SENCKENBERG
world of biodiversity

Leibniz
Association

SENCKENBERG ANNUAL REPORT 2022–2023

// RESEARCH FOR THE FUTURE

// CONTENT

Dear Members, Friends, and Supporters of Senckenberg,

Two challenging years have passed. Until September 2022, we struggled with the COVID-19 pandemic. While the world has largely overcome this crisis, new disasters are unfolding. Many countries are still embroiled in decade-long conflicts, and the impact of climate change and biodiversity loss continues to put stress on people and nature alike: e. g., forest fires, extreme weather events, or dry water bodies. Moreover, the Russian invasion of Ukraine and the subsequent war, now in its third year, is causing massive destruction. Besides countless fatalities, the blasting of the Kakhovka dam in June 2023 created an unprecedented disaster, with social, economic and environmental consequences that will last for decades.

For over 200 years, Senckenberg has been committed to studying nature and its complex links to humans. 2022 and 2023 boasted a wealth of forward-looking activities and events in all our research domains and museum work. A pivotal task is to support decision-makers in politics and business in tackling environmental crises and to provide up-to-date information, knowledge and possible solutions. The Kunming-Montreal Global Biodiversity Framework offers hope for a sustainable future. The "Berlin Declaration", a joint statement by Senckenberg and partners, calls on politicians to take immediate action against biodiversity loss. In addition, the "Frankfurt Declaration" is an urgent appeal to the German government to create the conditions required for a nature-positive economy instead of an irresponsible overexploitation of nature. Senckenberg also published two new policy briefs on nature-based flood protection and the protection and sustainable exploration of the oceans.

To achieve a sustainable future, we need to reach – and unite – as many people as possible. Indeed, there is no better place than a research museum to inspire and support the societal transformation towards a safe and just pathway for our planet and humankind. Our museums in Frankfurt, Dresden and Görlitz are institutions of trust that provide authentic and curated knowledge to a broad audience. Since the easing of COVID-19 restrictions, visitor numbers have boomed: almost 960,000 people attended our exhibitions in 2022 and 2023, along with 2.1 million visitors to the Senckenberg website – an impressive indication of the public's high interest in our topics.

Meanwhile, the year 2024 is already well advanced. We are on track with our extensive systemic biodiversity research and the contributions to much-needed solutions. We will continue to pursue our ambitious goal of understanding nature and its almost infinite diversity in order to sustainably use and preserve it for future generations. Senckenberg is an inclusive research institution, ready to continue outstanding research as the basis for innovative solutions. We are glad to have so many people and partner organizations by our side. Thank you for your continued support.

Prof. Dr. Klement Tockner
Director General, Senckenberg Society for Nature Research

Carsten Kratz
President, Senckenberg Society for Nature Research

SHARING THE LEGACY OF DISCOVERING NATURE

Our planet experiences constant change. Adaptation and evolution shape life on Earth, and the multitude of interactions among the biosphere, the rivers, oceans and ice, the solid Earth and the atmosphere keep our planet habitable. Some of these interactions, however, change at unprecedented rates due to human activity. How can we maintain the integrity of nature, keep planetary climate conditions within safe boundaries and ensure the well-being of nine billion people? Senckenberg aims to answer these questions in the course of its strategic development. Andreas Mulch, Senckenberg Director of Science, highlights key elements in this area.

CURIOSITY AND RESPONSIBILITY – FOR THE BENEFIT OF NATURE AND HUMANS

We as humans have become an integral part of the Earth and have profoundly accelerated the changes impacting our planet. With such acceleration affecting all facets of life on Earth, where is our planet headed? Senckenberg investigates nature in an integrative, interdisciplinary fashion through targeted research, education and dialogue with society. While fascination and curiosity remain our primary source of inspiration, our research program strives to explore nature as a systemic entity. We address nature's challenges while fostering scientific excellence in the various disciplines that contribute to an understanding of the Earth system. Ultimately, our mission inspires us to be curious and responsible in our research efforts and actions and to develop solutions that mitigate human impact on nature and the loss of biodiversity. We do so with the goal of preserving Earth as a habitable planet for generations to come.

ADVANCING SCIENCE FOR TRANSFORMING SOCIETIES

Our expertise ranges from the analysis of biodiversity, covering all major organismic groups in the oceans, the rivers and on land, to Earth and Climate Sciences and the evolution of humans. Halting the loss of biodiversity as a consequence of human actions will remain one of the key challenges for our global societies. The year 2023 reflects a landmark in our institutional efforts. Collectively, we

Ultimately, our mission inspires us to be curious and responsible in our research efforts and actions and to develop solutions that mitigate human impact on nature and the loss of biodiversity.

designed a strategic growth program to explore and protect the diversity of life, from the genome to entire ecosystems, thereby capitalizing on the foundations built by the LOEWE Centre for Translational Biodiversity Genomics. As part of this program, we will also expand the network of Senckenberg institutes across Germany and extract as yet undiscovered knowledge stored in our collections through digitization. Knowledge is a common good and needs to be accessible. We envisage that sharing and collectively exploring the legacy of hundreds of years of nature collections will accelerate efforts worldwide to identify how to best preserve the resilience of ecosystems and combat biodiversity loss. This institutional growth will further allow us and our interdisciplinary institutional partners to engage in a systematic and coordinated dialogue with society to align societal and scientific interests for the benefit of humans and nature.

STRENGTHENING OUR INSTITUTIONAL RESILIENCE IN A RAPIDLY CHANGING WORLD

Human well-being requires a habitable planet. To help foster such habitability, we continuously strive to remain a learning and trusted institution. We document and analyze nature's diversity in our collections and explore past, present and future dynamics of the Earth system. Through national and global collaboration and enduring partnerships, we promote being stewards of nature. In 2022 and 2023, we strengthened our partnership with universities through the establishment of new professorships and joint recruitment. We also inaugurated our first Leibniz Campus at the University of Tübingen. Scientists from various disciplines will come together at this campus to explore the potential of ancient DNA from cave sediments and study human interactions and their impact on past ecosystems through time.

BEING ONE SENCKENBERG

As an institution, we benefit from almost 300 years of studying nature. Scientists and staff at seven institutes across Germany contribute to a coherent research program. Being One Senckenberg is the motivation and foundation for our collective actions. We remain curious and constantly explore how Being One can best be achieved through fostering the freedom of the individual and the diversity within our institution. Being One means being committed – committed to excellence in our work, to equality, mutual respect and responsibility for humans and our planet.

Prof. Dr. Andreas Mulch

RESEARCH HIGHLIGHTS

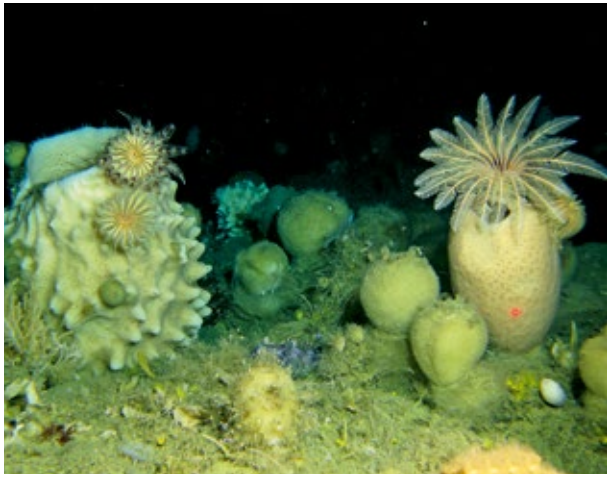
INTRODUCTION

Sharing the legacy of discovering nature underscores the relevance and urgency of global collaboration. Climate change and biodiversity loss are remarkable twin challenges for our global society. We require systemic rather than individual scientific approaches to investigate Earth as a well-balanced system with a long evolutionary history and identify the key elements that at much shorter times maintain habitability for billions of humans. Our research program aims at exploring the manifold interactions between the biotic and abiotic world. In concert with our global partners and through interdisciplinary approaches we foster scientific excellence for the future of all life on this planet.

Prof. Dr. Andreas Mulch

GEOBIODIVERSITY IN ALL ITS FACETS

To study and preserve the diversity of life on earth – that is our goal. The responsible scientists present our four research fields.



01 BIODIVERSITY, SYSTEMATICS AND EVOLUTION

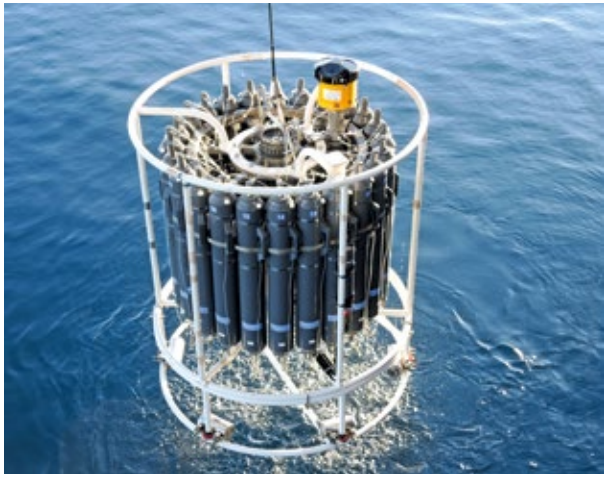
The focus "Biodiversity, Systematics and Evolution" forms the basis of all of Senckenberg's research fields, on land and in the water. Special emphasis is placed on living and extinct life forms. It is our goal to explore and understand our planet's biodiversity – we record species, analyze their distribution, their relationships and their evolutionary connections.

Prof. Dr. Thomas Schmitt is the director of the Senckenberg German Entomological Institute in Müncheberg, Brandenburg, and a jointly appointed professor for entomology at the University of Potsdam. His research emphasis lies on biogeography, conservation biology, ecology and evolutionary biology.

02 BIODIVERSITY AND ENVIRONMENT

We are investigating the increasing influence of humans on biodiversity and the environment. We are particularly focussing on 1) long-term research of species and environmental variables in observatories (Long-Term Ecosystem Dynamics) and 2) "Biodiversity Conservation" where we investigate changes in biodiversity to develop conservation and management strategies.

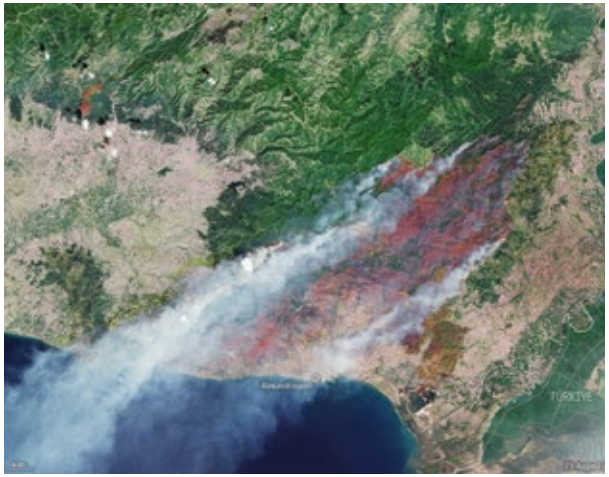
Prof. Dr. Peter Haase is a freshwater ecologist and head of the research station Gelnhausen, which includes the Department of River Ecology and Conservation. Within the Senckenberg research program he serves as head of the research field "Biodiversity and Environment." In addition, he is a professor at the Faculty of Biology at the University of Duisburg-Essen.



03 BIODIVERSITY AND CLIMATE

Within this research field, scientists investigate the multiple interactions between biodiversity and climate, in the past and present, at local, regional and global scales, including the development of future scenarios. To address these objectives, we use a wide variety of methods, ranging from geological studies to field observations and genetic analysis up to large-scale climate and vegetation models.

Prof. Dr. Susanne Fritz heads the Geobiodiversity Research group at the Senckenberg Biodiversity and Climate Research Centre and Goethe University Frankfurt. Her research in macroecology, biogeography and palaeontology focuses on biodiversity patterns and processes at global and regional scales and over millions of years.



04 BIODIVERSITY AND EARTH SYSTEM DYNAMICS

To understand the evolution of life in the Earth system with the associated biological and geological interactions as well as crises in the evolutionary history – this is one of Senckenberg's primary missions. We study the diverse interactions among geodynamics, Earth surface processes, and climate change, including the evolution of humans and our natural and cultural environmental conditions.

Prof. Dr. Andreas Mulch is a member of the Senckenberg Board of Directors and Director of the Senckenberg Research Institute and Natural History Museum Frankfurt. He is a professor in Geosciences at Goethe University Frankfurt.

01
Antarctic sponges like it cold! View of the seabed in the eastern Weddell Sea at a depth of 200 m: various species of the genus *Rossella* with swimming spiny animals and roughly football-sized demosponges.

02
According to a 2022 study, Indonesia's forest area has decreased by 9.79 million hectares, or 11 %, in the last 20 years. Around a third of the old primary forests have been cleared in the process.

03
A water sampler with a CTD probe is lowered to measure conductivity, temperature and depth. Hydrography influences biological processes in the oceans. The development of algal blooms, for example, depends on temperature and light.

04
In the summer of 2023, dozens of fires raged across Greece. This satellite image from August 23 shows the fire front extending over approx. 70 kilometers near Alexandroupoli in the northeastern Evros region.

THE SOSA PROJECT

Marine biodiversity is increasingly under threat – and at the same time still largely unknown. The Senckenberg Ocean Species Alliance (SOSA), founded in 2022, has set itself the task of advancing the discovery and protection of often overlooked marine invertebrates – with innovative methods and an international network.

Marine invertebrates are diverse and beautiful. Scientists bring samples from expeditions from all over the world, many of which contain species that no human has ever seen before. SOSA's goal is to describe and name as many of them as possible.

Our knowledge of the biodiversity of the oceans is extremely fragmentary. It is estimated that around 90 percent of marine species have not yet been recorded or scientifically described, and they do not have a name. At the same time, environmental changes and other harmful human impacts are causing a massive decline in biodiversity. Many species go extinct before we even get to know them.

MARINE INVERTEBRATES RECEIVE TOO LITTLE ATTENTION

The situation is even more dramatic for marine invertebrates. Invertebrates are as useful as they are numerous – they make up 95 percent of all animals. Yet they are severely underrepresented in terms of their detection, conservation and general public awareness. As a result, we are in danger of losing many species forever. To meet this challenge, the Senckenberg Ocean Species Alliance (SOSA) was launched in 2022. As a project based at the Frankfurt location, SOSA builds on Senckenberg's broad expertise in the fields of taxonomy and biodiversity research, while at the same time being embedded in an international network of experts and institutions.

RETHINKING AND ACCELERATING TAXONOMY

Serving as an international hub, SOSA pools scientific and technical expertise to optimize and speed up the very lengthy processes involved in the taxonomic description of new species. It can often take ten or even twenty years for a new species to be adequately studied, scientifically described, named and published – far too long, given the rapid rate of species loss. The SOSA "Discovery Unit" aims to streamline and simplify these processes. Equipped with state-of-the-art macroscopic and microscopic technology, it provides morphological images of the highest quality and offers a description-oriented publication model, among other things.

PROTECTING AND RAISING AWARENESS

To better protect marine invertebrates, SOSA also coordinates the specifically established Marine Invertebrate Red List Authority (MIRLA), a sub-section of the IUCN Red List of Threatened Species. Environmental pollution, global warming and interventions such as deep-sea mining are increasingly threatening marine ecosystems. MIRLA is intended to serve as a powerful tool to raise awareness among stakeholders such as national environmental authorities, non-governmental organizations, national parks and researchers about the opportunities to protect these often overlooked marine invertebrates. At the same time, SOSA takes its activities to the public to sensitize and inspire as many people as possible regarding these fascinating marine creatures.

Prof. Dr. Julia Sigwart & Dr. Torben Riehl

Microscopic work is a major part in the process of describing new species. Here, a technical assistant in SOSA's "Discovery Unit" examines new sample material.

MEDICAL BIODIVERSITY RESEARCH: THE GENOMES OF BATS

Bats are endowed with extraordinary traits and talents. Some of these could also be of great benefit to us "mammalian" humans. Reason enough for an international group of researchers to study these fluttering animals.

Bats – they are the only mammals able to fly; they "see" with their ears, i.e., they use echolocation to find their way in complete darkness; and they occasionally grow very old, even older than humans in relation to body size. But they have other "superpowers" as well.

Bats have the ability to tolerate pathogens that are fatal to other mammals, such as rabies, Ebola, or corona viruses. They apparently have a special immune system that allows them to live with viruses without becoming seriously ill or showing severe symptoms of disease.

LEARNING FROM BATS

What causes the bats' "superpowers" and what is the reason for their presumed virus tolerance? Scientists from various disciplines, including biology, genomics, immunology and gerontology, aim to find a detailed answer to this question. The overarching goal of the "BATPROTECT. Learning from Bats: New Strategies to Extend Healthspan and Improve Disease Resistance" project is to achieve a breakthrough in understanding the molecular basis for the high life expectancy and disease resistance of bats in order to find new ways to prevent and combat diseases in the future.

THE KEY IS IN THE GENES

To understand the evolution and basis of these unique adaptations, the members of the Bat1K consortium – a global consortium of scientists, bat researchers, students, volunteers, and conservation organizations founded in 2017 – have made it their goal to sequence the genomes of all 1,474

currently known bat species. The laboratory center at the LOEWE Center for Translational Biodiversity Genomics significantly contributes to this endeavor. Using state-of-the-art technology, over 150 high-quality bat genomes will be sequenced here over the next few years. A comparison with other mammals has already revealed differences in the genes that control inflammatory reactions and contribute to the immune response.

FOSSIL VIRUS SEQUENCES DISCOVERED

The initial analyses revealed, for example, that the virus tolerance of bats has left traces in their genomes. When viruses multiply in the cells, in rare cases pieces of the genetic material of a virus can be integrated into the host genome. And indeed, such "fossil virus sequences" could be detected in the newly sequenced genomes, which indicates that bats already survived various viral infections in the past.

Now sequenced: the genome of the greater mouse-eared bat (*Myotis myotis*).

AN ERC GRANT FOR BATPROTECT

To support a detailed investigation of the reasons behind the bats' high life expectancy and disease resistance, a team of four research groups from Cologne, Dublin, Singapore and Frankfurt has been awarded an ERC Synergy Grant by the European Research Council, totaling around 12 million euros for the period from 2024 to 2030. The team will study the ageing and immune responses of bats in the wild and in captivity, identify the relevant genes and validate them in cell lines of bats and model organisms.

ALMOST TOO GOOD TO BE TRUE

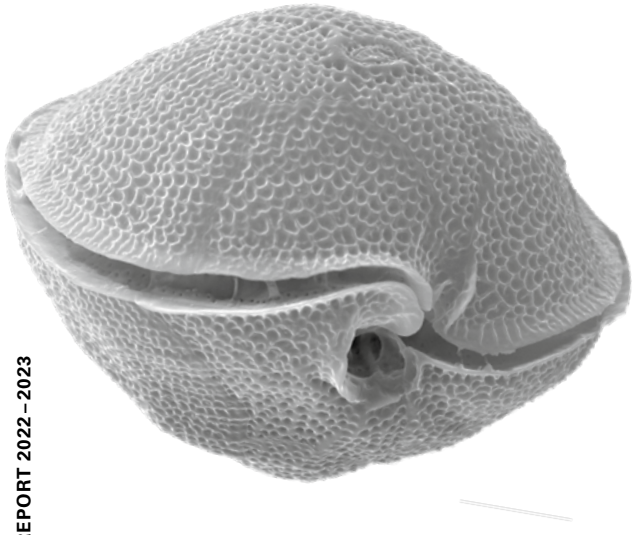
Living a long life without health problems or being able to contain infectious diseases are goals for which we humans have not yet found comprehensive solutions. The spectacular abilities, adaptations and traits of bats suggest that answers to this quest could be found in nature. Although the BATPROTECT researchers' studies are still in the beginning stages, initial results suggest that there is a good chance of finding new ways to increase human life expectancy and prevent age-related diseases.

Prof. Dr. Michael Hiller & Dr. Carola Greve

A look inside the TBG lab.

DINOFLAGELLATES – UNDERESTIMATED DANGER AND RESOURCE ON THE OCEAN FLOOR

There are many reasons to study marine, benthic dinoflagellates more closely and to make the findings available to others. These fascinating single-celled organisms play an important role in aquatic food webs. Some produce toxins that can be dangerous for other marine animals and even for us humans!



Gambierdiscus lewisii has been discovered and described from Heron Island, Great Barrier Reef, Australia in 2019. It can be toxic.

In 2014, the world's first guide to marine benthic dinoflagellates was published. Until then, only about a dozen researchers worldwide had studied the taxonomy of this group of organisms. Five experts joined forces and in 2023 published a new edition of the Senckenberg Book: "Marine Benthic Dinoflagellates – Their Relevance for Science and Society" (see page 58).

SOME SPECIES PRODUCE TOXINS …

Most dinoflagellates are planktonic, while benthic representatives live either epiphytically or in between marine sediments. Some species successfully form symbiotic relationships; others live as parasites. The toxins of *Gambierdiscus* species accumulate in the food chain and can cause ciguatera disease, one of the most common forms of food poisoning when fish and seafood are consumed. And we remember the mass proliferation of *Ostreopsis* species on the Ligurian coast, which sent hundreds of vacationers to hospitals with symptoms of poisoning.

… OTHERS ARE IMPORTANT PRIMARY PRODUCERS

Dinoflagellates contribute significantly to the biodiversity of marine ecosystems and their primary production. They can also be beneficial to humans. The planktonic species *Crypthecodinium cohnii* has already been used in the industrial production of omega-3 fatty acids as a dietary supplement. Some toxic compounds play a considerable role in medical research, e. g., in the development of therapeutics against cancer. In general, benthic dinoflagellates have proven to be very useful and important for basic evolutionary research.

AND THE BOOK?

The second edition also focuses on the taxonomic-systematic treatment of this group, i.e., the recording of biodiversity. This is an essential basis for understanding the dinoflagellates' value and working toward their protection. The authors have spared no effort: The book covers 242 species in 63 genera, with 64 species and 20 genera added compared to the first edition. Lavishly illustrated with more than 240 color images, around 250 electron micrographs and more than 330 drawings, it is a valuable and useful compendium for anyone interested in this fascinating group of organisms.

PD Dr. Mona Hoppenrath

RESEARCHERS IDENTIFY NEW **DINOSAUR GENUS AND SPECIES**

It lived around 210 million years ago in southern Germany in the modern-day Swabian Alb and was an herbivore: *Tuebingosaurus maierfritzorum*. The new dinosaur species resembles the large, long-necked dinosaurs and is a member of the Sauropodomorpha group.

The bones were already unearthed 100 years ago. Held in the Tübingen Paleontological Collection, they had previously been identified as the remains of a *Plateosaurus*. As part of a large-scale project, Dr. Omar Rafael Regalado Fernandez and PD Dr. Ingmar Werneburg from the Senckenberg location in Tübingen re-examined all dinosaur bones stored there. The majority originated from a quarry near Trossingen on the edge of the Swabian Alb.

OLD FINDS WERE INSPECTED ...

When the two scientists examined a partial skeleton found in 1922, they discovered that many of the bones did not correspond to those of a typical *Plateosaurus*. A broader and more strongly built pelvis with fused sacral vertebrae plus unusually large and robust long bones suggested that the animal moved on four legs – contrary to the conventional theory about *Plateosaurus* locomotion. This suggests that the animal was much closer to the large sauropods that appeared later, such as *Brachiosaurus* or *Diplodocus*.

... AND NEWLY CLASSIFIED

Today's paleontologists are aware of the frequent inaccuracies in taxonomic classification in the past. *Plateosaurus* lived in many regions of Europe around 210 million years ago. For that reason, some bone finds were prematurely assigned to this genus in the past. After a detailed comparison of all anatomical features, Regalado Fernandez and Werneburg concluded that this was a species and genus hitherto unknown. The dinosaur's new name, *Tuebingosaurus maierfritzorum*, is a tribute to the university town of Tübingen and the zoologists Prof. Wolfgang Maier of Tübingen University and Prof. Uwe Fritz of the Senckenberg Natural History Collections in Dresden.

Overall, the project revealed that early European dinosaurs were much more diverse than previously assumed. The individual parts of the *Tuebingosaurus maierfritzorum* skeleton, which had been stored separately before, have now been reunited. They can be admired in the Tübingen Paleontological Collection alongside thousands of other treasures, including two complete *Plateosaurus* from Trossingen, partial skeletons of two sauropods and a stegosaur from Tanzania.

Senckenberg researchers Ingmar Werneburg (left) and Omar Rafael Regalado Fernandez from Tübingen with the femur of their recent discovery.

Dr. Omar Rafael Regalado Fernandez & PD Dr. Ingmar Werneburg

WHAT IS THE STATE OF BIODIVERSITY IN EUROPEAN RIVERS?

An international team of researchers investigated the development of biodiversity in rivers in 22 European countries from 1968 to 2020. In August 2023, they reported in the renowned journal "Nature" that although biodiversity had increased significantly over the reporting period, this positive trend has stagnated since 2010 and many river systems were unable to fully regenerate. They are therefore calling for additional measures to revive the recovery of biodiversity in inland waters.

Rivers are unique habitats. Nowhere else is the biodiversity higher than in, on and around the water. However, our watercourses are subject to high pressure and degradation and could lose their biodiversity, along with the ecosystem services. But we can act to prevent this.

Although mayflies, stoneflies and caddisflies are flying insects, they spend most of their lives in the water as larvae. These and many other invertebrates contribute to important ecosystem processes in freshwater. They decompose organic matter, filter water and transport nutrients between aquatic and terrestrial areas. In addition, such invertebrates have long been a key element in monitoring water quality.

MANY POTENTIAL HAZARDS

Monitoring is immensely important because rivers and lakes are exposed to significant anthropogenic pressure and are among the ecosystems at the highest risk of biodiversity loss. They accumulate fine sediments and pollutants and must contend with organically contaminated wastewater as well as with canalization, the construction of dams and impoundments, excessive water extraction, invasive species and climate change.

COUNTERMEASURES SHOW AN EFFECT

"In response to the poor condition of water bodies in the 1950s and 1960s, important countermeasures were taken to restore freshwater habitats, for example with the US Clean Water Act of 1972 and the EU Water Framework Directive of 2000," says co-author Ellen A. R. Welti formerly Senckenberg and now with the Smithsonian's Conservation Ecology Center, USA. These measures led to a significant decrease in organic pollution and acidification starting around 1980, which has contributed to an increase in freshwater biodiversity over the past 50 years. Nevertheless, the number and impact of stressors threatening these ecosystems continues to increase worldwide, and the biological quality of rivers remains inadequate in many places.

CURRENT STUDY RESULTS SHOW MINOR IMPROVEMENTS

The scientists analyzed data from 1,816 time series collected between 1968 and 2020 in river systems in 22 European countries, comprising 714,698 observations of 2,648 species from 26,668 samples. The analyses show that species diversity, at 0.73 percent per year, as well as functional diversity, at 2.4 percent per year, and species abundance, at 1.17 percent per year, have increased significantly over the 53-year period. "However, these increases

Sampling of invertebrates living at the bottom of a near-natural stream section.

The substrate is agitated by hand or foot and the current sweeps the animals into the landing net.

mainly occurred prior to 2010 and have unfortunately settled at a more or less constant level since then," says first author Peter Haase. The freshwater communities downstream of dams, urban areas and farmland recovered at a slower rate. The fauna at sites that are warming faster also showed a lower increase in species diversity, abundance of individuals and functional diversity. Non-native species are found in 70 percent of the river sections, with an average proportion of 4.9 percent. They appear to be better able to cope in urban areas and more heavily polluted localities than the native fauna – which could lead to a loss of rare and sensitive native species.

WHAT ELSE CAN WE DO?

In addition to a package of measures that provides for the expansion of wastewater networks and sewage treatment plants, the research team outlines the importance of reducing the input of fertilizers and pesticides from agricultural land and adapting our river systems to future climatic and hydrological conditions. Finally, the collection of environmental data and the monitoring of organismic diversity must go hand in hand in order to protect biodiversity.

Prof. Dr. Peter Haase

WORLD BIODIVERSITY COUNCIL PUBLISHES **ASSESSMENT REPORT ON INVASIVE ALIEN SPECIES AND THEIR CONTROL**

Invasive species are an underestimated threat. This was emphasized by 86 experts from 49 countries in their study published in September 2023. It is the first report to address the problem globally and comprehensively and to provide evidence, tools and options for dealing with invasive species.

The diurnal Asian tiger mosquito (*Aedes albopictus*) feasting on blood.

More than 37,000 species have colonized new regions as a result of human influence. It is estimated that a new species is added somewhere in the world every single day – and the trend is rising. The tiger mosquito, raccoon and Pacific oyster, for example, have gained a foothold in Germany – with dramatic consequences for our ecosystems. The Caribbean false mussel is causing enormous economic damage to Indian fisheries, and commercial mussel beds in New England are threatened by the European green crab. Moreover, diseases such as malaria and West Nile fever are spread by invasive mosquito species such as the tiger mosquito and the yellow fever mosquito.

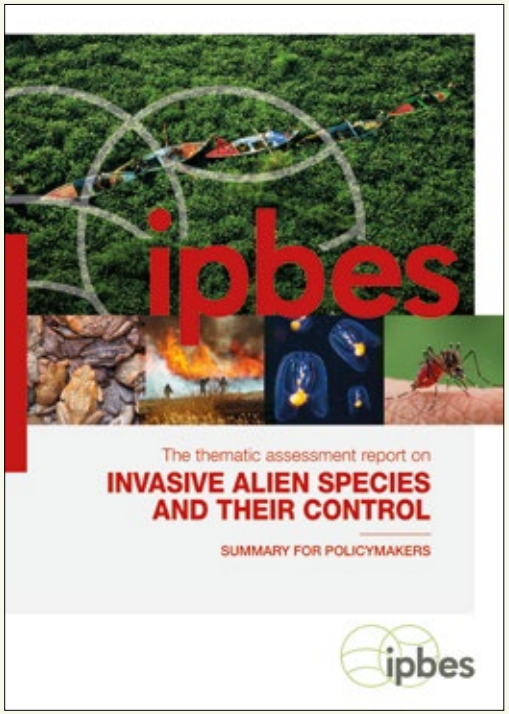
NEGATIVE EFFECTS SHOWN FOR 3,500 SPECIES

About 6 percent of alien plants, 22 percent of alien invertebrates, 14 percent of alien vertebrates and 11 percent of alien microbes are considered invasive. More than 2,300 invasive species are found in areas inhabited by Indigenous peoples and local communities – people who are particularly dependent on nature. These species threaten the people's quality of life and their cultural identity. Overall, invasive species are a key factor in 60 percent, and the unique cause of 16 percent, of extinction events worldwide. In addition, the newcomers cause annual costs of over 392 billion euros, which have quadrupled every decade since the 1970s.

WHAT CAN WE DO ABOUT THIS?

The IPBES report identifies solutions: Prevention and early detection are key, for example during border controls of imports. Eradication is effective for species that tend to spread slowly. Often, the cooperation of authorities with Indigenous groups and local communities can help to counteract the problems. Countries must cooperate across borders and share information. The authors call for regulations at an international level, sufficient funding for (control) measures, increased public awareness and involvement, information systems accessible to everyone and the closing of knowledge gaps. However, it is particularly important to implement measures quickly and monitor their success.

Dr. Hanno Seebens



NEGOTIATED AND ADOPTED AT THE 10TH IPBES PLENARY MEETING

The IPBES Assessment Report on Invasive Alien Species and their Control is composed of six chapters and a 56-page Executive Summary for Policymakers (SPM). The SPM presents the key messages and policy options, as approved by the IPBES Plenary on September 2, 2023 in Bonn, Germany.

THE MoSaiKTeiL PROJECT

The Upper Lusatian Heath and Pond Landscape is considered one of the most biodiverse regions in Germany. As part of a six-year project, three consortium members and over 25 regional partners have been working since early 2022 to foster both protection and sustainable development of this hotspot of biodiversity in Germany, closely involving the local population.

"MoSaiKTeiL: Peatlands, Sands, Pines and Ponds – New Approaches to the Sustainable Development of the Upper Lusatian Heath and Pond Landscape" is funded by the German Federal Agency for Nature Conservation (BfN) with funds from the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. The project area of around 2,050 square kilometers contains over 1,000 ponds amidst nutrient-poor pine forests, sandy grasslands and heath, with dry and aquatic habitats alternating with intermediate or transitional bogs.

BIOSPHERE RESERVE FOR 30 YEARS

The Upper Lusatian Heath and Pond Landscape is one of the 30 most important biodiversity hotspots in Germany. Among the numerous habitat types, 26 are protected under EU law. There are >1100 species of vascular plants, including sheath grass

Part of the cultural landscape that has evolved over centuries: the Commerau Ponds offer a small-scale mosaic of varying habitats.

and floating water-plantain, two species strictly protected under EU law. White-tailed eagle, bittern and hoopoe are examples of a total of 47 species listed in the EU Birds Directive. At least 3,600 animal species can be found in the region, including threatened vertebrates such as fire-bellied toads, otters and 16 bat species, as well as numerous invertebrates for example rare digger wasps, wild bees, dragonflies and diving beetles.

PRESERVING BIODIVERSITY

The overarching goal is to maintain and, in the long term, increase biodiversity in the project area's characteristic habitats. The focus is on specific conservation measures (see map), accompanied by monitoring. These include the (re)wetting of peatlands or the summering and desilting of ponds. Pine forest are cleared of woody undergrowth in order to promote rare lichen, wintergreen and clubmoss species, and overgrown heathlands are subjected to topsoil removal, which also applies to the root-infiltrated topsoil of sandy heaths.

ADVANCING PUBLIC RELATIONS AND ENVIRONMENTAL EDUCATION

A range of activities in public relations accompanies the measures. People can acquire knowledge and skills needed to actively participate in shaping the future towards sustainable development. To raise awareness of this unique and valuable landscape among younger generations, the program includes special offers for children and young adults. Regional (environmental) educational institutions are part of our network and support the target group-oriented transfer of knowledge.

Current events and new developments can be found on the MoSaiKTeiL project website (www.mosaikteil.de); the project team looks forward to all input, support and participation.

Prof. Dr. Christiane Ritz, Prof. Dr. Karsten Wesche & Dr. Julian Ahlborn

The project map shows study and mitigation areas in the individual habitats and provides information on tourist destinations and environmental education facilities.

- **Pond**
- **Sandy heath**
- **Pine forest**
- **Peatland**
- **Project partner**
- **Educational institution / Museum**
- **Nature trail**

Microplastics are solid, water-insoluble plastic microparticles measuring five millimeters or less. Their effects on marine organisms have not yet been sufficiently studied.

1,600 MICROPLASTIC PARTICLES **PER KILOGRAM OF OCEAN FLOOR!**

Analyses of soil samples from the western Pacific Kuril-Kamchatka Trench reveal an alarming insight: the deep sea is full of microplastics!

According to a recent study, around 500,000 tons of plastic waste end up in the oceans every year. The bulk of it is not washed back to shore but remains in the water. Some 220,000 tons – not counting heavy plastics such as PVC and PET – sink to the ocean floor, including 6,000 tons of microplastics. Currents carry the particles farther down to the deepest regions.

SAMPLES FROM A DEPTH OF 6,000 TO 10,000 METERS ...

As part of our study, Senckenberg scientists and their colleagues from Goethe University and the AWI examined the microplastic content of 13 sediment samples from 7 stations, which were collected in 2016 by multicorer from the research vessel "Sonne" in the Kuril-Kamchatka Trench at depths from 5,740 to 9,450 meters. Each kilogram of sediment contained between 215 and 1,596 microplastic particles, mostly smaller than 25 micrometers, constituting 14 different types of plastic. Polypropylene, a plastic used worldwide for packaging, predominated, along with acrylates and polyurethane from paint production.

To better understand the sedimentation conditions in the trench and the bioturbation, i.e., the circulation of the sediment by marine organisms on and in the soil, the sediment cores from the individual stations were compared to each other.

... REVEAL A DYNAMIC ENVIRONMENT

To date, the deepest seabed has been considered a relatively unaffected and stable environment where microplastics are deposited and remain in situ. Thus, it is astonishing that samples taken just a few meters apart showed entirely different compositions – illustrating the highly dynamic conditions in the deep-sea trenches. Not only do currents and eddies keep the sediment in motion, but the organisms living there, including sediment cleaners, "eat" it along with microplastic particles, thus affecting the food chain. This is especially alarming since our study found that biodiversity at the bottom of the Kuril-Kamchatka Trench is even higher than in its shallower reaches – indicating that the biotic communities there are at particular risk due to the oceans' steadily increasing plastic pollution!

Serena Abel & Prof. Dr. Angelika Brandt

AGRIFUTURE: **IDENTIFYING PATHOGENS IN REAL TIME**

The new "AgriFuture" web application makes it possible to quickly identify any plant pathogen on your own. The process is based on the latest genome sequencing technology.

The conventional method for identifying pathogens is a complex and challenging undertaking. Traditionally, the pathogens must first be isolated and cultivated in the laboratory before DNA extraction and analysis can be carried out. It can take days or even weeks before results are available. In addition, traditional methods only target individual pathogens and require in-depth specialist knowledge and expensive laboratory infrastructure.

FOCUS ON METAGENOMES

To remedy this situation, Senckenberg scientists have teamed up with the company "dreistrom.land" and developed a new approach to detecting pathogens. The procedure is mobile and can be carried out by anyone after a short training session. DNA sequencing is done using nanopores. Instead of individual gene segments, as is common with other methods, the complete genetic material, the so-called metagenome, is examined in one sample here. Metagenomes contain the genetic material of the plant as well as that of pathogens and other organisms present in and on the plant at the time the sample was taken. The new technique can therefore be used to detect any pathogens – the process usually only takes a few hours.

HOW EXACTLY DOES THE PROCEDURE WORK?

To ensure ease of use, a publicly accessible, free web portal has been developed that handles the bioinformatics tasks for the users, which include scientists, agricultural advisors, authorities and other stakeholders involved in the identification of plant pathogens. Once the sequencing of potentially infected seeds or an infected plant has begun, the generated data are automatically transmitted to the portal and compared with the DNA sequences of pathogens from a reference database. The analysis itself then takes place on a high-performance server. Once the pathogen has been identified, the result is sent back to the user's laptop in real time. Depending on the amount of pathogen DNA in the sample, the analysis can take as little as a few minutes.

Prof. Dr. Marco Thines

Field work. Before portable DNA sequencing can begin, the DNA must first be extracted from the cells and purified.

03 BIODIVERSITY AND CLIMATE

TOGETHER AGAINST EXTREME WILDFIRES IN EUROPE

As part of the "FirEURisk" project, 38 partner institutions from 19 countries are developing a strategy to increase Europe's resilience to extreme forest fires. They benefit from the valuable experience gained in southern European countries.

2023 was one of the worst years for forest fires in Europe! More than half a million hectares were destroyed by forest fires. 2023 saw the largest individual fire since the 1980s. Sparked on August 19 near Alexandroupoli, Greece, it devastated almost 100,000 hectares and claimed many lives.

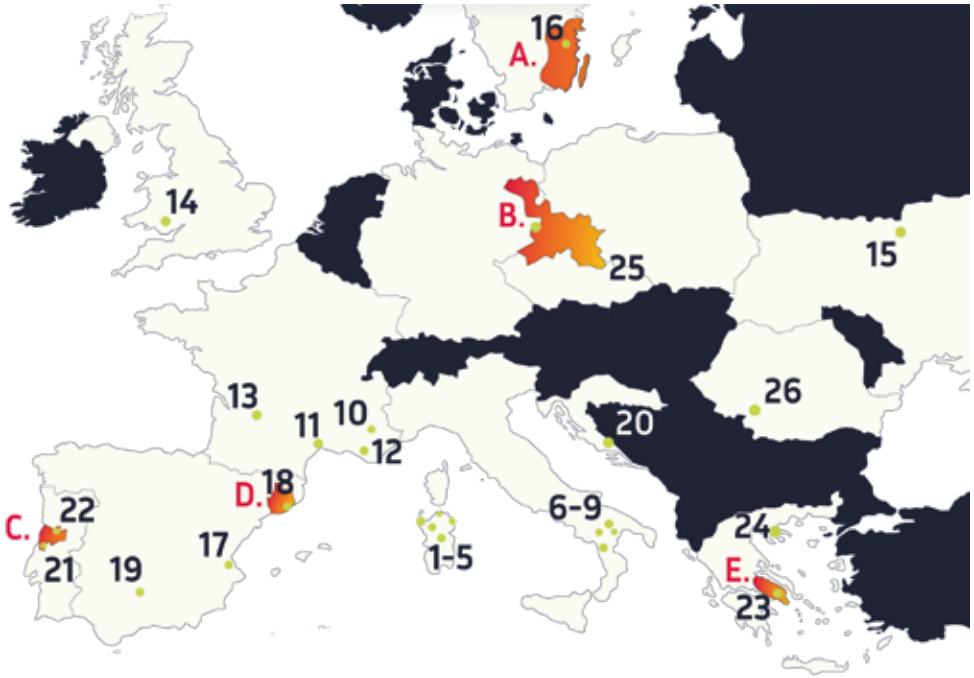
Forest fires occur with increasing frequency in regions where they were previously rare. In Central and Northern Europe, for example, they have been less frequent and severe than in Southern Europe – but this is about to change.

CLIMATE MODELS PREDICT HOTTER AND DRIER SUMMERS

To date, we have had more rain in summer than in winter. However, climate models predict considerably drier summers in the future, rivaling other regions in Europe that already experience frequent fires. To counter this growing threat, a coordinated approach is needed from all parties involved. And this is precisely the FirEURisk action plan. The project brings together researchers, practitioners, policymakers and citizens. It aims to investigate risk factors for forest fires and develop capacities to prevent extreme fires and minimize their impact.

ADAPTING DEFENSIVE MEASURES TO CLIMATIC AND SOCIO-ECONOMIC CHANGES

"We must prepare ourselves for increasingly severe fires occurring in areas where they did not happen before," says FirEURisk coordinator Domingos Xavier Viegas from the University of Coimbra, Portugal. "Based on the experience of the Mediterranean countries, FirEURisk is developing guidelines, policies and recommendations that can be adopted by Central and Northern European countries." These strategies will be tested and implemented at pilot sites and so-called "demonstration areas" (see map) to prepare all European countries for the changing conditions.



Implementing the project's results: The solutions developed as part of FirEURisk are tested regionally in 5 pilot sites (A–E) across Europe, and methods are applied locally in 26 demonstration areas.

FIRE RISK INCREASES THREEFOLD

"The events of recent years show that the changes predicted by science, such as the decline in precipitation and the occurrence of repeated and prolonged heatwaves due to global climate change, are becoming the new normal," summarizes Senckenberg researcher Thomas Hickler. According to the latest forecasts, the risk of fires will increase threefold in the near future – days with a very high to extreme fire risk will therefore occur two to three times more frequently. We need to act quickly and fortify our ecosystems. Above all, society must be prepared so people know what to expect, what options are available to counter the ever-increasing risk of forest fires, and what measures must be taken in the event of a fire.

Prof. Dr. Thomas Hickler

SAVING THE NATURAL PHARMACY OF THE FUTURE!

Montane ecosystems are home to some of the greatest diversity of medicinal plants, but they are also among the most threatened by environmental changes in the Anthropocene. Dr. Spyros Theodoridis – seen here working in the field – is investigating their vulnerability to climate and land use changes.

Medicinal plants and active ingredients from nature could secure medical care for humankind – if we comprehensively study and protect them now. Only six percent of all known plant species have been pharmacologically analyzed to date. Some of them could disappear before we know their effects.

People have relied on the healing properties of plants for thousands of years. In some places, they are still the only freely available remedy. Even though most medicines today are products of synthetic chemistry, half of the world's approved medications use ingredients from medically active plants or were developed based on them. The painkiller morphine is extracted from the opium poppy; the salicylic acid for aspirin is a plant hormone found in the bark of willow trees. New, sophisticated methods for analyzing bioactive plant substances are currently opening up possibilities for the discovery and use of new active ingredients. Scientists from the Senckenberg Biodiversity and Climate Research Center Frankfurt and the Center for Macroecology, Evolution and Climate at the University of Copenhagen have drawn attention to the potential of this as yet untapped resource. They

are calling for higher investments in this type of research and at the same time for better protection of known medicinal plants from the dangers of climate change and biodiversity loss.

NEW RESEARCH DISCIPLINES OPEN UP A WIDE RANGE OF OPPORTUNITIES

"Medicinal plants and their bioactive substances offer tremendous opportunities for the future medical care of humanity – as a nature-based, cost-effective and efficient health resource. But our knowledge in this field is still fragmentary," explains Senckenberg researcher Spyros Theodoridis. "Of roughly 374,000 known plant species, only 15 percent have been chemically analyzed to date – and just six percent have been studied from a pharmacological point of view." The rapid developments in the fields of metabolomics (the study of metabolic products) and genomics are now opening up new possibilities for the systematic analysis of bioactive plant substances and their integration into complex ecosystems. For example, genes responsible for the synthesis of the substance paclitaxel, which is used in cancer therapy, have been identified in the yew genome.

RACE AGAINST TIME

At the same time, traditional as well as still undiscovered medicinal plants are threatened by human impact. Their sustainable and fair extraction poses a challenge. Once a plant's medicinal properties become generally known, demand on the international market often increases and the natural stock is excessively depleted. Well-proven plants such as *Sideritis*, used as Greek mountain tea to treat colds and other ailments, are therefore on the brink of extinction. At the same time, collecting *Sideritis* is currently the only source of livelihood for thousands of people in the Balkans. The local population should be involved in the development of sustainable cultivation concepts.

Based on the example of Europe, a series of indicators have been developed to assess the medical and socio-economic potential of ecosystems in different regions and their potential vulnerability. The Mediterranean region and areas close to the poles stand out, in particular. "The bioactive plant substances that we use as remedies fulfill specific tasks in nature in the interaction between plants and ecosystems – from pollination to soil quality," says Theodoridis. Extreme temperatures, periods of drought and increased CO_2 concentrations in the atmosphere can disrupt this complex interaction. "Climate and biodiversity research must work together here to create the basis for suitable conservation concepts and to safeguard 'medicinal biodiversity' for future generations. Through transdisciplinary research, we can achieve nothing less than a sustainable transformation of global healthcare."

Dr. Spyros Theodoridis

Numerous medicinal herbs such as aconite, mint and juniper grow along this mountain stream in the Taygetos Mountains in southern Greece.

A bumblebee pollinating the ironwort *Sideritis raeseri*. The "Greek mountain tea" obtained from it has been approved by the European Medicines Agency as an effective remedy for colds and gastrointestinal complaints.

In Salzburg, Austria, butterflies are retreating to ever higher, cooler areas such as the High Tauern range.

BUTTERFLIES IN DISTRESS

Butterflies are sensitive to climate change and intensive agriculture. Faced with rising temperatures, mobile species are retreating to higher altitudes.

We are all increasingly feeling the effects of global warming. Extreme weather events such as heavy rainfall or droughts are steadily on the rise. Climate change also severely impacts plants and animals and changes their habitats. In the Austrian state of Salzburg, the average altitudinal distribution of butterflies has shifted upward by around 300 meters over the last 70 years, as demonstrated by Prof. Dr. Thomas Schmitt, Director of the Senckenberg German Entomological Institute in Müncheberg, along with researchers from Austria and Poland. This shift has been particularly pronounced in the last ten years. Apparently, the species could initially still buffer the climate change before reacting to the steadily increasing warming by moving to cooler, higher regions.

SPECIALIZED BUTTERFLIES ARE UNABLE TO RETREAT

The still widespread mobile species, in particular, react to climatic changes in this way. Highly specialized butterflies, by contrast, are usually faithful to their habitat and are virtually trapped there. The intensively used landscape hardly allows these species to migrate. The researchers emphasize the need to make the landscape more permeable for specialized butterfly species through ecological management and additional nature reserves that offer the insects better protection against climate change.

At present, however, much of the high-quality habitat in the valleys of Salzburg has been largely destroyed by intensive agriculture and forestry and the ever-growing settlement, industry and traffic infrastructure. Sites replete with wildflowers and butterflies are now almost entirely restricted to higher altitudes.

LONG-TERM STUDIES AS AN IMPORTANT BASIS FOR CONSERVATION

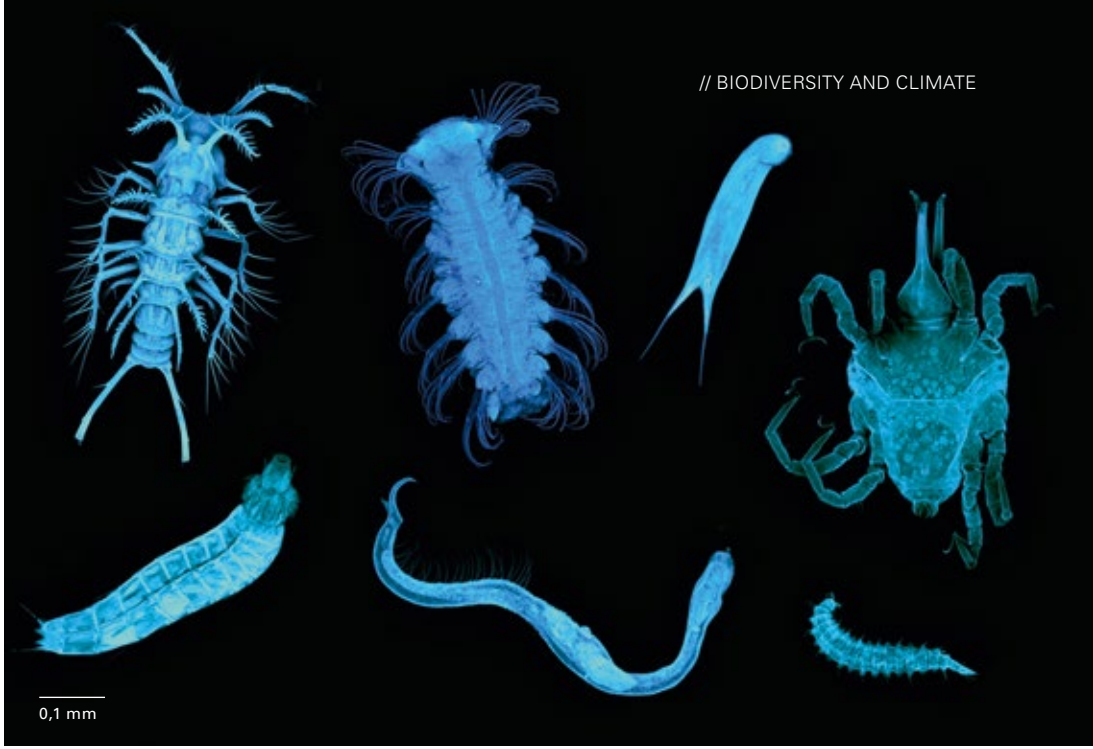
For their study, the scientists analyzed data from long-term observations. A total of 80,000 data sets from the entomological collections of the Salzburg Museum of Natural History alone were included. "Butterflies, like all insects, are subject to strong annual trends," explains Thomas Schmitt. "This is why such long-term monitoring is essential to analyze valid facts and reveal general trends. Conservationists can use these results as a basis for their work."

Prof. Dr. Thomas Schmitt

Heat-loving butterflies such as the Adonis blue (*Lysandra bellargus*) are also retreating from the lowlands, where their habitats have been largely destroyed by the high land use intensity.

DON'T FORGET
THE LITTLE ONES!

The small animals on the Antarctic seabed are the ecosystem's composters. They consume what sinks down to them through the water. In the process, they release nutrients – fertilizer that allows microalgae to grow in the water. The cycle is perfect. But what ends up at the bottom depends on whether sea ice forms and melts on the surface. A team of researchers has now investigated these relationships in detail.



Diversity of Antarctic meiofauna: (top) copepod, polychaete, gastrotrich, marine mite, (bottom) kinorhynch and nematodes.

The Antarctic sea ice has reached its smallest extension since measurements began in 1979. To investigate the effect of changes in the ice cover on various organisms on the seabed, researchers from Senckenberg and the University of Rostock compared the communities of small meiofauna and the larger macrofauna in different regions of the Southern Ocean.

Using the research vessel "Polarstern", they collected samples in five regions of the Weddell Sea and along the Antarctic Peninsula. The analysis included a total of 585,825 meiofauna specimens measuring between 32 and 500 micrometers, such as nematodes, copepods and tardigrades, and 3,974 macrofauna specimens such as polychaetes, bivalves and isopods larger than 500 micrometers. The result: the small animals are more dependent on the extent of sea ice than larger animals. "We compared consistently ice-free regions with areas covered by sea ice seasonally or year-round," explains Senckenberg researcher Dr. Gritta Veit-Köhler. "When there is continuous ice cover and minimal melting, only a few microalgae from the ice reach the seabed. If there is no or very little ice, an algal bloom can develop in the open water, but the 'additional supply' of ice algae is missing." This causes a limited food supply for the communities on the sea floor.

Most of the animals in both size classes were found where the ice cover regularly opens and closes. "Here, we see intense algal blooms in the open water as well as ice algae that sink to the bottom when the ice melts. We have an ample food supply, and most of the animals live here," says Dr. Friederike Weith from the University of Rostock. However, there are clearly different dependencies for the meiofauna and macrofauna. What happens to these specially adapted communities on the sea floor if the ice cover above them changes permanently? As the smallest organisms are most affected by this, the researchers recommend including the meiofauna in future assessments of the state of the Southern Ocean. "Climate change is altering Antarctic ecosystems. To avoid further pressure on Antarctic marine life, protected areas must be designated, with a special focus on the smallest creatures", summarizes Dr. Heike Link from the University of Rostock.

Dr. Gritta Veit-Köhler, Dr. Friederike Weith (Säring) & Dr. Heike Link

04 BIODIVERSITY AND EARTH SYSTEM DYNAMICS

HOW EUROPEANS SURVIVED THE ICE AGE MAXIMUM

An incredible research project: using the genomes of several hundred hunter-gatherers who populated Europe and parts of Asia during the Ice Age to trace the colonization of the continent. This is the largest genome analysis of our ancestors for this era. It involved 125 scientists, who made astonishing discoveries that shed new light on our ancestors' evolutionary history.

Approx. 7,000-year-old male skull and stone tools from Gross Fredenwalde, Brandenburg. These hunter-gatherers lived at the same time as the first European farmers, without any genetic mixing of the populations.

Modern humans began to gain a foothold in Eurasia around 45,000 years ago. Scientists have long been interested in how humans reacted to the increasingly cold climate, the advance and retreat of the glaciers, and how they resettled the continent after the last Ice Age. To investigate these questions, an international team of researchers, led by the University of Tübingen, the Senckenberg Centre for Human Evolution and Palaeoenvironment, Peking University and the Max Planck Institute for Evolutionary Anthropology in Leipzig, focused on the genetic material of 356 Ice Age hunter-gatherers, who are considered the ancestors of modern humans in Western Eurasia. They lived 35,000 to 5,000 years ago and thus also during the coldest phase of the most recent Ice Age around 25,000 years ago, known as the "Last Glacial Maximum" (LGM).

The oldest evidence of migration during global warming: skulls of a man (left) and a woman, buried around 14,000 years ago in Oberkassel, North Rhine-Westphalia. Genetically, they originate from the south.

GENOME COMPARISONS REVEAL ASTONISHING DIVERSITY

The genome analyses revealed that even before the LGM, genetic diversity in Europe was greater than previously thought. Surprisingly, the genomes of populations in western and south-western Europe (present-day France and Iberia) differ significantly from those in central and southern Europe (present-day Czech Republic and Italy). The Gravettian culture, which dates back to between 32,000 and 24,000 years ago, therefore consisted of at least two different populations, contrary to previous assumptions.

PEOPLE FLED TO THE SOUTHWEST TO ESCAPE THE COLD

The researchers were able for the first time to directly substantiate the theory that humans sought refuge in southwestern Europe during the coldest phase of the last Ice Age, which offered more favorable climatic conditions. From there, after the LGM, the descendants of the Western Gravettians spread north and east across Europe. However, unlike previously believed, the Italian peninsula probably did not serve as a retreat: the genome of hunter-gatherers of the Gravettian culture from central and southern Europe is no longer detectable after the cold maximum, meaning they must have died out. Instead, people of other origins settled there, presumably moving from the Balkans to northern Italy and spreading as far as Sicily.

Reconstruction of a member of the Gravettian culture, 32,000 to 24,000 years ago, inspired by the archeological finds at the Arene Candide site, Italy.

ACTIVE GENETIC EXCHANGE AFTER THE LGM

Around 14,000 years ago, the descendants of this group appear to have spread across Europe and displaced other populations. The research team speaks of a major genetic exchange. The warming of the climate and the spread of forests throughout Europe may have prompted the people from the south to expand their range. Meanwhile, the earlier inhabitants may have been displaced by the loss of their habitat, the mammoth steppe.

Prof. Dr. Cosimo Posth

GERMANY'S OLDEST **HUMAN FOOTPRINTS**

The excavation team discovered fossil footprints of early humans at the Pleistocene site of Schöningen. Along with the animal tracks preserved there, they provide an insight into the living conditions and environment of these early humans.

Schöningen site: Among the numerous animal tracks, those of a rhinoceros and several elephants are particularly easy to recognize. But the highlight is the three human footprints.

Lignite was once mined in Schöningen, but today the abandoned open-cast mine is a true hotspot for paleoenvironmental research. Archeological excavations began in the 1980s.

NUMEROUS FINDS OVER FOUR DECADES ...

Along with signs of many animal species, clear indications of human presence were also found, as evidenced by stone tools, broken bones or bones with cut marks, and wooden artifacts such as throwing and digging sticks. In 1994, the famous "Schöningen spears" were discovered – the oldest fully preserved wooden hunting weapons in human history.

... AND FINALLY DIRECT EVIDENCE OF HUMAN PRESENCE

Another sensation followed in July 2020 with the discovery of previously unknown footprints at the site among many other animal tracks. While their human origin soon seemed apparent, it required scientific proof. "We closely examined the fossil footprints. Combined with information from sedimentological, archeological and paleontological analyses, they offer insights into their origin, the environment at that time and the local mammal fauna," explains Dr. Flavio Altamura, first author of the study published in May 2023. In addition to the human prints, the team found tracks of the extinct elephant *Palaeoloxodon antiquus*. The pachyderm had straight tusks and was the largest land animal at the time – adult bulls reached a body weight of up to 13 tons. "The elephant tracks measure an impressive 55 centimeters across," says Schöningen excavation manager Dr. Jordi Serangeli. "Another track was left by a rhinoceros (*Stephanorhinus kirchbergensis* or *Stephanorhinus hemitoechus*) and is the first footprint of its kind from the Pleistocene in Europe."

IT WAS *HOMO HEIDELBERGENSIS*

Back to the human footprints. Left around 300,000 years ago, they are the oldest of their kind in Germany and, based on current knowledge, were made by *Homo heidelbergensis*. The three prints vary in size, came from different individuals and correspond to modern shoe sizes 37, 33 and 27, which correlates to body sizes of around 1.50 meters, 1.35 meters and 1.10 meters, respectively.

Dr. Jordi Serangeli & Dr. Flavio Altamura

MESSELOPHIS VARIATUS – A BOA THAT GAVE BIRTH TO LIVE YOUNG

The "Messel Pit" UNESCO World Heritage Site has revealed a new sensation: A team of researchers from Argentina and Germany discovered the world's first (and also earliest) fossil evidence of viviparity in snakes, thereby extending the temporal distribution of this reproductive strategy in snakes by over 47 million years, and questioning the environmental scenario traditionally associated with the evolution of viviparity.

Fossil plate of *Messelophis variatus* and position of the embryos (see frame).

The vast majority of modern reptiles lay eggs, a reproductive strategy known as oviparity. But there are exceptions: certain lizard and snake species give birth to live young. To date, only two cases of viviparity are known from fossils of terrestrial reptiles. Now another example has been added with *Messelophis variatus*.

TWO EMBRYOS IN THE BODY

The snake, which measured around 50 centimeters long, lived during the Eocene, some 47 million years ago. *Messelophis variatus* is related to present-day dwarf boas from Central America. The species is one of the most common snakes found in Messel. But this specimen astonished the researchers: When examining the fossil, they found several skull bones that belonged to small boas no more than 20 centimeters long. The scientists were looking at a pregnant female with at least two embryos inside the rear third of its body.

VIVIPARITY IN MESSEL POSES A MYSTERY

Giving birth to live young is a sensible survival strategy for colder regions. Many of today's viviparous lizards and snakes evolved in colder regions. The offspring are better protected from temperature fluctuations within the female body. During the Eocene, however, the area around Lake Messel boasted a greenhouse climate with average temperatures of 20 degrees Celsius. Why the boas did not lay eggs in these conditions remains an unanswered question. Perhaps additional fossils from this unique site can help solve this mystery.



Dr. Mariana Chuliver, Dr. Agustín Scanferla & Dr. Krister Smith

INTRODUCTION

Modern infrastructures are the basis for top performance in research. They serve as hubs of collaboration when it comes to recording, describing and understanding biodiversity. Today's challenges are complex, and the key to success lies in how we engage with others – how we build and maintain research platforms, analyze our samples and share knowledge resources. Rapid technical developments in imaging, lab approaches and also curation transform the way we deal with collection specimens. Digitization is in full swing and many data sets are already searchable online, making them available to researchers around the world. The following examples from different institutes within Senckenberg showcase how our infrastructure is developed to meet the needs of our time.

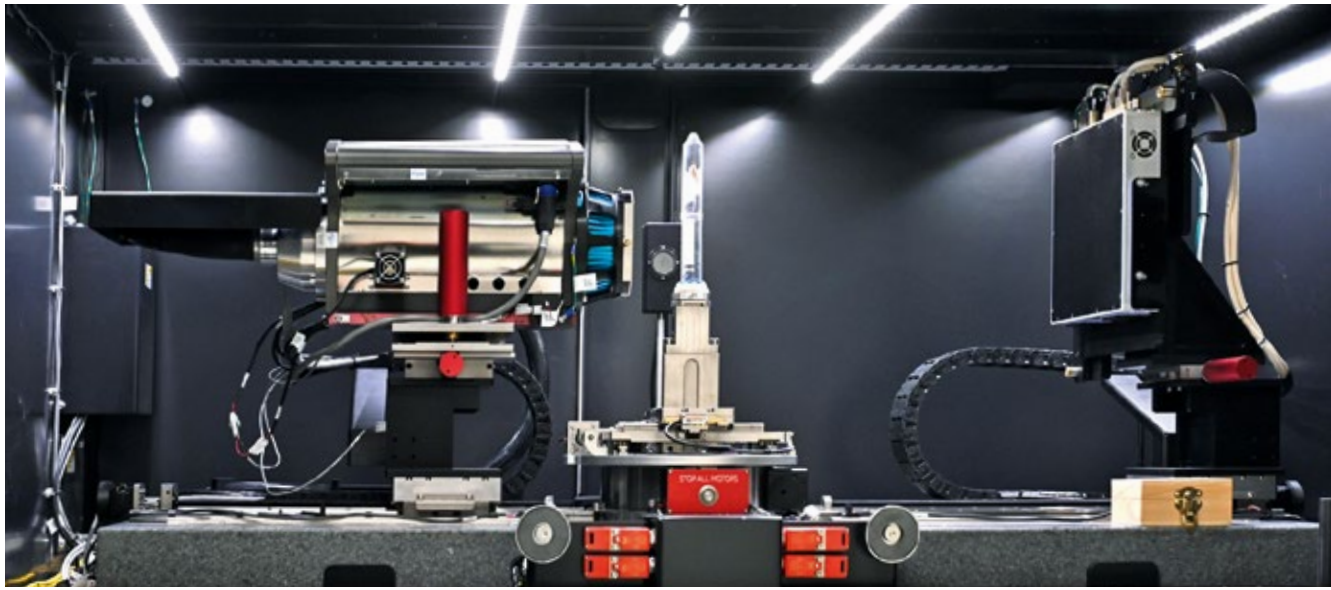
Prof. Dr. Karsten Wesche

RESEARCH INFRASTRUCTURES

Frontal Micro CT image of a 40 mm small juvenile of the rope eel, *Erpetoichthys calabaricus*. Impressive is the dentition of the jaws and bones of the palate. Even at this tiny size, ropefish already are carnivorous predators. Rope eels inhabit rivers in Africa and are considered living fossils, as they show a large number of primitive features not found in other ray-finned fishes.

THE MARVELS OF MICRO-CT

Senckenberg has been operating two new computed tomography scanners since 2022. And while a scan can take several hours, it is worth every minute of effort.



View inside the specimen chamber of the Zeiss XRadia in the Dresden laboratory. The large cylindrical metallic object on the left is the source, which generates the X-ray beams. In the middle is the specimen stage, which holds the object that will be CT-scanned. On the right is the flat panel that detects the X-ray beams that penetrate the specimen and generates 2D images. After an image is recorded, the specimen stage continues to rrotate, and eventually the data of several thousand 2d images generated during specimen rotation are stored on a computer and then combined into a 3D dataset.

When it comes to examining rare specimens and valuable collections from archives and museum material, microcomputed tomography has become indispensable. It provides a view inside a wide variety of organisms and objects, delivering three-dimensional images down to the sub-millimeter range. The possible applications are diverse; therefore, the mammalogists, paleontologists, amber researchers, entomologists and malacologists at the Frankfurt location are delighted to have had access to the new Werth TomoScope® XS Plus 200 computed tomography scanner since early 2023. "Micro-CT allows us to examine the internal structures of extant and extinct species, for instance the ear region of small mammals or the detailed anatomy of fossil insects embedded in amber or copal. The scanner is also used in the SOSA project. Even the pore space of rocks can be visualized and measured with the device," says mammalogist PD Dr. Irina Ruf. The main advantage: it is now possible to analyze the objects without damaging them, where in the past the examination required thin sections and other preparations.

The Senckenberg Institute in Dresden has also used a new computed tomography scanner since August 2022: a ZEISS Xradia Context micro-CT. Its users include ichthyologist Dr. Ralf Britz, who works on general questions of phylogenetics, taxonomy and comparative anatomy. The working group recently completed a project that used computed tomography to study troglobionts in southwest India – tiny fishes that live in groundwater contained in pores and crevices in laterite rock. Britz is delighted: "These are not just spectacular images – the knowledge gained from these high-resolution scans is tremendous. As a first result, we were able to identify and describe a new species of tiny subterranean catfish from these groundwaters."



Dr. Ralf Britz, PD Dr. Irina Ruf & Dr. Mónica M. Solórzano Kraemer

NEW LABORATORIES FOR DRESDEN

Cutting-edge equipment is used to research Senckenberg's treasure trove of collections in Dresden – in new laboratories at an international level.

Dresden geoscientists at work in the new geochronology and isotope laboratory.

Senckenberg's geoscientific and bioscientific collections play a key role in the search for sustainable solutions in the face of the climate and biodiversity crisis. The Senckenberg Natural History Collections in Dresden alone house 7.5 million of the approximately 42 million objects in this incredible treasure trove of archived minerals, fossils, rocks and animal specimens. In 2022, the Dresden institute received new laboratories with state-of-the-art equipment to further advance collection-based research into species conservation and environmental protection and the sustainable extraction of raw materials. Their installation was made possible thanks to funding from the European Regional Development Fund (ERDF) and the Free State of Saxony.

STATE-OF-THE-ART EQUIPMENT ENABLES WORLD-CLASS RESEARCH

The Senckenberg Natural History Collections in Dresden are the oldest research museum at Senckenberg and probably in the entire world. The oldest object in the collection is a silver specimen from 1477; at the same time, it holds one of Europe's largest collections of tissue samples and DNA. New cooling capacities and clean rooms were created for these, allowing centuries-old animal specimens to be examined safely. The geosciences department received a new geochronology and isotope laboratory, which will open up fresh avenues of research into the Ore Mountains and its raw materials. A new ancient DNA laboratory, the "Wink" cryo-collection and a microcomputer tomograph enable world-class research in Dresden.

THE ANALYSIS OF "HISTORICAL" DNA IS BECOMING INCREASINGLY IMPORTANT

Molecular biological methods have become indispensable in modern evolutionary research. The methodology can be applied to all organisms and provides insights along a timeline of many millions of years. It makes it possible to record the genetic biodiversity that creates the diversity of species, can provide information about relationships and explain the underlying mechanisms. Due to legal requirements such as the "Nagoya Protocol," which regulates access to genetic resources and participation in the utilization results, the analysis of historical DNA from museum specimens is becoming increasingly important. Specializing in the analysis of ancient DNA, the new laboratories in Dresden are expected to make important contributions to this future task.

Dr. Anna K. Hundsdörfer & Dr. Mandy Zieger-Hofmann

ICE AGE INSTITUTE TO BECOME CO_2-NEUTRAL

The Senckenberg Research Station for Quaternary Paleontology in Weimar can be supplied with 100 % renewable energy sources in the long term, according to the results of a feasibility study carried out in 2023.

Environmental and conservation aspects have always played a role at the Weimar Senckenberg location. Natural blooming areas and deadwood habitats for insects were created on the exterior grounds, and special nest boxes on the roof of the historic main building have provided breeding quarters for swifts from May to August for 20 years. The attic will soon become home to a nursery and winter roost for bats.

Energy-efficient renovation. The roof surfaces are covered with efficient PVT modules.

THINKING AHEAD

"Sustainability has always been a concern with our buildings: the power supply is provided by green electricity, and we draw a much of our service water from a rainwater cistern. As part of the energy-efficient complete renovation currently underway, we are installing a photovoltaic system on the roof of the outbuilding to generate our own solar power and thermal energy," says Technical and Conservation Manager John-Albrecht Keiler. By commissioning an open-ended feasibility study on the possibilities of CO_2-neutral heat generation, the Weimar quaternary researchers went a significant step further.

POSITIVE RESULTS SURPRISED EVERYONE

"The report concludes that we can supply our buildings exclusively with renewable energy sources and that it is possible to switch from natural gas to geothermal energy," says Dr. Martina Stebich, paleobotanist in the Weimar team and acting station manager. "It will lead us to security of supply and improved control of operating costs."

This conversion will enable the research station to lower its CO_2 emissions by around 34 tons per year, effectively reducing them to zero! The design planning has already been completed – construction of the geothermal plant is scheduled for 2025/2026.

Dr. Martina Stebich & John-Albrecht Keiler

Saxony's Minister President Michael Kretschmer and the former acting Director of the Senckenberg Museum, Prof. Dr. Karsten Wesche, symbolically hammered the last nails into the roof truss.

TOPPING-OUT CEREMONY FOR NEW SENCKENBERG CAMPUS

March 24, 2023, was a big day for the Görlitz institute with the topping-out ceremony at the Senckenberg Campus at Bahnhofstr. right in the City centre. The new building complex comprises almost 13,000 square meters of usable space and will provide room for collections and laboratories, a lecture hall and a scientific library. Over 100 Senckenberg residents and invited guests marveled at the construction progress, including Saxony's Minister President Michael Kretschmer.

Dr. Christian Düker

INTRODUCTION

What do we expect from the museum of today? Senckenberg is one of eight Leibniz research museums, and like our partner institutions, we conduct research on socially relevant topics. Thus, it is our goal to make the knowledge we generate here accessible and understandable for everyone. We aim to raise awareness of contemporary problems and lay the foundation for a comprehensive understanding of nature among the general public. Even more than before, we want our museums in Dresden, Frankfurt and Görlitz to become places of community where we practice social participation and shape the future together. The ivory tower is a thing of the past – our visitors actively engage with scientists and increasingly contribute to concrete research questions.

Prof. Dr. Klement Tockner

SCIENCE AND SOCIETY

THE FRANKFURT DECLARATION

In its position paper, an alliance of German scientific and non-governmental organizations appeals to the German government and the European Union to put an end to economic activity detrimental to nature.

November 29, 2022. One week before the start of the World Summit on Nature in Montreal, Canada, German scientists and representatives of NGOs presented the "Frankfurt Declaration" at a press conference in Berlin. Their demands aim to establish a form of economic activity that is in harmony with nature – now, and in close cooperation with science, business, politics and the public! In the evening, the initiators came together at the event "Business needs Nature: Towards a Nature-Positive Economy" at the Senckenberg Museum in Frankfurt. In front of around 200 guests, they discussed the specific implications with high-ranking international representatives from science, business and politics.

CONCRETE MEASURES PRESENTED ...

Following the panel discussion, the key points of the "Frankfurt Declaration" – six central demands to politicians – were presented, e.g., mandatory biodiversity reporting by companies and a level playing field regarding standardized, science-based sustainability regulations on biodiversity to prevent "greenwashing." Other points include deforestation-free supply chains and the inclusion of biodiversity in the German government's innovation agenda.

... WITH GUARANTEED SUPPORT

The alliance expected Montreal to make up for past failures and take immediate action. Politicians should not face this alone, so the demands are accompanied by six central offers from the scientific community. These include global biodiversity monitoring programs, a worldwide, publicly accessible biodiversity database and support in the development of solutions for redirecting environmentally harmful subsidies. The core objective is to create the conditions that make nature-positive, i.e., resource- and nature-conserving, business activities worthwhile. The long-overdue turnaround can only succeed if companies join in and use global biodiversity in a sustainable way. Nothing works without nature – this applies not only to the primary sector, but to every business worldwide, and to each of us individually. If we want a viable future, we must join the fight against biodiversity loss.

Prof. Dr. Klement Tockner

There is no higher value than that of biological diversity, according to the "Frankfurt Declaration!" In "The Fascination of Diversity" exhibition, the Senckenberg Natural History Museum Frankfurt presented a total of 1,138 animals and plants as well as geological objects on a huge display wall.

BROADENING PERSPECTIVES TOGETHER

Since 1821, the Senckenberg Natural History Museum has made it possible to experience and read about complex natural research and knowledge fields. We see ourselves as an agency for current issues and a democratic laboratory for a new enlightenment, paving the way for multi-directional communication between visitors and researchers.

A look into the special exhibition "Ecosystem of Excess": The "whale-dolphin" on the ceiling is its central exhibit.

Our mission is to explain what has made humans, life and our planet what they are today, how they are interlinked in the past, present and future, where this knowledge comes from and how scientific questions develop and relate. We use artistic research and visualizations to expand the fields of knowledge and presentations.

At the same time, the museum is a meeting place for science and society. It aims to promote dialogue at eye level and enable access for everyone – including participation, involvement and the opportunity to help shape the museum.

We are currently in the midst of a structural and content-related renewal process, taking a modular approach: The new deep-sea and marine research rooms or the coral reef (see p. 43) provide a glance ahead. The Aha?! Science Lab (see p. 50), where visitors become active participants, has already been implemented. Situational changes in the existing structure are under development, permanent exhibitions are gradually updated and, where they are a "museum within a museum" worthy of preservation, technically upgraded. Larger special exhibitions are being planned. The exchange with societal groups is essential here. Our activities are part of the sustainable and extensive conversion and expansion process under the title "Museum for Tomorrow" to be realized by the early 2030s. In 2023 the Frankfurt Museum attracted nearly 460.000 visitors, 60.000 more than before Covid, and was the most visited museum in Frankfurt.

The "Understanding Climate" exhibition shows how climate research works.

UNDERSTANDING CLIMATE

The special exhibition "Understanding Climate: Lessons from the Past" is part of a project on paleoclimate research and shows how science works. From October 2022 to July 2023, visitors could join researchers from Goethe University Frankfurt and Senckenberg in their search for clues to the Earth's past and watch as they deciphered information from climate archives and refined computer models. The reward: a better understanding of our Earth's past and future climate. The exhibition is designed as a sustainable project. The materials used are returned to the material cycle.

PINAR YOLDAŞ: AN ECOSYSTEM OF EXCESS

Since June 2023, a brand-new marine creature is inhabiting the Museum: a new species between a whale and a dolphin whose digestive system has adapted to the plastic-polluted seas. No real animal, of course! The "whale-dolphin" was created by international artist Pınar Yoldaş as part of her exhibition series "An Ecosystem of Excess" to draw attention to environmental pollution caused by humans. Pınar Yoldaş makes it visually tangible by showing lifelike organs in glass vessels – similar to wet specimens stored in formalin. But what looks like science is actually art. With these unique exhibits, Yoldaş creates extraordinary, almost uncanny encounters and opens up a new perspective that leads to a special awareness for the pressing challenge of our time. A clean ocean begins with the behavior of each of us! Senckenberg Natural History Museum cooperated here with Schirn Kunsthalle Frankfurt and their exhibition "Plastic World."

FLORALIA: MERIAN – SCHULTZ – CRESPO

Three artists, three eras, three oeuvres that celebrate plants and nature: In cooperation with the Crespo Foundation, we presented the plant portraits by three female masters of the artistic and scientific exploration of nature. From September to December 2023, visitors could admire an exquisite selection of drawings and paintings as well as prints and experimental photographic works by Maria Sibylla Merian (1647–1717), Elisabeth Schultz (1817–1898) and Ulrike Crespo (1950–2019). The works by Merian and Schultz are part of the Senckenberg collections and were shown here for the first time. The exhibition combines the works of the three Frankfurt-based artists, placing them in a new context and illuminating the relationship between nature, science and art over a period of 400 years.

"Pink field bindweed" – Sheet from the 1679 work "The Caterpillars' Wondrous Transformation and Peculiar Flower Food" by Maria Sibylla Merian.

Search picture in the exhibition. Hidden here is a specimen of *Curculio glandium* commonly known as the acorn weevil.

CITY INSECTS: FRANKFURT'S LITTLE HELPERS

Many natural habitats are increasingly being lost and cities are becoming havens for insects. The animals also perform important functions here, as they are pollinators, scavengers or pest controllers and do much more. From September 2023 to December 2024 the "City Insects: Frankfurt's Little Helpers" exhibition invites visitors to get to know these fascinating and irreplaceable little urban creatures and to explore them together with scientists. The exhibition is part of the Senckenberg research project "SLInBio: Urban Lifestyles and the Valorization of Biodiversity – Dragonflies, Grasshoppers, Bumblebees and their Ilk".

Arrival at the preparation workshop of the Frankfurt Natural History Museum. Our visitors' favorite is being restored here.

ANACONDA AND CAPYBARA ARE BEING RESTORED

The favorite exhibit of many visitors to the Senckenberg Natural History Museum in Frankfurt: an anaconda devouring a capybara. It was put on permanent display in 1927, so it is no surprise that time has taken its toll. In February 2023, the exhibit was removed to be restored by our taxidermists together with experts from other museums. The display case will also be completely renovated and air-conditioned. The highlight exhibit is scheduled to return in summer 2024.

Prof. Dr. Brigitte Franzen

Students in action. The vacuum cleaner principle of feeding used by large sauropods can be actively tested with a gripper arm. The students were able to pick leaves themselves (below).

MORE MUSEUM FOR EVERYONE

Guided Tours and Workshops by the Education & Outreach Team

FOCUS ON SPECIAL EDUCATION SCHOOLS

In collaboration with the Department of Biology Didactics at the University of Frankfurt and teachers from special education schools, we designed, tested and successfully established guided tours and workshops for students with various special needs. Guided by simple questions and using playful methods, the students discover special objects in the museum. In the workshop, they practically and independently test their skills as "researchers" by comparing, measuring and describing their subjects. Special content and working materials were developed for this purpose. The focus is on curiosity, the joy of discovery and working with objects – with a sense of achievement for everyone.

TEACHING CLIMATE KNOWLEDGE IN THE GARDEN

In addition to numerous guided tours, lectures and workshops on the special exhibition "Understanding Climate: Lessons from the Past," several special events took place in the Senckenberg Biodiversity and Climate Research Center's garden in the summer of 2023: Following a popular science lecture, participants were able to interact directly with scientists, ask questions and hold discussions over a summer drink.

Before heading outdoors on a discovery tour, the participants received an introduction to insect identification in the Aha?! Science Lab.

and themed stations in the room provided insights into reef research. An intensive and instructive time with a new impetus for dealing with permanent exhibitions and the interplay between curation and educational work.

Dr. Eva Roßmanith

A CITY FOR INSECTS: EDUCATION AND OUTREACH TO SUPPORT INSECT DIVERSITY IN FRANKFURT

In line with the special exhibition "City Insects – Frankfurt's Little Helpers," the museum has been offering various educational programs since 2023. In regularly scheduled public topical tours, microscopy courses and workshops for school classes, we present the fascinating side of insects. In addition, the "city insects" can frequently be seen outside the museum, e. g., during the City Nature Challenge. The exhibition and accompanying program are part of the project "SLInBio – Urban Lifestyles and the Valorization of Biodiversity: Dragonflies, Grasshoppers, Bumblebees and Co" by the FEdA initiative.

MEET US IN THE REEF

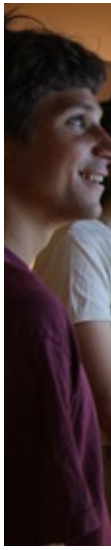
To continually equip an exhibition with new content, show new perspectives and act in the most sustainable way possible while also exploring what particularly appeals to visitors – that was the approach of the project "Temporary Permanence – Innovative and Flexible Communication of Current, Socially Relevant Topics in Permanent Exhibitions," which we were able to implement in the permanent Coral Reef exhibition starting in 2023. Parts of the exhibition were developed and implemented in collaboration with the Youth Advisory Board, workshops were held to explore and visualize the diversity of forms and soundscapes above and below the water using artistic methods, and guided tours

We have developed special educational stations for the "Meet the Reef!" exhibition in order to engage in a direct exchange with visitors.

MUSEUM & EXHIBITIONS
FROM GÖRLITZ

In our museums, we show how research works and how we arrive at our findings – this is the focal point of "Senckenberg Backstage." The new traveling exhibition "Groundwater is Alive!" also provides insights into the everyday life of researchers. The exhibition organizers offer a look into their profession and report on new approaches and opportunities.

During a virtual dive, visitors can explore life in a karst cave – shrunk down to the size of a groundwater isopod.



"GROUNDWATER IS ALIVE!"

It would have been hard to imagine a better start. The exhibition opened in May 2022 on the grounds of the State Garden Show in Neuenburg on the Rhine before moving on to Görlitz in October.

"Groundwater is Alive!" provides insights into the underwater world beneath our feet and features new technologies, some of which are being used for the first time worldwide (see page 49). The tour begins with "Groundwater in Space and Time," its formation and distribution on Earth and the slow evolution of organisms in this cold, dark habitat. At a media table, Senckenberg and its project partners present the latest research findings, such as the influence of nitrates or drought as a result of climate change. Results from the project-accompanying research by the Universities of Landau and Koblenz and the Institute of Groundwater Ecology in cooperation with citizen scientists from the Neuenburg and Freiburg area are integrated into the exhibition. In the second area, "Groundwater Habitat," visitors encounter various organisms that live there and play a very specific role in the system's function. Most of them are just a few millimeters in size, such as the well snail or the cave isopod, while others, such as the olm, are comparatively huge. To round off our visit to the exhibition, we focus on the relationship between "Humans and Groundwater": our all-too-often careless use of this valuable, limited resource shows just how little we value and appreciate it – including any possible solutions.

"Groundwater is Alive!" is currently on display in Lübeck. In October 2024, it will move on from there and be presented at various locations in Germany and probably in neighboring countries as well.

This multimedia exhibition offers visitors a glimpse into the entire range of collections and research at the Senckenberg Institute Görlitz.

SENCKENBERG BACKSTAGE – COLLECTING, PRESERVING, RESEARCHING

Do you want to take a look behind the scenes of our research and the collection magazines? This is possible in the explorative permanent exhibition in Görlitz, which has been on display since July 2022. Visitors will encounter pinned butterflies, skulls and skeletons of large and small mammals, microscope slides and vials filled with alcohol for preserving soil animals, herbarium specimens of vascular plants, mosses and lichens, samples of volcanic rocks and much more. They can choose from a variety of digital content via touchscreens and gain practical insights into working with scientific collection objects. Members of the museum staff also have their say: scientists and taxidermists as well as doctoral candidates and students present their day-to-day work in an exciting and authentic way.

The new offer was created as part of the project "museum4punkt0 – Digital Strategies for the Museum of the Future." An internal project team produced over 80 videos, animations, photo series and 3D objects that can be called up.

MUSEUM4PUNKT0 WORK EXHIBITION

The Germany-wide joint project "museum4punkt0" is driven by new ideas for museum display and outreach in a digital society, the exchange between colleagues within the network and innovative and experimental projects. As part of a work exhibition on June 24, 2022 in Berlin, the 27 partners in the network showed representatives from politics, the media and the museum scene how knowledge can be communicated digitally today. Since the start of the project, the team at the Senckenberg Museum in Görlitz has developed a total of eight applications.

Visitors can browse according to their individual interests and delve into specific topics.

Happy faces at the "museum4punkt0" workshop and presentation at Haus Bastian – Center for Cultural Education of the Staatliche Museen zu Berlin.

"FAMILY-FRIENDLY ADVENTURE DESTINATION" RATING

The Görlitz Natural History Museum is one of seven recreational facilities and locations that were awarded the "Family-friendly Adventure Destination" certificate from the Marketing Association of Saxony for the first time in 2023.

Dr. Christian Düker

MUSEUM HIGHLIGHTS
FROM DRESDEN

Senckenberg Dresden is home to two research units, the Museum of Zoology and the Museum of Mineralogy and Geology. We picked out one exhibition highlight each: Our geoscientists will take you on a fascinating journey through geological history, and our ornithologist has teamed up with a Dresden artist to bring to life the fascination of birds' nests.

The exhibition "Earth in Motion" particularly appealed to young, up-and-coming researchers.

EARTH IN MOTION

Our blue planet is in constant motion, always changing its face – and this has been the case for over 4.5 billion years! Its hot interior drives vital dynamic processes such as plate tectonics, volcanism and mountain building – entire continents and oceans are created and disappear. Most of us associate volcanic eruptions with danger and destruction. Yet this is how carbon dioxide first entered the atmosphere. Together with other gases, it creates a natural greenhouse effect, without which the average global surface temperature would be -18 °C instead of a pleasant 15 °C.

Where does this knowledge come from? Rocks and the minerals and fossils they contain are archives of life and geological history. Scientists can read them like a book. They provide insights into the formation and evolution of the Earth and life. Not everything has been studied yet. But one thing is certain: the diversity of life on Earth is inextricably linked to the geological processes in and on it!

From July 2022 to March 2024, visitors to the Japanese Palais were able to go on a geological journey through time and find out why and how life on Earth was able to develop in the first place.

THE CONCEPT OF THE POP-UP EXHIBITION "A NEST" WAS A SUCCESS

Out of the museum – into the city! As part of the City of Dresden's KREATIV.RAUM.BÖRSE project, Senckenberg presented the pop-up exhibition "A Nest" in a vacant storefront from June to September 2023.

A look inside the exhibition:
a wall full of nests.

At the center are 50 of a total of 1,000 pictures taken over a period of five years by Dresden photographer Karen Weinert, to which we added original objects. "When we humans talk about 'nest building,' we think of a home of our own or a place where we want to spend our private lives," says ornithologist Dr. Martin Päckert. "Bird nests, on the other hand, are usually not 'dwellings' in the true sense of the word but serve one primary purpose: birds lay their eggs in them and raise their offspring, so strictly speaking, they are cradles or nurseries." Each nest looks different and is fascinating in its own, unique way. The exhibition offered the opportunity to discover the nests' artistic architectural styles, to take the time to examine and explore them and to learn what goes on in their interior – insights that we are usually denied. And that is precisely what makes the exhibition so interesting.

Highlights include casts of the world's largest bird egg, which comes from the extinct elephant bird of Madagascar. The exhibition also features interactive elements such as a nest camera that shows a brooding blue tit, and hands-on stations. Here, visitors can explore bird calls or help build a giant nest. Bird nests have an astonishing number of facets – you can learn more about these fascinating structures in the small, exquisite science exhibition, which is now on display at the Senckenberg location in Görlitz.

Sinah Hoffmann

INCLUSIVE AND BARRIER-FREE IS POSSIBLE

It started with a big goal: to do everything possible to ensure that people with disabilities can participate in cultural life on an equal footing. Implementing inclusion in our museums is a long journey. The difficulties are often due to the structural conditions, financial possibilities and personnel capacities for planning and implementing the measures. But we have already achieved a lot.

GUIDANCE SYSTEM FOR THE BLIND: ENTERING THE EXHIBITION WITHOUT A GUIDE?

All floors of the Görlitz museum were newly accessible to visitors with mobility impairments when it reopened after renovation in November 2003. In the meantime, almost all exhibitions have been made barrier-free (which has also been the case in the Frankfurt Natural History Museum since 2018). Since August 2022, the museum in Görlitz has adapted its tour for the blind and visually impaired. A free audio guide system leads visitors to 30 stations on 4 floors. For visitors with a mobility cane, this works via a floor guidance system. Once at the station, acoustic descriptions of the exhibits start automatically. Tactile models are available at some stations, such as the hand and skull of a gorilla or the shell of an ammonite. In addition, there are original objects like the skins of wolves, wild boar, otters and beavers as well as a scent station.

Models of a gorilla hand and skull in the rainforest exhibition enable accessibility for visually impaired and blind visitors.

A worldwide novelty: Holograms of groundwater animals. Using gesture control, you can interact with, enlarge or rotate them.

INNOVATIVE, INTERACTIVE – AND WITH AN EYE ON INCLUSION!

The exhibition "Groundwater is Alive!" (see page 44) employs various new techniques – and inclusion was of special concern to us. For the first time worldwide, we are realistically displaying groundwater animals using a new type of hologram technology with gesture control. There are numerous 3D models of the animals living in the groundwater that can be touched. At the wheelchair-accessible media stations, the panel texts and content can be accessed via QR codes in German, English, French and Polish. Profile and Braille lettering on the models as well as rough and therefore tactile QR codes enable visually impaired people to access the exhibition texts; users of conventional screen readers or borrowed tablets can have the texts read aloud to them.

MUSEUM GUIDE PUBLISHED IN SIMPLE LANGUAGE

The new quick guide of the Senckenberg Natural History Museum Frankfurt presents many popular Senckenberg highlights such as *Diplodocus*, anaconda or dodo simply and clearly, in short sentences and words. The 64-page brochure was produced in cooperation with Lebenshilfe Landesverband Hessen e. V. The result is a clearly designed and attractively laid-out booklet for a special target group, which guides visitors through the permanent exhibition in a way that is easy to understand. It can be purchased at the museum ticket office for one euro or downloaded free of charge from our homepage.

What differences do you see between quagga and zebra? This question from the Quick Guide in Simple Language encourages visitors to make their own observations.

Dr. Christian Düker & Dr. Eva Roßmanith

AHA MOMENTS
IN THE MUSEUM

Since June 2022, the Aha?! Science Lab at the Frankfurt location has invited visitors to participate, discover and explore. In one-and-a-half years, over 140,000 enthusiastic visitors have taken advantage of this new offer.

Almost like in a real laboratory or collection magazine: The Aha?! Science Lab captures the workplace character of natural scientists.

As a part of the museum visit designed for adults, young people, families and children aged eight and over, the exhibition offers its own collection of objects to touch, examine and explore. Binoculars and microscopes provide new insights, while research boxes and books encourage intensive exploration of minerals, skull bones, shark teeth and much more.

ACTIVE PARTICIPATION IN RESEARCH

Interested visitors can even support in-house research projects, for example as a citizen scientist in the "WildLIVE!" project by analyzing photos from camera traps in Bolivia or South Africa. Another project from the field of malacology requires a delicate touch: the collecting involves sorting tiny mollusk shells from sand samples. We deliberately use digital media only to a very limited extent in the exhibition so that visitors can concentrate on the original objects and on direct interaction with experts and each other. The Aha?! Team of natural scientists and students is always available to answer questions and support visitors in their own discoveries.

Two boys examine the vascular bundles of trees with a handheld microscope.

The Aha?! team is always on hand to help with any questions.

IN DIALOG WITH SCIENTISTS

Several times a month, researchers present their topics on "Science Live," from the anatomy of spiders and climate research on fossils to expeditions or live broadcasts from laboratories – a unique opportunity to enter into dialog with scientists. The latter also get to see themselves and their topics in a different context for once, leading to their own "Aha?!" moments.

Dr. Eva Roßmanith, Prof. Dr. Brigitte Franzen & Dustin Gohlke

A BUZZING SQUARE METER

A joint project by Senckenberg and "DIE ZEIT" invites hobby gardeners to support insect research

It was a small package of seeds that readers of Germany's largest weekly newspaper DIE ZEIT found in between the pages of the edition issued on May 4, 2023. Two different mixes were created by Senckenberg entomologists, one with seeds for wild flowers, one with seeds for flowers of agricultural landscapes. They were ready to go, or rather ready to grow in readers' gardens or on balconies.

"1m² for a greener world" is a joint campaign by Senckenberg and DIE ZEIT to mobilize for "rewilding" the nature around us. The campaign invites people to sow insect-friendly plants, among them wild mallow, white sweet clover, dyer's chamomile and others – on one square meter. The idea is to create many small islands for insects to develop and grow throughout the year.

The mix makes the difference. Carefully selected flower seeds are geared towards the feeding needs of indigenous insects and are also beautiful to look at.

The notable decline of insects in Germany is due to the loss of food resources but also of habitats, especially those where individuals can safely go through their developmental stages in the course of the year. With increasing agricultural and forest management activities as well as housing projects, new traffic lanes and industrial zones, humans take up more and more space that is lost for insects. And in their gardens many people don't know or understand the needs for local, insect-friendly plants and flowers and look for easy-to-care-for evergreen plants that are often not native and of little value for insects.

But this campaign wasn't only about planting flowers; those involved could also contribute to Senckenberg's scientific endeavors: Is this the right mix of seeds for different regions in Germany? Which insects are attracted by which plants, and how does urbanization factor into all of this? Hobby gardeners participating in the project were encouraged to take photos of "their square meter" to document insect populations and behavior. These photos were then evaluated by Senckenberg scientists to draw conclusions for further research. Most importantly we wanted to assess if taking this first little step can change the participants' gardening practices to being more insect-friendly.

Small seeds, big effect. Sow the seeds in May, then keep them moist and watch them until they germinate ... and on!



Prof. Dr. Steffen Pauls, Dr. Daniela Warzecha & Dr. Matthias Nuß

INTRODUCTION

Pulling out the red carpet for biodiversity research! In 2022 and 2023, the Senckenberg Society was once again busy creating special moments and spaces of dialogue for excellent scientific work to shine. From gala nights to award winners, we are proud to showcase what makes Senckenberg unique and impactful. And we are thankful to our partners who support so many projects both with funding and their passion for Senckenberg's mission. A lot of the activities showcased here have been driven by Beate Heraeus, who served as president of the Supervisory Board from 2012 to 2023. This is her legacy, and we are sincerely thankful for all her contributions.

Carsten Kratz

THE SENCKENBERG SOCIETY

Dinner among dinosaurs at the "Senckenberg Night" 2022. On April 30, Chairwoman Heike Spiller of the "Friends of Senckenberg" and her representative Simone Loewen warmly welcomed the evening's guests together with Senckenberg Director General Klement Tockner.

VOICES FROM THE SENCKENBERG NIGHT

April 30, 2022. The 12th Senckenberg Night attracted visitors with a topic that is close to all our hearts: the protection of forests!

Our planet's forests are in deplorable shape! The tropical rainforests have shrunk to less than half their original size, and the remaining forests are threatened by fire, deforestation and fragmentation. In Germany, too, the damage is visible everywhere: storms, drought and bark beetles are taking their toll on our forests. To draw attention to the precarious situation, the Senckenberg Society has put forests on the agenda of its charity gala. Around 250 guests from politics, business, society and science experienced an entertaining interplay between award ceremonies, things worth knowing and points to consider.

The highlight of the evening was the presentation of the Senckenberg Prize in the categories "Nature Research" and "Commitment to Nature." With this award, the society honors people exceptionally committed to biodiversity and climate protection: Prof. Alexandre Antonelli and Kristine McDivitt were the recipients in 2022 (see page 54).

In the same vein, we all support "our forest" for many different reasons. Here are quotes from some of our guests:

"The loss of nature and biodiversity is the biggest challenge we all face on this planet. Because the species that disappears never comes back. There is hope in this narrow window of time."

Prof. Alexandre Antonelli,
award winner

"Whoever you are and whatever you're good at – you get up every morning and do something. You take action. You offer your support and fight for a world that is in harmony with nature."

Kristine McDivitt Tompkins,
award winner

"Forests are multi-talented hotspots of biodiversity and so incredibly important for our lives! Our award winners are committed to preserving our "green lungs" with enormous dedication and creativity!"

Heike Spiller, Chair of the
"Friends of Senckenberg"

"Images of cleared rainforests or the sight of withered trees at our latitudes make our hearts bleed. This feeling must spur us into collective and decisive action because our forests as the basis of life are under threat!"

Angela Dorn, former Hessian Minister for
Science and the Arts

"Anyone who has had the opportunity to experience our charismatic award winners Kristine McDivitt Tompkins and Alexandre Antonelli knows that everyone can contribute in their own way – as Kristine so eloquently put it."

Simone Loewen, Deputy Chair of the
"Friends of Senckenberg"

"A forest is more than the sum of its trees. If there are trees outside hospitals and birds sing, patients get better faster!"

Dirk Steffens, TV presenter and
environmentalist

RAISING AWARENESS OF SPECIES EXTINCTION AND CLIMATE CHANGE

The Friends of Senckenberg views itself as a multiplier for Senckenberg topics and aims to generate donations for outreach work and for the Frankfurt museum. Its program includes lectures, discussion evenings, excursions and the biennial "Senckenberg Night" charity gala.

Senckenberg Night 2022 on April 30, 2022.
From left to right: Heike Spiller, Prof. Dr. Andreas Mulch, Prof. Alexandre Antonelli, Simone Loewen, Prof. Dr. Klement Tockner, Kristine McDivitt Tompkins, Dr. Christof Schenck, Dr. h. c. Beate Heraeus

In 2022, experts from Senckenberg spoke at events organized by the Friends of Senckenberg about species extinction, the forests of the future, the renaturation of rivers and the importance of the oceans for humanity. After a two-year break due to the pandemic, the 12th "Senckenberg Night" took place at the end of April under the motto "The World of Forests" (see page 52–53). As part of the gala event, two highly committed and charismatic personalities were awarded the Senckenberg Prize – Prof. Alexandre Antonelli in the "Nature Research" category and Kristine McDivitt Tompkins in the category "Commitment to Nature." Both work toward researching and preserving biodiversity in rainforests and the renaturation and protection of vast mainland and coastal areas in South America. At the preceding "Youth Earth Talk," teenagers and young adults had the opportunity to chat with the two award winners and being inspired by their journey "from knowledge to action."

In early 2023, the oceans and their inhabitants were on the agenda, or more precisely: marine invertebrates and the Senckenberg Ocean Species Alliance (SOSA) project initiated by Senckenberg to research and protect them. During the lecture evening entitled "Planetary Boundaries and Environmental Crises – Scenarios for Our Future," the participants learned just how precarious the situation is for the human species. Other events led through the special exhibition "Creating Climate Knowledge," drew attention to the impressive but little-known urban flora during a #Krautschau (herbage view) walk, and finally provided information on the important role of biodiversity for our soils and groundwater.

Under the motto "The City and the Green: from Trees to #Krautschau," geoecologist Dr. Julia Krohmer led a botanical walk through Frankfurt on September 19, 2023.

We are already looking forward to the events, talks and encounters in 2024, and we are always delighted to welcome new friends and guests!

Heike Spiller, Simone Loewen & Anke Gahmig

WITH HEART AND MIND
FOR BIODIVERSITY AND CLIMATE

Since 2004, Dr. h. c. Beate Heraeus has been committed to Senckenberg; for eleven years she served as President and Chair of the Board of Directors – with unequaled skill, unbridled energy and not least with professional, communicative and social competence. On November 15, 2023, she handed over her office to her long-standing deputy Carsten Kratz.

Dear Beate, in his laudatory speech on the occasion of your farewell as President, Klement Tockner called you a "loyal supporter and determined advocate of biodiversity and climate protection." What was the driving force behind this honorary position?

Nature and its protection have been very close to my heart since childhood and have become a constant in my life. Since I became active on the WWF Executive Committee in 1995, I have been committed to a mindful approach to nature. The mandate at Senckenberg in 2004 offered the opportunity to create a closer link between scientific knowledge and economic necessities and to mediate here. Senckenberg immediately drew me under its spell. In hardly any other organization have I met so many people with such a burning passion for their field.

Dr. h. c. Beate Heraeus was awarded the Golden Senckenberg Medal for her outstanding achievements at the 2023 General Assembly.

What did you see as your role?

I quickly realized that the branch of Science was thriving. But to maintain and promote the innovative, stimulating power of the Senckenberg civil society, we needed support and drive from outside. This is where the committees come into play. The members of the Board of Directors and the Board of Trustees can make a difference through their knowledge, experience and contacts in business and politics. We therefore needed more active committee members.

Are you satisfied with the development when you look back over the last 20 years?

Since 2003, the number of members of the Board of Trustees, who advise and support Senckenberg in non-material and economic matters, has grown to 50. But above all, it is about uniting people so that this movement can grow. If I am happy about one thing, it is that I have infected not only my children but also our friends in family business with the idea toward a responsible approach for the Earth. But we need to reach even more people and create an optimistic mood for the Great Transformation. This will ultimately also lead to social peace.

What can Senckenberg do here?

The Frankfurt and Berlin Declarations initiated by Senckenberg and its partners in 2023 are a step in the right direction – biodiversity is an important driver of the future economy. We also need to encourage more mindfulness and awareness in the programs of our museums and exhibitions. We need to reintroduce people to nature and make it clear that its destruction is endangering the survival of our own species. Science can provide the facts for this. The planned new museum in Frankfurt also offers great prospects in this regard.

So, much remains to be done. You will stay involved with Senckenberg as a member of the Board of Directors. Would you like to give a preview of your future activities?

When we look at the problems arising from the biodiversity loss and climate change, we realize how urgently we need to turn the tide! A commitment to nature means a contribution toward the continued existence of humanity. It depends on each and every one of us to create and promote a sustainable world for our grandchildren. And with Senckenberg behind us, we can truly make a difference.

Thorsten Wenzel asked the questions.

FUNDRAISING FOR SENCKENBERG

In addition to funding from the federal and state governments, the Senckenberg Society works with partners who support our vision and mission and are financially involved in specific projects.

Thanks to funding from private individuals, businesses and foundations, numerous research projects, exhibitions and other initiatives could be realized in 2022 and 2023. From small amounts to larger donations, Senckenberg is grateful to have so many supporters at its side.

EXHIBITION EDMOND 2.0

Edmond 2.0 is a follow-up project to the dinosaur excavation carried out in full view of the public on the grounds of the Senckenberg Natural History Museum until 2022. As part of this project, the scientific results obtained during the investigation of the finds are staged and presented as part of the museum's permanent exhibition. Particular attention is given to the reconstruction of the habitat and living conditions 70 million years ago. Edmond 2.0 was made possible by generous three-year funding from the Lipoid Foundation.

Public excavation in Frankfurt: The finds include an 8 cm long tooth of a *T. rex* as well as bones and teeth of an *Edmontosaurus*.

EDUCATION & OUTREACH, AHA?! SCIENCE LAB

The "Aha?! Science Lab" has quickly become a flagship of our Frankfurt Natural History Museum in Frankfurt (see page 50) – to the delight of our Education & Outreach team. To ensure its continued operation, Senckenberg has established the "Aha?! Science Lab Foundation Alliance." The following seven Frankfurt foundations will support the operation and further development of this special hands-on laboratory in the museum until 2028: Aventis Foundation, Commerzbank Foundation, Deutsche Bank Foundation, Dr. Marschner Foundation, DZ Bank Foundation, Ernst Max von Grunelius Foundation and Frankfurter Sparkasse Foundation.

New exhibit: enlarged model of a marmalade hoverfly with aphids.

SUMMER AND CHRISTMAS MAILINGS INITIATIVE

Every summer and at Christmas, Senckenberg sends out a fundraising mailing dedicated to very special exhibits in the museum. The focus of the 2022 Christmas mailing was the model of a marmalade hoverfly for the special exhibition "City Insects – Frankfurt's Little Helpers," while the 2023 summer mailing asked for support for the restoration of the exhibition highlight "Anaconda Devours Capybara." The mailings are primarily aimed at members of the Senckenberg Society and the general public, whose generous donations made it possible to build or restore these exhibits, respectively.

Dr. Martin Čepek & Charlotte Hemmink

AWARDS AND NOMINATIONS **FOR SENCKENBERGERS**

In 2022 and 2023, many Senckenbergers once again received awards and nominations for their work in the field of science and science communication. We proudly present a selection of recipients below.

Prof. Dr. Katerina Harvati

- **Membership in the Leopoldina 2022**
  German National Academy of Sciences Leopoldina

Dr. Thomas Kastner

- **Lawrence R. Klein Award 2022**
  Pan Pacific Association of Input-Output Studies

Prof. Dr. Willi Xylander

- **Order of Merit of the Federal Republic of Germany 2022**
  Federal President

Prof. Dr. Angelika Brandt

- **Carlo Heip Excellence Award in Marine Biodiversity 2023**
  International Association for Biological Oceanography (IABO)

Anthony Buaya

- **Oscar Brefeld Prize 2023**
  German Mycological Society e. V.

Dr. Ulrike Damm

- **Highly Cited Researcher in the field of Plant and Animal Science 2023**
  Clarivate™

Prof. Dr. Katrin Böhning-Gaese

- **Science Communication Medal 2023**
  Göttinger Literaturherbst GmbH
- **Member of the German Council for Sustainable Development**
  Federal Government

Anne Kiefer

- **Leibniz-Apprentice Award 2023**
  Leibniz Association

Dr. Martin Päckert

- **German Photo Book Prize 2023**
  Photographic Images Festival e. V

Prof. Dr. Klement Tockner

- **German Champion Award of the Frontiers Planet Prize 2023**
  Frontiers Research Foundation

SENCKENBERG
PUBLICATIONS 2022–2023

The Senckenberg Society for Nature Research publishes a variety of series. The following list summarizes the volumes and titles published in 2022 and 2023. Further information about the publications can be found at www.senckenberg.de/en/Science/Senckenberg-Publications.

SCIENTIFIC JOURNALS

- ARCHIV FÜR MOLLUSKENKUNDE, Volume 151 (1–2), 152 (1–2), Dr. John M. C. Hutchinson, Dr. Heike Reise, Dr. Katrin Schniebs, Prof. Dr. Julia D. Sigwart (Editors-in-Chief)
- ARTHROPOD SYSTEMATICS & PHYLOGENY, Volume 80, 81, Dr. Klaus-Dieter Klass (Editor-in-Chief)
- CONTRIBUTIONS TO ENTOMOLOGY, Volume 72 (1–2), 73 (1–2), Prof. Dr. Thomas Schmitt (Editor-in-Chief)
- GEOLOGICA SAXONICA, Volume 68, 69, Prof. Dr. Jan-Michael Lange (Editor-in-Chief)
- MARINE BIODIVERSITY, Volume 52 (1–6), 53 (1–6), Prof. Dr. Pedro Martínez Arbizu (Editor-in-Chief)
- PALAEOBIODIVERSITY AND PALAEOENVIRONMENTS, Volume 102 (1–4), 103 (1–4), Dr. Peter Königshof, Prof. Dr. Dieter Uhl (Editors-in-Chief)
- SOIL ORGANISMS, Volume 94 (1–3), 95 (1–3), Prof. Dr. Willi Xylander, Prof. Dr. Nico Eisenhauer (Editors-in-Chief)
- VERTEBRATE ZOOLOGY, Volume 72, 73, Prof. Dr. Uwe Fritz (Editor-in-Chief)

SCIENTIFIC MONOGRAPHS AND BIBLIOGRAPHIES

- ACARI – Bibliographia Acarologica, Volume 22 (1–3), 23, Dr. Axel Christian (Editor-in-Chief)
- NOVA SUPPLEMENTA ENTOMOLOGICA, Volume 27, Prof. Dr. Thomas Schmitt (Editor-in-Chief)

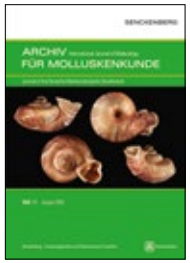
POPULAR SCIENTIFIC PUBLICATIONS

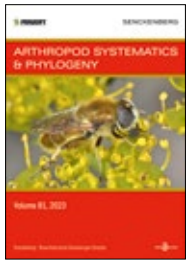
- SENCKENBERG-BUCH, Prof. Dr. Klement Tockner (Publisher)
  Band 87, Starke-Ottich, I.; Zizka, G.: Wildnis in Frankfurt
  Band 88, Hoppenrath, M.; Chomérat, N.; Horiguchi, T.; Murray, S. A.; & Rhodes, L.: Marine benthic dinoflagellates – their relevance for science and society
- SENCKENBERG – natur • forschung • museum, Band 152, 153 (1–4), Prof. Dr. Klement Tockner, Dr. h. c. Beate Heraeus (Publisher), Thorsten Wenzel (Editor-in-Chief)

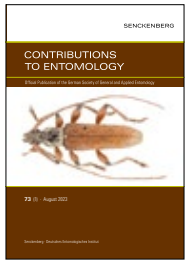
OTHER PUBLICATIONS

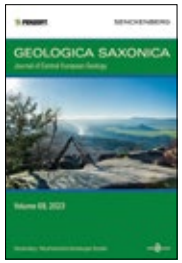
- SENCKENBERG Annual Report 2021, Prof. Dr. Klement Tockner (Publisher), Thorsten Wenzel (Editor-in-Chief)
- POLICYBRIEF 06/2022, SGN (Publisher), Naturbasierte Lösungen verbessern Hochwasserschutz und Biodiversität
- POLICYBRIEF 12/2022, SGN (Publisher), Vielfalt in der Finsternis – Wirksamer Meeresschutz braucht mehr Wissen über Arten.
- Grundwasser lebt! Zumkowski-Xylander, H.; Fritzsche, F.; Weber, A.; Xylander, W.
- Floralia. Merian – Schultz – Crespo Franzen, B.; Wagner, E. (Hrsg.)

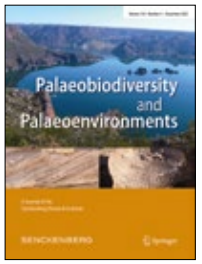
SCIENTIFIC JOURNALS

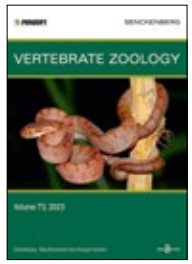




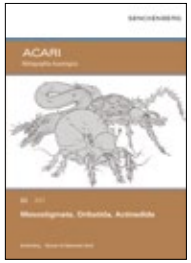


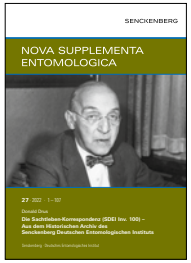




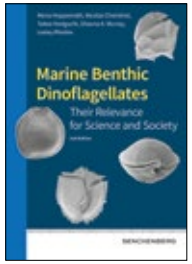


SCIENTIFIC MONOGRAPHS AND BIBLIOGRAPHIES

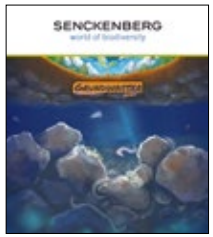




POPULAR SCIENTIFIC PUBLICATIONS



OTHER PUBLICATIONS



BODIES AND COMMITTEES
OF THE SENCKENBERG GESELLSCHAFT FÜR NATURFORSCHUNG (SENCKENBERG SOCIETY FOR NATURE RESEARCH)

HONORARY PRESIDENT
Prof. h. c. Wolfgang Strutz

BOARD OF DIRECTORS
Prof. Dr. Klement Tockner
// Director General

Dr. Martin Mittelbach
// Administrative Director

Prof. Dr. Angelika Brandt

Prof. Dr. Andreas Mulch

EXECUTIVE COMMITEE OF THE SUPERVISORY BOARD
Carsten Kratz
// President

Dr. Holger Alfes

Dr. h.c. Beate Heraeus

Bernd Loewen

Dr. Dorothee Lux

Dr. Stefan Johannes Stupp

SUPERVISORY BOARD
Elected members
Carsten Kratz

Dr. Holger Alfes

Dr. h. c. Beate Heraeus

Bernd Loewen

Prof. Dr. Jochen Maas

Emmerich Müller

Kathrin Quandt

Prof. Dr. Enrico Schleiff

Dietmar Schmid

Delegates
Dr. Dorothee Lux

Dr. Tim Metje

Jana Podßuweit

Dr. Stefan Johannes Stupp

Delegates (information status)
Marco Keser

Veronica Kuntze

Dr. Inge Schlotzhauer

Dr. David Schnieders

Additional members
Dr. Ina Hartwig

Dr. med. Kosta Schopow

Guests
Sabine Dittrich

Prof. Dr. Heinz Riesenhuber

Dr. Stephanie Kramer-Schadt

Prof. h. c. Wolfgang Strutz

Board of Directors

SCIENTIFIC ADVISORY BOARD
Prof. Dr. Stephanie Kramer-Schadt
// Chair

Prof. Dr. Bodil Bluhm

Prof. Dr. Henrik Krehenwinkel

Ass.-Prof. Dr. Jacqueline Loos

Prof. Dr. Hermann Parzinger

Dr. Marian Vanhaeren

Prof. Dr. Alfried P. Vogler

Prof. Dr. Hildegard Westphal

Prof. Dr. Ricarda Winkelmann

SCIENTIFIC COMITTEE
Delegation
Prof. Dr. Katrin Böhning-Gaese

Prof. Dr. Brigitte Franzen

Prof. Dr. Uwe Fritz

Prof. Dr. Katerina Harvati

Prof. Dr. Pedro Martínez Arbizu

Dr. Torben Riehl
Prof. Dr. Thomas Schmitt
Dr. Martina Stebich
PD Dr. Andrea Sundermann
Prof. Dr. Karsten Wesche

Elected members

Prof. Dr. Christiane Ritz // Chair
Dr. Lutz Kunzmann // Vice Chair
PD Dr. Raffael Ernst
Prof. Dr. Susanne Fritz
Prof. Dr. Thomas Hickler
PD Dr. Mona Hoppenrath
Dr. Gerald Mayr
Dr. Christian Printzen
Prof. Dr. Dieter Uhl

Co-opted members

Lennart Gries
Prof. Dr. Michael Hiller
Dr. Kerstin Höntsch
Sabine Wilke

BOARD OF TRUSTEES

Boris Rhein // Chair
Friedrich von Metzler // Vice Chair
Rainer Ballwanz
Burkhard Balz
Ralf Baukloh
Dr. Auguste Prinzessin von Bayern
Volker Bouffier
Dr. Werner Brandt
Detlef Braun
Dr. h.c. Josef Buchmann
Dr. Alexandra Budde
Friederike von Bünau
Dr. h. c. Udo Corts
Dr. Philipp Demandt
Prof. Dr. Frank E. P. Dievernich
Prof. Dr. Christian Duve
Dr. Susanne Eickemeier
Annika Fink
Dr. Alexander Frey
Dr. Thomas Gauly
Sen. E. h. Prof. Carlo Giersch
Thomas Groß
Joachim Häger
Klaus Hamacher
Dr. Fabian Heilemann
Donatus Landgraf von Hessen
Prof. Dr. Eckart von Hirschhausen
Prof. Dr. Barbara Ischinger
Mike Josef
Prof. Dr. Dr. h. c. mult. Matthias Kleiner
Michael Kretschmer
Prof. Dr. Harald Lesch
Dr. Stephanie Prinzessin zu Löwenstein
Dr. Michael Meister, MdB
Prof. Dr. Manfred Niekisch
Dr. Lutz Raettig
Frank Riemensperger
Dr. Cornelius Riese
Dr. h. c. Petra Roth
Dr. Christof Schenck
Prof. Dr. Martin R. Stuchtey
Prof. Dr. Manfred Schubert-Zsilavecz
Prof. Dr. Kristina Sinemus
Heike Spiller
Dirk Steffens
Wolfgang Steubing
Karl-Heinz Streibich
Prof. Dr. Martin R. Stuchtey
Arno Walter
Dr. Ingo Wiedemeier
Ulrich Wilhelm
Prof. Dr. Alexander Zehnder

DIVERSITY AND INCLUSION COMMITTEE

Prof. Dr. Julia D. Sigwart // Chair
Frank Berndsen
Jana Bingemer
Dörte Florack
Nadina Giardino
Dr. Sabine Holst
Dr. Kerstin Höntsch
Eva Kleibusch
Àngel Blanco Lapaz
Dr. Thomas Lehmann
Francesca Lanterna
Dr. Lisa Lehnen
Dr. Martin Päckert
Patrick Falk von Salm
Editha Schubert
Sabine Wilke

SENCKENBERG
BY THE NUMBERS 2022–2023

The Senckenberg Gesellschaft für Naturforschung (Senckenberg Society for Nature Research, SGN) was founded in 1817. Under the roof of SGN, 8 research institutes, 5 research stations and 3 natural history museums in Germany conduct research in bio- and geosciences. The misson of its Articles of Association is to make science and scientific findings accessible to the public through teaching, publishing and the natural history museums. The natural history museum in Frankfurt is one of the largest in Europe. Here are some key figures.

8 RESEARCH INSTITUTES
Dresden, 2 × Frankfurt, Görlitz, Jena, Müncheberg, Tübingen & Wilhelmshaven

with

3 NATURAL HISTORY MUSEUMS
Dresden, Frankfurt & Görlitz

5 RESEARCH STATIONS
Gelnhausen, Hamburg, Messel, Schöningen & Weimar

* founded in April 2024

834** STAFF MEMBERS FROM 50 COUNTRIES OF ORIGIN

7,200 MEMBERS

1.957 PUBLICATIONS

- **1.652** Articles in Scientific Journals
- **102** Contributions to Scientific Books
- **21** Scientific Books
- **182** Museum and popular science publications

FOLLOWER APPROX.
90.096

- **26.957** Facebook
- **12.858** Twitter
- **10.468** Instagram
- **34.800** TikTok
- **1940** YouTube
- **1703** LinkedIn
- **590** BlueSky
- **780** Threads

PRESS RESPONSE 2022–2023
52,044
mentions in analog and digital media

4,229** Citizen Scientists in **32** Citizen Science Projects

41.4** **MIO.**
COLLECTION OBJECTS

524 NEW SPECIES
DISCOVERED BY SENCKENBERG EMPLOYEES

APPROX.
2.1 MIO.
DIGITAL VISITORS

956,930
ACTUAL VISITORS

- **874,276** Frankfurt
- **21,085** Dresden
- **61,569** Görlitz

** Status: 31/12/2023

Imprint

Publisher:
Prof. Dr. Klement Tockner,
Senckenberg Society for Nature Research
// Senckenberg Gesellschaft für Naturforschung (SGN),
Senckenberganlage 25, 60325 Frankfurt am Main, Germany

The SGN is a member of the Leibniz Association.

Head of Communications:
Sabine Wilke

Editor-in-Chief:
Thorsten Wenzel

Editorial Collaboration:
Isabell Clasen, Katharina Decker, Burcu Kirtas

Credits:
Front Cover: Gritta Veit-Köhler; p. 3 top left: Gritta Veit-Köhler, top right: Anna Hundsdörfer, SNSD, bottom left: Sven Tränkner, bottom right: Oliver Laux; p. 7: T. dos Santos Miranda; p. 8 left: Tomas Lundaelv, left: Ulet Ifansasti/Greenpeace; p. 9 left: Daniel Kersken, right: Picture contains modified Copernicus Sentinel data (2023), processed by ESA; p. 10: Torben Riehl; p. 11: Carly Rospert; p. 12: shutterstock.com/oNabby; p. 13 bottom left: Oliver Farcy, top right: Sven Tränkner, middle: Sven Tränkner; p. 14: Mona Hoppenrath; p. 15: Valentin Marquardt/Tübingen University; p. 17: Senckenberg; p. 18: James Gathany/CDC; p. 20: Jan Noack; p. 22: shutterstock.com/chayanuphol; p. 23: AgriFuture; p. 24: fireEUrisk/fireurisk.eu; p. 26/27: Spyros Theodoridis; p. 28: Thomas Schmitt; p. 29: Stephan Durst and Jan Schuckenbrock; p. 30: Volker Minkus; p. 31 bottom left: Jürgen Vogel, LVR-LandesMuseum Bonn, top right: Tom Bjoerklund; p. 32: Flavio Altamura; p. 34/35: Ralf Britz, SNSD; p. 36: Geosciences Department, SNSD; p. 37 bottom left: John-A. Keiler/Evelin Haase, top right: CDU Landesverband Sachsen; p. 38–40: Sven Tränkner; p. 42 middle/bottom: Goethe-Universität/SGN; p. 43 top: Sven Tränkner; p. 44: SMNG; p. 45 left/middle: Jacqueline Gitschmann, right: SPK/photothek.de/ Thomas Trutschel; p. 46: SNSD; p. 47: Tobias Ritz; p. 48: Willi Xylander, SMNG; p. 49 left: SMNG, right: Sven Tränkner; p. 50: Sven Tränkner; p. 51 left: Daniela Warzecha, right: DIE ZEIT; p. 52: Sven Tränkner; p. 54 left: Oliver Laux, right: Julia Krohmer; p. 55–56: Sven Tränkner; back cover: Gritta Veit-Köhler; all other images: SGN

Design:
www.ca-di.de

English Translations:
Hendrik Herlyn / hhactitis@gmail.com

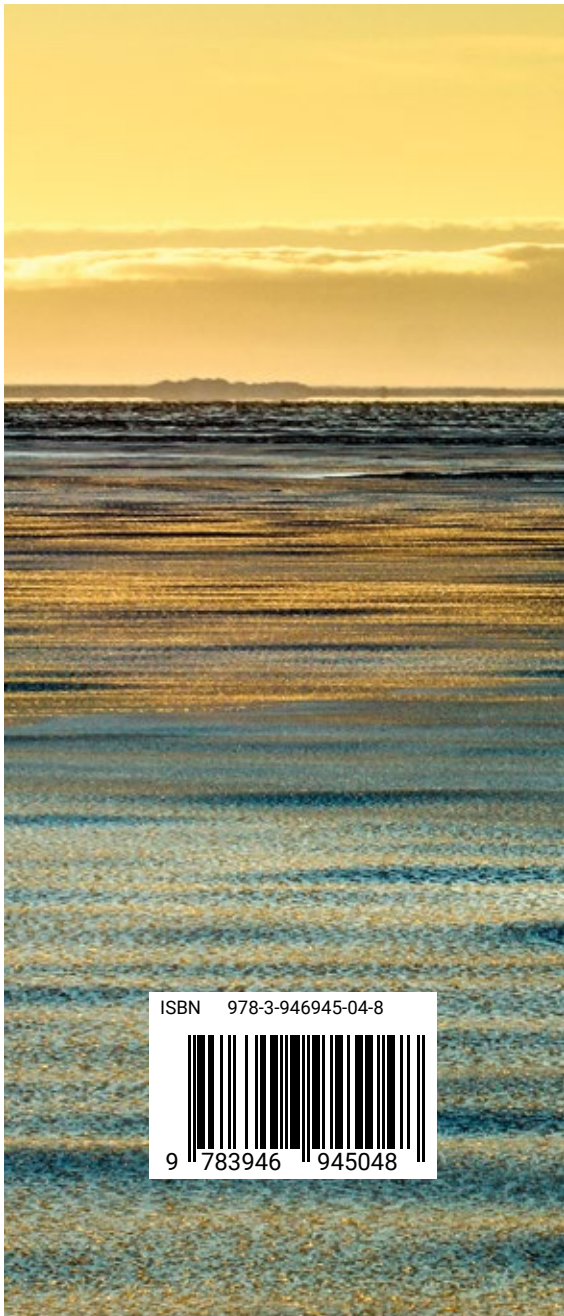
Printed by:
Druck- und Verlagshaus Zarbock GmbH & Co. KG

ISBN 978-3-946945-04-8
Printed in Germany

WWW.SENCKENBERG.DE

Ice algae – brought to light by the "Polarstern." Ice algae grow in the brine channels on the underside of the sea ice. When the ship breaks through the ice sheet, many floes are turned upside down and the brownish-green algae on which the microorganisms of the Southern Ocean feed (see page 29) become visible.

View from the deck of the "Polarstern." When ice crystals that have risen due to freezing are evenly mixed by wave movements on the water's surface, they form a slushy mix known as "grease ice." Turbulent weather conditions cause the ice layer to break up into round chunks called "pancake ice," as seen here.



ISBN 978-3-946945-04-8

9 783946 945048