinates the research activities concerning the development of progressive electrolytes and deals with the ageing of batteries. »It is often not an easy task to understand why batteries do age at all. Various mechanisms play a role across different time scales. Based on the on-site gas analysis, we want to understand the ageing of the materials and cells that are being developed in the project better and to improve their lifespan using suitable measures,« explains Prof. Adelhelm.

To achieve this, the chemists use, for example, a new thin-film plant to cover electrode materials with protective layers. AB

Coordinating battery research

The German Research Foundation has set up the Priority Programme »Polymer-Based Batteries« (SPP 2248) funded with more than twelve million euros. The programme is coordinated by the Jena-based chemist and material scientist Prof. Dr Ulrich S. Schubert.

Besides the University of Jena, universities in Bochum, Dresden, Freiburg, and Karlsruhe participate in the coordination team. Over the next six years, the Priority Programme will merge the activities conducted across Germany and promote research into new organic or polymer materials for storing energy. »This will allow to pool German expertise in the field of polymer-based, printable, metal-free batteries in order to develop energy storage devices for new applications in healthcare, sensor technology, and the Internet of Things,« states the coordinator Prof. Schubert.

The Priority Programme covers various topic areas. Besides modelling with the aim of identifying promising materials, it also concerns the basic understanding of redox processes and possible side reactions. In addition, the team will conduct the research into the design and synthesis of redox-active polymers and develop new electrolytes. Furthermore, the processes taking place within the composites are to be explained through detailed characterization. Schubert is optimistic that decisive innovations can be created within this field as a result of the new programme. AB

Battery test in a laboratory at the Center for Energy and Environmental Chemistry Jena (CEEC).

Converting coal into electricity has no future.

Farewell to fossil energy

A new research group focusing on the bioeconomy as a social change to be funded with three million euros.

The days are numbered for using fossil fuels to produce energy and as raw materials for industry because these resources are finite. As a result, Germany and most other industrial nations are looking to renewable raw materials. Sociologists of a junior research group at the Friedrich Schiller University Jena are investigating the social changes that may accompany this turning point. The German Federal Ministry of Education and Research will be funding the seven scientists with around three million euros over the next five years as part of the programme concentrating on the bioeconomy as a social change. »We are assuming that linear growth expectations must change within a society which is shaped by the bioeconomy,« says the head of the junior researcher group, Dr Dennis Eversberg. He believes the society needs to stop focusing on permanent growth and develop alternative prospects instead. »It is a big challenge for the modern society which has always defined progress as creating more and better,« says Eversberg. The Jena-based researchers want to conduct case studies in various regions of Europe in which a conversion to the bioeconomy has already taken place, for example, the so-called bioenergy villages in Germany or the timber industry in Finland. sh

Welbedacht dam on the Caledon River, on the border of South Africa and Lesotho.

Soil erosion in South Africa

The joint project granted 2.3 million euros »South African Land Degradation Monitor« (SALDi) is coordinated by the University of Jena.

Geographers from the Friedrich Schiller University Jena are coordinating the project which is investigating the soil conditions and changes to landscapes in South Africa. The aim is to establish an automated monitoring system which can be used to identify loss of land precisely, for example that caused by soil erosion in South Africa over the long term. The German Federal Ministry of Education and Research will be funding the project over the next three years. Apart from the University Jena, the project involves the universities of Augsburg and Tübingen, the German Aerospace Centre as well as several partners in South Africa. Based on this project funding, Jena's Professorship of Physical Geography and the Professorship of Earth Observation received three new positions for young researchers.

The term »degradation« describes a worsening soil productivity, the decline in protective vegetation, and the destruction of entire landscapes as a result of erosion. Consequently, land that could be used for farming and forestry disappears and upsets the balance of the ecosystem.

»It is rather important and a political imperative to analyse land degradation based on standardized, scientific data, particularly in a country like South Africa with a moderate to tropical climate and in which an increasing population and annual climate fluctuations play a key role,« says project coordinator Dr Jussi Baade. ch

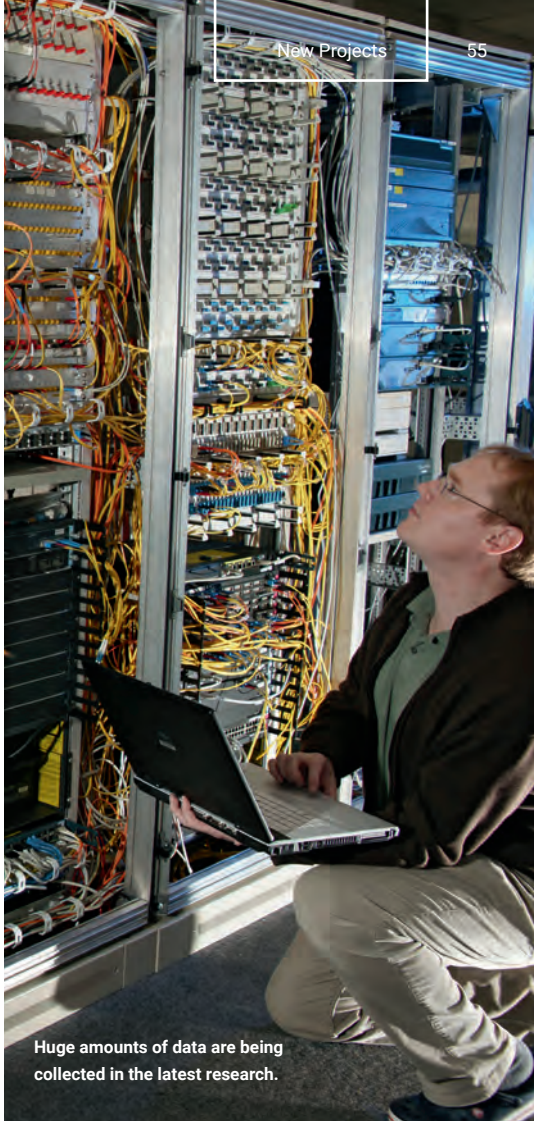
Paths into a digital future

Free State of Thuringia is to fund a project on digitalization of life sciences with 1.3 million euros.

Pneumonia is still considered a dangerous condition. The interdisciplinary research project »DigLeben« aims at identifying yet unknown parthogens in pneumonia patients using machine-learning methods. Funded by the new state funding scheme »ProDigital«, the project is due to start in 2020 and is about to run for five years. Researchers from four faculties of the University will cooperate with its colleagues from the University Hospital and their partners from external institutions.

The objective of the initiative is to prove that the immense amounts of data created in research can be increasingly processed using machine learning and artificial intelligence. »In the project, the innovative applications in biology and medicine for these methods should represent examples for the future and thus stand for milestones in the digitalization within the life sciences,« says professor of bioinformatics Prof. Dr Manja Marz, the spokesperson for the new research network.

The project is divided into seven subprojects. Five of these work on various biomedical questions. In two projects, reseachers will develop methods of machine learning that can be used in other projects. AB



Huge amounts of data are being collected in the latest research.

Crises in Latin America

The main phase of »Merian-CALAS« project has begun. 1.2 million euros financial support to boost the cooperation with Latin America.

How do Latin American societies resolve crises? Researchers from Germany and Latin America are working together to look into this question. The Federal Ministry of Research and Education contributed twelve million euros for the six-year main phase of the large joint project »Maria Sibylla Merian Center for Advanced Latin American Studies in the Humanities and Social Sciences« (Merian-CALAS). The University of Jena, which received 1.2 million euros, is involved alongside the universities of Bielefeld, Hanover and Kassel. By establishing the »Center of Advanced Latin American Studies« at the University of Guadalajara (Mexico) over the last two years, the Jena-based researchers and their partners have already created a platform for the work that is to follow. Parallel to the beginning of the main phase, also the regional centres in San José (Costa Rica), Quito (Ecuador), and Buenos Aires (Argentina) started with their activities.

The Merian-CALAS project is based around centrepieces known as »Laboratories of Knowledge« which have been established at the regional centres and are dedicated to one of the project topics: peace, inequality, environment, or identity. Apart from the Laboratories, the topics are also being studied in Germany and Latin America. A transatlantic tandem from each of the German universities and one of the Latin American partners will manage each of these subprojects. sh

The joint project »Merian-Calas« focuses on Latin America.

New »Jena Postdoc Study«

Led by Dr Hanna Kauhaus, the Graduate Academy of the University (photo) shed light on the career situation and paths, and qualification conditions of postdocs in Jena. Over 400 researchers were surveyed for the second »Jena Postdoc Study« (www.jga.uni-jena.de/jgamedia/-p-3589).
The study shows that most postdocs are satisfied with the working conditions, but are more critical of their own career prospects. Above all, they consider their chances of achieving a professorial position to be low. According to the authors, the study shows that the need for job security for postdocs has grown in recent years. US

From fossil to robot and back again

An international research team from Humboldt University Berlin, the Friedrich Schiller University Jena, and the École Polytechnique Fédérale Lausanne has studied the movement of an early land-based vertebrate. The team working with Prof. Dr John Nyakatura used the fossil of the *Orobates pabsti*—a one-metre-long prehistoric lizard—to design and build a biomimetic robot (photo)—the OroBOT—to provide new insights into the biology of the ancient fossil (DOI: 10.1038/s41586-018-0851-2). The early tetrapod *Orobates* was found in 1998 in the Bromacker area near Tambach-Dietharz, Thuringia. It is a well-preserved skeleton dating back almost 300 million years and is now on display in the Castle Museum in Gotha. US

Test system for medicines

Painkillers and antipyretic drugs, for example, ibuprofen and aspirin, are the most commonly prescribed medications across the globe. Nonetheless, the basic mechanisms of these medicines are not yet fully understood. Pharmacists at the Friedrich Schiller University Jena have developed a cell model which can be used to investigate these mechanisms in detail. According to the study of the researchers working with Dr Jana Gerstmeier and Markus Werner (photo), they have succeeded in explaining the complex effect of anti-inflammatory agents on the formation of the body's own signalling substances in immune cells during an inflammatory reaction (DOI: 10.1096/fj.201802509R). As the study leader Gerstmeier says, this will enable to develop specific new active substances with reduced side-effects in the future. US

Green meadow in Antarctica

Jena-based ecologists have returned from the Antarctic with extensive data from a long-term study. Over the last four decades, the scientists working with Dr Hans-Ulrich Peter have observed significant changes in flora and fauna caused by the climate change. The new data is cause for alarm: King George Island has been turning greener each year (photo).
As a result of the retreat of glaciers and longer periods without ice, the local grass species *Deschampsia antarctica* has been spreading over areas rapidly. In addition to the changes in the Antarctic's vegetation, the researchers mainly collected data about sea birds and seals. Their latest results prove that it is not just grasses and other plants that are occupying the space left by the glaciers, but skuas, gulls, and terns, too. US

Molecules for quantum computer

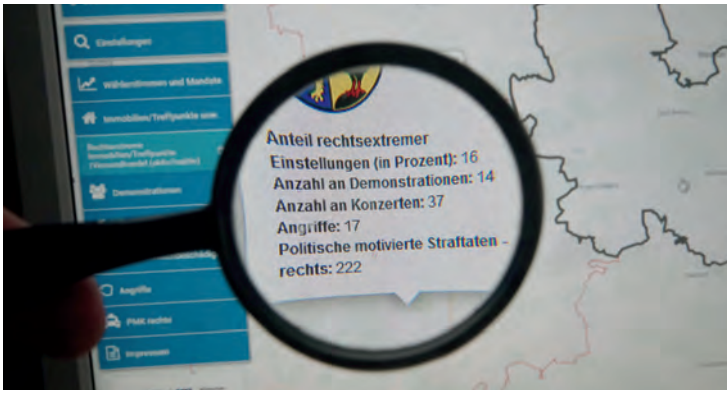
Jena-based chemists working with Prof. Dr Winfried Plass and Benjamin Kritzel (photo) have succeeded in synthesizing a molecule that might be able to take over the functionality of a computing unit in a quantum computer—a qubit (DOI: 10.1039/c8cc06741d). This is a coordination compound which contains organic and metal components. The organic material forms a framework in which the metal ions—in this case copper—are arranged in the shape of a perfect equilateral triangle. The electron spin of the three copper cores interact to such a degree that the molecule achieves a spin state turning it into a qubit that can be addressed from the outside. sh

Adapter protein is dispensable

Using a model of the cell migration of interneurones, pharmacologists from Jena University Hospital were able to show that this prenatal cell migration process, which is controlled by specific receptor molecules, remains almost unchanged even when Arrestin beta 1 cannot be formed (DOI: 10.1016/j.celrep.2019.01.049). Hitherto, it was believed that the adapter protein beta-arrestin was vital for the functioning of the so-called G-protein-coupled receptors (GPCRs) in the cell membranes. In their study, the researchers have now disproved this assumption. According to the team working with Prof. Dr Ralf Stumm and Friederike Saaber (photo), it is far more decisive that there is neither too little nor too much of the messenger substance that controls the migration process. vdG

Skype no replacement for proximity

The closer one's friends, the stronger one's regional identity—this is one way of summing up the results of the study carried out by psychologists from the Friedrich Schiller University Jena (DOI: 10.1037/dev0000677). According to this study, life satisfaction increases when people can identify with the region in which they live. In order to establish this connection, it is essential to be close to related persons. Skyping with family members who live far away does not replace the link; says the head of the study, Dr Elisabeth Borschel. In other words, even in the age of modern means of communication, relationships cannot be maintained outside of time and space. There is also a correlation between the forming of a regional identity and establishing one's own social environment. Those who identify with their surroundings find it easier to establish a social network, too. sh



Map of right-wing extremism

Since 2017, social scientists at the Friedrich Schiller University Jena have been collating data on right-wing extremism and group-focused enmity in Thuringia. The team working with Dr Axel Salheiser has now used this data to create an interactive map, which has been published online (www.komrex.uni-jena.de/topografie). This map can be used to trace right-wing extremist activities and their distribution across the 23 districts and district-free cities in Thuringia between 2014 and 2017. It includes concerts, demonstrations and xenophobic attacks. Furthermore, the researchers disclose buildings from the right-wing extremist scene. Data concerning right-wing extremist or ethnocentric attitudes within the population of the respective region has also been incorporated. This information has been sourced from the »Thüringen-Monitor«, which is carried out on a regular basis. sh

Dr Romi Zäske as a solo artist (left image) and with the Psycho-Chor (centre image) during a performance at the UN Headquarters in New York in 2018. Image right: Zäske with a research participant in the laboratory. She is using an EEG to test how voices are processed by the brain.

»The Voice«

Romi Zäske is a psychologist. Romi Zäske is a singer. The human voice is both the subject of her research and her artistic medium. The portrait of an ambitious scientist, who combines profession and hobby in a harmonic way.

BY UTE SCHÖNFELDER

The Psycho-Chor with »Quiet« on YouTube

New York City, Midtown Manhattan, March 2018: a group of nine young women stands in the foyer in front of the conference room of the UN headquarters and sings. »I can't keep quiet, no oh oh oh oh oh oh.« Groups of visitors, members of staff, security personnel all pass through the lobby; some linger, swing in time, pull out their smartphones. »I can't keep quiet, for anyone, anymore«. The singers are performing an a cappella version of a calm, yet powerful song by the American singer MILCK. One year ago, it had been the hymn of the protest movement, which led hundreds of thousands of women wearing pink-coloured knitted headwear onto the streets of Washington to march against US President Donald Trump. The nine singers are members of the Jena-based Psycho-Chor. They are not wearing »pussy hats«; instead they simply wear red-orange flowers on their black outfits. Romi Zäske stands a step in front of the others and sings the solo parts. »Let it out, let it out, let it out now. There'll be someone who understands.«

How we identify and recognize voices

Anyone who hears Zäske singing on this cold spring day in New York—whether live or via a Facebook video—will know what a powerful means of expression the human voice can be. And not just when it is used as artistically as by the singers from the Psycho-Chor. Age, gender, mood—the voice tells us all about it. Even about a person's attractiveness one is able to form an opinion based on their voice, regardless of what they say or sing.

Romi Zäske is well aware of this; and not just because she is an experienced singer. The 37-year-old has a PhD in psychology and is conducting research at the Friedrich Schiller University Jena to figure out what the voice reveals about our vis-à-vis. »Besides visual perception, the voice is the most important source of information about another person,« she says. »Everyone uses it; although most are unaware of doing so.« It is largely the mood of a person that is revealed by their voice: joy, anger, rage or sadness are displayed through the pitch, speaking rate and intensity.

Romi Zäske is interested in the neuronal coding processes when learning and recognizing voices. In her research team at the Institute of Psychology, she uses electroencephalography (EEG), among other methods, to examine these processes. »We are investigating how and by which structures the brain perceives and memorizes voices,« she explains. »The first time we hear a voice, the EEG data look different than when we already know the voice.«

The fact that the passionate singer would also work researching the human voice was neither planned nor expected in the beginning. »It all happily fell into place by chance,« she says, smiling. Despite this, Romi Zäske's career is not the result of fate. Instead, it is the result of a lot of hard work and persistence since the moment back in 2005 when she stumbled across her lifelong subject.

She was an ERASMUS student at Glasgow Caledonian University when she noticed an ad for a job as a student research assistant. She applied and got the job—working in the laboratory of Stefan Schweinberger, who taught at Glasgow University. During this role, she learnt how to use the EEG, helped

to carry out studies about social perception, read all about the topic, and had a light-bulb moment.
After her year in Glasgow, she returned to Leipzig to complete her psychology degree. In the meantime, Schweinberger was appointed to the professorship for General Psychology in Jena, and Zäske also moved to the Friedrich Schiller University to complete her diploma thesis. She had already chosen voice perception as her topic.
Subsequently, she obtained her doctorate, entered university teaching, spent time abroad, acquired third-party funding and published in scientific journals, as well as set up her own small research group. »The classic academic career,« summarizes Romi Zäske. She wants to finish her »Habilitation«, the highest academic degree in Germany over the next year. And afterwards? Romi Zäske is hesitating slightly, before answering that question. »I certainly want to stay in science.« Whether and how this will work in the long term, however, is anything but predictable. Even if she will continue to this path, she will need to »think in all possible directions,« Zäske says, describing her life plan. Up to now she has not had a real »Plan B« as an alternative to a research career.

Jena offers the perfect environment—both professionally and privately

One thing is clear; if she ever had to leave Jena for professional reasons, it would be a very difficult decision. If she had to choose between Leipzig and Jena again, she would take the same decision. »As a classic university town, Jena is my perfect habitat,« she says with certainty. Short distances, close networks, a relaxed flair—these are all important criteria for quality of life in her opinion. This environment also accommodates her attitude to life—namely not to live her professional and private life side by side, but as two sides of the same coin. Colleagues from the University sing together with her in the Psycho-Chor; many research partners are also friends. »At the moment it feels great living in Jena.« By contrast, she could not imagine having a professional singing career. Singing is her private passion. »That's the nice thing about the fact that I do it without obligation, just for fun.«
Unlike in her scientific career, which she pursues with reflection and focus, she has a more intuitive approach to singing. She never trained as a singer; just like walking or riding a bike, she learnt to sing as a little girl in the village near Köthen in Saxony-Anhalt in which she grew up. Whenever a radio was running somewhere and playing the pop hits of the 1970s and 80s there was no stopping her. She recorded songs on cassettes and just started singing: songs by Abba, the Beatles, Roxette.
She was never shy about performing in front of an audience. Quite the opposite, in fact: »As a child, I often used to sing in front of my friends and family.« Her parents encouraged her talent, »although we were not a very musical family.« Later, Romi Zäske had keyboard lessons and learnt to read music, »which helps me to work with music today.«
She has been doing this for more than five years in the Psycho-Chor. Since summer semester 2014, she has been singing in the 70-person choir and is one of its most experienced members. »In the beginning, I didn't think that a choir was for me«, she says now. Actually, she had imagined herself on stage as the lead singer of a band. »But that has never happened.« Now, she is a convinced choir singer; which is not least due to the conductor, Maximilian Lörzer. »He always knows how to motivate me and all the others with his own enthusiasm—it is just great fun.« The demand for musical talent in the choir is high; Romi Zäske says that over the years she has grown both musically and in her personality. She now frequently sings solo parts, as happened last year in New York. »It was an amazing experience.« She hopes to sing a solo from »Kiss from a Rose« by Seal with the choir soon. »I would really like to perform that in front of an audience.«
About eight to ten concerts a year she performs with the Psycho-Chor. Then there are two to three solo performances, like with the University's summer festival in 2017. Unfortunately, she does not have time for more. After all, Romi Zäske's main job is in research—and she wants it to stay that way. ■

To America with a sword

The day-to-day life of students is shaped by lectures, seminars and training periods. It is important to collect credit points in order to embark on an academic career or find a good position in business with the best possible degree. It is no different in Jena than it is at other universities. Yet, the creative environment at the University sometimes sparks unusual ideas, which are not included in any curriculum: here, we introduce some students who have forged their own sword and taken it into »tournament«.

BY TILL BAYER

It all began back in November 2017. Materials science students Michéle Scholl and Maximilian Keller were wondering how they could apply their theoretical knowledge about metallic materials in practice. Then they had an idea: they wanted to forge their own sword.
Their idea was well-received both by their fellow students and by the lecturers at the Otto Schott Institute of Materials Research. Soon, there were lectures and workshops in which the participants acquired knowledge about swords and the blacksmith craft. Staff members from the Institute's technical department also supported the students with their expertise and ingenuity. Michéle Scholl and her fellow campaigners sketched designs for the sword blade and looked for sponsors to provide the forging coal and a thermal imaging camera.

Both brain power and muscles required

And then it began: they started forging. In addition to brain power, it was muscular strength that was now required. In May 2018, six members of the team travelled to Mellenbach in Thuringia for a weekend, where they found a remote traditional forge. »In theory, we could have done the forging in the backyard of our Institute, but after half an hour or so there would have been complaints about the noise,« says Scholl, smiling. So, instead, they swung the forge hammer all day in Mellenbach.
The initially round metal rod was firstly treated with massive sledgehammers. Then, after removing it from the fire, the team smoothed and levelled the glowing piece of steel to create a flat, straight shape. The next stages were also carried out manually, including grinding the tinder that the forge fire leaves on the material and »normalizing«, in which the tension in the metal is released by slow heating and cooling. The team had to check carefully whether cracks were forming. This can happen if the blaze is not at the right temperature. Finally, after the last two steps of hardening and grinding, they held the finished blade in their hands.
The finishing product looks brilliant, literally. The sword is around 75 centimetres long, weighs just under three kilograms and has been christened with the name »Hugin«. The matt-shimmering, silver-coloured steel looks flawless to the naked eye. And this impression has been confirmed by tests. The team subjected »Hugin« to various different test procedures, using X-rays, ultrasonic and Eddy-current testing. These methods identify even the smallest hairline cracks or inclusions in the metal. The tests also included the so-called destructive measures, in which the blade is bent and stretched until it breaks. Needless to say, the students didn't use the real »Hugin« for this; instead they used a twin sword that they had made at the same time.
During the forging preparations there were already considerations to take part in a worldwide competition. When Scholl met a representative of the »The Minerals, Metals & Materials Society« (TMS) at a materials science conference, who suggested that she competed in the next international competition run by the organisation, »she didn't need any special persuasive skills.«
So, the team came together again to put the final touches to »Hugin«. A pommel was made for the sword handle. It was designed in the shape of a raven head; inspired by the name of the sword—a raven from Nordic mythology. In March 2019, Michéle Scholl and »Hugin« embarked on their journey. The »TMS Bladesmithing Competition« was held in San Antonio in the US state of Texas.
But how do you transport a sword to the USA? You obviously can't just pack it in your hand luggage. In order to avoid being considered a dangerous weapon, »Hugin's« blade had to be blunted. The sword was wrapped in a fishing bag and covered in a protective layer of foam and polystyrene. With her bag, Scholl naturally attracted the attention of the police as she landed at the airport. But she didn't face any trouble. The officers were impressed and called their colleagues over to look at the unusual piece of luggage.
Unfortunately, »Hugin« came home from the competition empty handed. Nevertheless, Michéle Scholl draws a positive balance. »We are proud that we got so far.« She enjoyed the competition so much that in two years she would like to compete again with a new sword. ■

In Nordic mythology, the raven »Hugin« flies around the world each day to whisper the latest news into the ear of Odin, the father of the gods. »Hugin« is also the name of the sword that a group of Jena materials science students forged. Just like its mythical eponym, the sword also travelled around the world to enter the »TMS Bladesmithing Competition«.

Climate change: talking is not enough—act now!

Scientists at Jena are getting involved in the »Scientists for Future« movement. Physician Prof. Dr Ekkehard Schleußner is one of the organizers. He writes about his motivations here.

COMMENTARY BY EKKEHARD SCHLEUSSNER

School demonstration on 12 April in Jena. The protesting young people are getting more and more support from the world of science.

School pupils from across the world have been taking to the streets every Friday for months to demonstrate for immediate and lasting measures against global warming. The movement, known as »Fridays for Future«, was started by Greta Thunberg in Stockholm and has since inspired many people to take personal action to ensure that the scientific facts are acknowledged and finally acted upon. Yet, the reaction from many in the media and politicians was more a discussion of whether the »truants« should be punished, rather than a serious discussion of their demands.

The »Scientists for Future« is a step against this. In February, experienced scientists from the field of biodiversity and transformation research drafted a statement that was signed by more than 700 researchers. By the time the petition had ended in March, it had been signed by 26,800 German-speaking scientists. The core message is as follows: »As scientists and scholars, and based on robust scientific evidence, we declare:

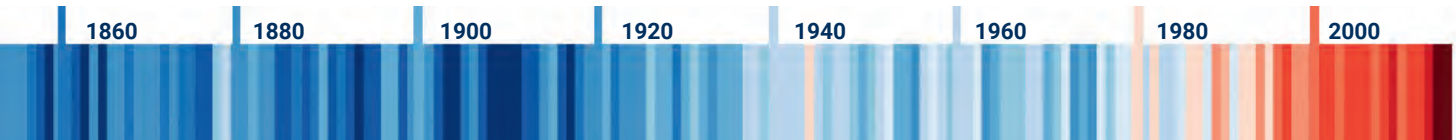
These concerns of ›Fridays for Future‹ are justified and supported by the best available science.

The current measures for protecting the climate, biodiversity, and forest, marine, and soil resources, are far from sufficient. The enormous mobilization of the ›Fridays for Future‹ movement shows that young people have understood the situation. As scientists and scholars, we strongly support their demand for rapid and forceful action. Politicians in particular have a responsibility to create the necessary framework conditions in a timely manner. In particular, climate-friendly and sustainable action must become simple and cost-effective, while climate-damaging action must become unattractive and expensive«.

Researchers from Jena have picked up on these appropriate and important actions and have acted to provide concrete support to the »Fridays for Future« in Jena. Scientists regularly take part in the youth demonstrations. On 12 April, the school demonstration was followed by a public speech by Prof. Dr Markus Reichstein, director of the Max Planck Institute for Biogeochemistry, entitled »The global shift—more than just global warming«. Reichstein is one of the authors of the petition.

Our main goal is to share the scientific facts concerning man-made climate change, such as with the lectures by Dr René Orth (Max Planck Institute for Biogeochemistry) in the previous winter semester. At present, professors from the University of Applied Sciences Jena are holding the public lecture series entitled »Interdisciplinary Perspectives on Sustainability«. »Scientists for Future« is the result of the expertise and dedication of scientists who, together with the young generation, want to take social responsibility for the future of our planet—and to demand that leaders from the world of business and politics do the same! ■

The statement by the »Scientists for Future«



Temperature timeline: 2015, 2016, 2017 and 2018 were the four warmest years across the globe since weather records began. (https://svs.gsfc.nasa.gov/13142)

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