SCIENCE HISTORY
Approved for species protection

ARCHAEOGENETICS
The bitter legacy of slavery

IRON RESEARCH
A legend from the 3D printer

ALL EARS
Recording is running. Ever since the development of good quality sound technology, we have been able to create background music whenever – and nearly wherever – we want it. As a current survey confirms, nearly two-thirds of people living in Germany listen to music, podcasts or the radio over their headphones several times a week. Using special technologies, researchers have been able to trace the effect of soundwaves, and can even turn them to good use.
Dear reader,

Who thinks of physics or neurobiology when listening to “Bad Guy” by Billie Eilish or Beethoven’s Ninth Symphony? Instead, we let the sounds transport us, the voices touch our emotions, and the rhythms carry us away. But before any of that can happen, we first have to actually perceive sound. Sound reaches our ears in the form of waves; it is converted to electrical signals, which are then unscrambled by our brain’s busy switchboards. This last sentence may admittedly sound a bit flippant. But this is how one of the researchers featured in our “Focus” article describes the essence of his work – and it is far from trivial. What actually happens in our brain when it processes sound? Why do we perceive some tones or sounds as pleasant and others as unpleasant? And what’s behind the success of hit songs like “Yesterday?”

From the melancholy and gentle Beatles song, we move on to the raw reality of the animal kingdom. When dusk falls, the great hunt begins. Bats swoop through the air in search of prey. The animals use ultrasound to locate their targeted prey even in complete darkness. They have developed sophisticated hunting methods to ensure that moths and grasshoppers do not escape them. But the creatures they hunt have their own defenses.

Speaking of ultrasound: we experience its practical application on our own bodies, for example during a thyroid gland examination. But how else can ultrasonic frequency help us? In fact, scientists are using ultrasound to join particles into three-dimensional structures. And such acoustic holograms are far more than just gimmicks. One day, they could be used to produce artificial tumors or organoids for testing pharmaceuticals, and in this way, probably also reduce the number of animal tests.

We wish you an exciting reading experience full of surprising insights!

Your editorial team
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CLOSE TO HEAVEN:
THE VERY LARGE TELESCOPE
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They are called Antu, Kueyen, Melipal and Yepun – in the language of the indigenous Mapuche people, the names of the Sun, the Moon, the Southern Cross, and Venus. These four telescopes form the heart of the most advanced observatory in the world, at an elevation of 2,635 meters on the Cerro Paranal in the middle of the Atacama desert in Chile. From here, the astronomers probe the depths of the universe with the main mirrors, each with a diameter of 8.2 meters, and the four movable 1.8 meter auxiliary telescopes. This telescope facility, the Very Large Telescope of the European Southern Observatory (VLT), can be connected to an interferometer that produces images of the sky with an angular resolution of thousandths of an arc second. This level of precision would enable the two headlights of a car on the moon to be distinguishable from one another.

However, the telescope is only as good as its instruments. Max Planck scientists have helped to invent some of these, such as the GRAVITY and MATISSE interferometers, the SPIFI spectrograph and the SPHERE planet hunter. Recently, researchers under the direction of the Max Planck Institute for Extraterrestrial Physics succeeded in getting a clearer view into the heart of the Milky Way with their hi-tech optics. There they were able to observe that a star does not orbit the supermassive black hole at the heart of our Milky Way along a closed path, but rather describes an open curve in the form of a rosette. Albert Einstein predicted this effect more than a hundred years ago.
NEW TEAM, NEW IDEAS

In July 2020, three new Vice Presidents took office at the Max Planck Society. Asifa Akhtar, Director of the Max Planck Institute of Immunobiology and Epigenetics in Freiburg, is the first female Vice President of the Biology and Medicine Section. Born in Pakistan, Akhtar wants to advance internationalization at the Max Planck Society and is the contact person for the Max Planck Schools. Equality and diversity are also important to her. The Vice President of the Humanities, Social and Human Sciences Section is Ulman Lindenberger, Director of the Max Planck Institute for Human Development in Berlin. In this position, he will take over the scientific management of the Minerva Foundation for the Promotion of Scientific Cooperation with Israel. Lindenberger is also keen to provide new stimuli for the appointment procedure at the Max Planck Society. Klaus Blaum, Director of the Max Planck Institute for Nuclear Physics in Heidelberg, is the Vice President of the Chemistry, Physics and Technology Section. He is responsible for technology transfer and Cyber Valley, but the issue of sustainability is also close to his heart. Blaum also aims to improve the exchange with the Chinese Academy of Sciences. Nicola Leibinger-Kammüller, Chairperson of the Management Board of Trumpf, took office as an external member of the Executive Committee.

www.mpg.de/15105526

IDENTIFYING VICTIMS

During the Nazi era, the predecessors of several Max Planck Institutes used the remains of victims of the Nazi regime for their research. After the end of World War II, the Institutes kept and in some cases even used these specimens, most of which were sections of brain tissue, until the Max Planck Society had them interred in 1990. In 2015 and 2016, still more specimens were discovered at the Max Planck Institutes of Psychiatry and Brain Research. Max Planck President Martin Stratmann responded to these findings by having an external expert committee investigate the identity and origins of all the victims whose remains had been found. In the spring of 2020, the commission presented its initial results in the form of an interim report: they had succeeded in finding out the names of the victims in more than one thousand cases. Some of them had lived at the mental institution in Eglfing-Haar, near Munich. The Nazis had murdered them because of their physical or mental disabilities. Other victims came from the occupied Polish territories, were prisoners of war, or were executed by the Nazi Volksjustiz (the so-called People’s Justice).

www.mpg.de/14472738
GENE SCISSORS AGAINST HIV

It could be the first treatment to permanently eliminate the HIV virus from the body – the medications currently available are only able to keep it at bay. A team from the Heinrich Pette Institute – Leibniz Institute for Experimental Virology (HPI) in Hamburg and the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden has developed ‘gene scissors’ using an enzyme known as Brecl, which can cut the genetic material of the AIDS pathogen out of the genome of infected cells and thus remove the virus. The Hamburg-based biotech startup Provirex has developed this technology further so that it is now ready for use in the form of stem cell treatment. The HPI and the Medical Center Hamburg-Eppendorf are now preparing for clinical trials in which the treatment will be administered to eight patients.

www.mpg.de/14744748

AWARD-WINNING *

VOLKER SPRINGEL

Volker Springel, Director of the Max Planck Institute for Astrophysics in Garching, has been awarded the 2020 Gruber Cosmology Prize for his valuable contribution to simulations of the universe. Springel will share the US$500,000 prize money with Lars Hernquist from the Harvard-Smithsonian Center for Astrophysics. The two researchers have developed methods for testing theories about the formation of structures in the universe on scales that encompass stars, galaxies, and even the universe itself. To this end, they developed numerical algorithms and community codes that many other researchers are now also using.

FRIEDRICH BONHOEFFER

Friedrich Bonhoeffer, Emeritus Director of the Max Planck Institute for Developmental Biology inTuebingen, has been awarded the 2020 Gruber Neuroscience Prize. Bonhoeffer shares the prize with Corey Goodman from the University of California in San Francisco and Marc Tessier-Lavigne from Stanford University for their joint research into molecular mechanisms in the central nervous system. The discoveries made by these three researchers have fundamentally changed our understanding of the formation of neural networks in the brain and have led to insights into neurological and psychiatric diseases and how the nervous system recovers after injury.
PHOTOSYNTHESIS IN A DROPLET

Plants have been able to do it for millions of years, now humans may soon be able to do it too: photosynthesis, i.e. the harnessing of solar energy to convert carbon dioxide into usable carbon compounds. Researchers at the Institute for Terrestrial Microbiology in Marburg, working as part of the interdisciplinary research network MaxSynBio, have now developed minute compartments in which solar energy is converted into chemical energy, not unlike the process that takes place in natural chloroplasts in plants. To do this, they started by isolating the chloroplast membranes of spinach plants; the photosynthesis apparatus found on these membranes, which converts light energy into chemical energy, was then coupled with a metabolic module developed by the scientists themselves. This CETCH cycle, which consists of 18 enzymes, uses the energy to build carbohydrates from carbon dioxide in a way which is more efficient than natural photosynthesis. Working in cooperation with colleagues in France, the Max Planck scientists have developed a method with which they can encapsulate the metabolic pathway within tiny droplets. This enables them to produce thousands of standardized compartments or assign various attributes to individual droplets. The artificial chloroplasts can already fix carbon dioxide 100 times faster than previous systems. Another advantage is that these chloroplasts contain only the components that are absolutely necessary for photosynthesis. At the same time, they are not dependent on natural enzymes. In future, researchers will therefore be able to use the new artificial chloroplasts to test reaction pathways that do not occur in nature. Lifelike systems of this kind could be used to produce almost any kind of material in many technological areas, such as material science, biotechnology and medicine. They could also facilitate the use of ambient carbon dioxide, thus making it possible to exploit the greenhouse gas as a source of raw material in the future.

www.mpg.de/14788928
THE ANXIETY OVER TOILET PAPER

The rapid spread of COVID-19 throughout Europe and North America in March 2020 caused many people to stockpile large quantities of certain commodities. Some toilet paper manufacturers, for example, saw their sales rise by up to 700 percent. In a study of more than one thousand adults from 35 countries conducted at the end of March 2020, researchers at the Max Planck Institute for Evolutionary Anthropology in Leipzig investigated possible connections between personality traits and the purchase of these hygiene articles. They also analyzed the age, perceived level of threat, and quarantine behavior of the participants. The results showed that anxious people who felt more threatened by the pandemic stockpiled more toilet paper. Personality traits such as conscientiousness, perfectionism and cautiousness also affected their purchasing behavior. Moreover, it was found that older people stockpiled more toilet paper than younger people and Americans stockpiled more than Europeans. However, the results obtained by the scientists only partly explain the discrepancies in purchasing behavior. This means there must still be undetermined factors that explain this anxiety over toilet paper.

www.mpg.de/14938948 (in German)

INSIDE A QUASAR’S ENGINE’S ROOM

The first image of a black hole, which was successfully captured by the Event Horizon Telescope (EHT), was hailed as a scientific sensation. Almost exactly one year later, the collaborating researchers presented images of a so-called jet spewing from the black hole at the center of quasar 3C 279. Remarkable for their unprecedented detail, the photos show the gigantic mass shooting a beam of ionized gas into space at almost the speed of light. The international team led by Jae-Young Kim from the Max Planck Institute for Radio Astronomy in Bonn studied the shape of the beam near its baseline, where high-energy variable gamma radiation is believed to be generated. The telescopes linked in the EHT project show details that are shorter than a light year. This makes it possible to track the jet as far as the accretion disk believed to be at the edge of the black hole, and to observe the interaction between the disk and the jet. However, the normally straight jet appears to be twisted at its base. Furthermore, structures moving across the jet’s direction of travel, presumably parts of the accretion disk, are now visible for the first time. Comparisons of images captured on consecutive days clearly show that the structure is changing, perhaps because of the collision and shredding of orbiting matter on the accretion disk and the ejection of material in the form of a jet. This scenario was previously only seen in numerical simulations.

www.mpg.de/14660592

A look inside the heart of a quasar: the images capture the jet structure at the center of 3C 279 at different wavelengths, each at increasing angular resolutions. The observation dates, the telescope arrays used and the wavelengths are noted in each panel.
OVERCOMING THE WEAKER SELF

Although we should know better, we frequently make choices that are not good for us and then feel bad about them later on. However, we can strengthen our self-control by making simple changes to our environment. Researchers from the University of Helsinki and the Max Planck Institute for Human Development describe how psychology can be used to this end. Their advice includes using reminders and prompts, e.g. putting a photo of a carrot on the refrigerator door or putting running shoes next to the bed. Another useful idea is to give decisions a different angle: we can for example choose to welcome each flight of stairs as an opportunity to minimally increase our life expectancy. Furthermore, we should make harmful things less accessible, i.e. we should put potato chips and candy high up on the top shelf of the kitchen cabinet and keep fruit within easy reach on the table. Last but not least, we can increase our accountability by using social agreements to put ourselves under pressure, e.g. by arranging to meet other people to go jogging.

WHERE COVID-19 ALSO PUTS YOUNGER PEOPLE AT RISK

For people in Europe, age is one of the risk factors that influence the severity of COVID-19. However, although the populations of many countries in the southern hemisphere are on average younger, they are no less affected by the pandemic. According to a study by the Max Planck Institute for Demographic Research in Rostock, one reason for this is that the proportion of people of working age who suffer from pre-existing conditions is significantly higher there than in Europe. In Brazil and Nigeria, for example, the number of people in their early 20s who have cardiovascular disease is more than twice as high as in Italy. Chronic renal failure and chronic obstructive pulmonary disease are significantly more widespread among 40-year-olds in Brazil and Nigeria than in Italy; in fact, it is four times more prevalent among women in Nigeria. This also significantly increases the risks associated with COVID-19.
RELATIONSHIP CRISIS

Female giraffes are choosy: while they like to associate with some females, they prefer to avoid others. The result is a complex, multi-layered society of female giraffes. An international team including a researcher from the Max Planck Institute of Animal Behavior in Konstanz observed 540 female giraffes in Tanzania over a period of six years, thus gaining insight into the largest social network of wild mammals studied to date. The results showed that the animals live in discrete social groups of 60 to 90 females. These groups rarely mix, even when they share the same living space. However, humans are disrupting the animals’ social environment. The researchers have observed that individual giraffes living close to villages of indigenous Masai form less strong social bonds among themselves and have less contact with other females of their species. The Masai tolerate the giraffes, but the giraffes often encounter humans and cattle around the compounds. This could be causing the groups to split up. It is particularly common for females with calves to spend time close to human settlements, possibly because this means their calves are better protected from attacks by lions and hyenas. It therefore seems that female giraffes face a trade-off between their social bonds and the safety of their calves. This disruption of their social system – along with poaching and the loss of habitat and food supply – could be why the population of Masai giraffes has declined by 50 percent in recent years. However, the researcher still have to determine how disrupted social behavior is weakening the giraffe population.

www.mpg.de/14898269

Masai giraffe in the Tarangire ecosystem in Northern Tanzania. Populations here have declined by half in recent years.
**FRUITFUL ENCOUNTER**

Modern humans and Neanderthals interbred many times throughout the course of evolution. This has left traces in human DNA. Researchers at the Max Planck Institute for Evolutionary Anthropology in Leipzig and the Karolinska Institute in Sweden analyzed the biobank data of more than 244,000 women and discovered that one in three European women have inherited the Neanderthal receptor gene. 29 percent carry one copy of the Neanderthal gene, while three percent actually carry two copies. This means that the proportion of women carrying a Neanderthal variant of the gene is about ten times higher than for most other genes. Women with this variant have more progesterone receptors in their cells. This means they are more sensitive to the hormone and are better protected from miscarriage and bleeding. They also give birth to more children.

**MYSTERY OF THE SOLAR CYCLE IS ILLUMINATED**

Solar activity fluctuates in a rhythm of about eleven years, which is reflected in various phenomena such as the frequency of sun spots. A complete magnetic period lasts 22 years. Researchers have long been puzzling over what causes this cycle. There must be a connection with the conditions beneath the star’s “skin”: a layer of hot plasma — electrically conductive gas — that covers the surface of the sun to a depth of 200,000 kilometers. The plasma inside this convection zone is constantly in motion. A team of researchers led by Laurent Gizon from the Max Planck Institute for Solar System Research has now succeeded in drawing the most comprehensive picture to date of these plasma flows in a north-south direction. The researchers found that the flow symmetry is remarkably simple: the plasma makes a single circuit lasting approximately 22 years in each solar hemisphere. In addition, the flow toward the equator at the bottom of the convection zone causes spots to form closer and closer to the equator as the solar cycle progresses, a phenomenon that has long since been reflected by the well-known butterfly diagram.

![Diagram](https://www.mpg.de/14877152)

Modern humans and Neanderthals interbred many times throughout the course of evolution. This has left traces in human DNA.

![Diagram](https://www.mpg.de/15032287)

In brief

**MICROTRANSPORTER FOR THE BLOODSTREAM**

Another step has been taken towards the goal of accurately guiding medication through the bloodstream to diseased tissue. A team at the Max Planck Institute for Intelligent Systems in Stuttgart has developed a microrobot that resembles a white blood cell in size, shape and mobility. The researchers loaded a microtransporter with medicinal substances, guided it towards diseased tissue with the help of antibodies, and then rolled it through an artificial blood vessel using magnetic forces, thus simulating flow against the bloodstream. The ability to roll with and against the flow of blood in a blood vessel may make it easier to transport substances to a specific location, such as a tumor. In further tests, the microrobot targeted cancer cells and discharged an active substance at the location.

![Diagram](https://www.mpg.de/14901427)
QUANTUM LEAP TIPPING THE BALANCE

A new door to the quantum world has been opened: every time an atom absorbs or releases energy via the quantum leap of an electron, it becomes heavier or lighter. This is due to the connection between energy and mass, which Albert Einstein expressed in the formula \( E = mc^2 \). However, in an individual atom, this effect is as minuscule as the difference in mass that an ant weighing ten milligrams would make if it were standing on an elephant weighing six tons. Nevertheless, an international group led by a team from the Max Planck Institute for Nuclear Physics in Heidelberg has succeeded in measuring this infinitesimal change in the mass of individual atoms. In order to achieve this, they used the atomic balance known as Pentatrap. The charged atoms rotate in this trap, and the lighter they are, the faster they rotate. Since the orbital frequency can be determined very accurately, the researchers can determine the mass of the atoms with exceptional precision. In this way, they discovered that the rare metal rhenium has a previously unknown quantum state that could be of interest for future use in atomic clocks. This extremely sensitive atomic balance thus facilitates a better understanding of the complex quantum world of heavy atoms.

www.mpg.de/14793234

UNDERSTANDING WEATHER FORECASTS

Many Germans have difficulty correctly assessing weather risks. This was the result of a representative survey conducted by the Max Planck Institute for Human Development and the Hans-Ertel Centre for Weather Research. Over one thousand Germans aged between 14 and 93 answered factual questions about the weather and its effects. A large proportion of those questioned judged the risks incorrectly. For example, 44 percent of respondents believed that ground frost, which can cause icy conditions on roads and sidewalks, can only form at air temperatures of 0 degrees Celsius or below – a misconception that can become dangerous in traffic. Moreover, two-thirds of respondents incorrectly believed that higher temperatures mean higher levels of UV radiation. And if a thunderstorm were approaching, many respondents would probably not take shelter in time: only one in five correctly estimated that a 30-second delay between a lightning flash and the sound of thunder means that a thunderstorm is about ten kilometers away. Furthermore, only one in five respondents were able to correctly interpret information about the probability of rain. The research team therefore calls for a new type of risk forecast that not only states what the weather will be, but also what damage it can cause.

www.mpg.de/14847266

This storm cloud over Munich threatens heavy rain – this is probably clear to most people. However, four in five Germans did not understand what was meant by the probability of rain.
A TOUCH OF GOLD AND SILVER

One might think that gold leaf, which is only 0.1 µm thick, is actually quite thin. This is far from true: in fact, it can actually be several hundred times thinner. Working in cooperation with partners in Pisa and Lund, researchers at the Max Planck Institute for Solid State Research in Stuttgart have now created crystalline layers of gold and silver that are just one atom thick. The team also found that two-dimensional gold and silver behave like semi-conductors, even though three-dimensional forms of these precious metals conduct electricity very well. This unusual electrical behavior may be due to the fact that these ordered layers of gold and silver can only be produced between a substrate of silicon carbide and a sheet of graphene, i.e. a layer of carbon atoms. When they are in two-ply layers, the metals revert to their previous state as metallic conductors.

Combining single and double layers of precious metals could for example enable smaller diodes to be constructed than is possible today.

HEAT IN SPRING, DROUGHT IN SUMMER

The conditions for the extreme drought in the summer of 2018 were created that spring. Because the spring was very hot that year, the vegetation grew rapidly and absorbed a large amount of water from the soil early on, thus intensifying the summer drought, especially in Northern and Central Europe. The seasonal connection between a warm spring and a dry summer was discovered in a simulation carried out by an international team that included scientists from the Max Planck Institute for Biogeochemistry in Jena. The unusual climatic conditions affected the carbon balance of ecosystems differently from region to region, depending on the respective vegetation. Climate change will cause the risk of drought to increase. Informed decisions as to which plants should grow where could mitigate drought periods and their impact.

OUR Deepest View of the X-Rayed Sky

After 182 days, the x-ray telescope eRosita has completed its first full sweep of the sky. The resulting new map of the hot, energetic universe contains more than one million objects, roughly doubling the number of known x-ray sources discovered over the 60-year history of x-ray astronomy. Most of the new objects are active galactic nuclei at cosmological distances, marking the growth of gigantic black holes over cosmic time.

“This image completely changes the way we look at the energetic universe,” explains Peter Predehl, the project’s Principal Investigator at the Max Planck Institute for Extraterrestrial Physics in Garching. The universe viewed by x-ray looks quite different to the view through optical or radio telescopes. Most of the sources outside our galaxy are active nuclei of other galaxies. There are also clusters of galaxies that appear as extended x-ray halos. The eRosita data are also a treasure trove of rare and exotic phenomena, including many types of variable objects, merging neutron stars, and stars being swallowed by black holes.
Emmanuelle Charpentier receives the Nobel Prize in Chemistry, while the Physics Nobel Prize goes to Reinhard Genzel. The first, and until now, the last time that the Max Planck Society had scooped up two different Nobel Prizes in the same week was in 1995. “I am delighted that two Max Planck researchers won a Nobel Prize this year”, said President Martin Stratman. “It confirms the Max Planck Society’s status as one of the most successful scientific organizations in the world and it also reinforces our mission: we do not rely on programs, but on great minds, who we provide with sufficient funds for high-risk, long-term basic research. This also makes us highly attractive on an international level for top researchers from all over the world. But above all, these two Nobel Prizes demonstrate the exciting and innovative discoveries that arise from curiosity-driven basic research.”

The first cause for celebration came on the Tuesday of the Nobel Prize week in October: astrophysicist Reinhard Genzel, Director at the Max Planck Institute for Extraterrestrial Physics in Garching near Munich, was awarded the Nobel Prize in Physics – alongside U.S. physicist Andrea Ghez and UK-born mathematical physicist Roger Penrose. The Royal Swedish Academy honors the three scientists for their black hole research. “This really took me by surprise,” said 68-year-old Genzel. With his group, Genzel has been using high-precision methods to detect the black hole at the center of the Milky Way through years of experimental research. He emphasized that the Nobel Prize was a success for the entire Max Planck Society, which had provided his team with the necessary resources. “I am very happy that I could win this coveted trophy for the Max Planck Society,” Genzel said in an interview with the Süddeutsche Zeitung. He had not expected to win the Nobel Prize because he had already received the Crafoord Prize for Astronomy in 2012. “Usually, winning the Crafoord Prize means you are out of the race for the Nobel,” Genzel said. Somewhat less surprising, but no less gratifying, was the award received one day later by Emmanuelle Charpentier. The microbiologist had for years been tipped as a favorite for the highest scientific honor from Stockholm. Together with U.S. structural biologist Jennifer Doudna, the Frenchwoman receives this year’s Nobel Prize in Chemistry. The two researchers are being honored for their groundbreaking work on the genome-editing tool CRISPR-Cas9. The CRISPR-Cas9 technology is considered a revolution in the fields of medicine, biotechnology and agriculture. “I am overwhelmed and deeply honored to receive an award of such significance. I am now looking forward to celebrating the prize with my team, family, and friends via video call,” said Charpentier, Director at the Max Planck Research Unit for the Science of Pathogens in Berlin.
Surviving the Anthropocene

Humans have taken dominion over the Earth – and have done so to an extent that threatens the basis for human life itself. From the perspective of our author, the development of scientific and technical knowledge has played a key role in the transition to the Anthropocene, the geological epoch of humankind. But we still need to learn more about the close interrelationship between the Earth and humans to be able to actually understand and overcome the crises that we create through our own actions.

Has there ever been a time when the dependence of our globalized societies on knowledge was so clearly evident as today? Infection rates and epidemiological models, rapid mass testing and global vaccine research in a continuous sprint are deciding the fate of the global population. Chinese biomedical scientists were able to identify the genome of the newly emerged coronavirus and convey that information to the World Health Organization in only a few days. Continually warning about the preliminary nature of their knowledge, epidemiologists around the world are advising their respective political leaders, who must in turn protect their citizens from the lethality of an exponential spread and from societal collapse. Economists, educators and social scientists are measuring the effects of stopping entire nations in their tracks.

Crises brought on by epidemics have always made history. One need only consider the plague in Europe or the mass deaths that smallpox, measles and flu viruses caused when they were brought from the Old World and introduced into the indigenous populations of North and South America. However, the current pandemic is certainly assuming unprecedented proportions due to today’s circular interdependence of global economic and knowledge systems. What’s more, considering the deep impact it will have on our collective world, it will be important to draw lessons for the future from our experience with the Corona crisis and its causes.
Jürgen Renn received his doctorate in mathematical physics from the Technische Universität Berlin in 1987, before he turned his focus to the history of science. He conducted research and taught in Boston, Tel Aviv and Zurich, and became the founding Director of the Max Planck Institute for the History of Science in Berlin in 1994. His research focuses on topics including the long-term development of knowledge and the dynamics that have led to the Anthropocene. Renn is a member of the German National Academy of Sciences Leopoldina and of the International Academy for the History of Science. January of 2020 saw the publication of his book, The Evolution of Knowledge: Rethinking Science for the Anthropocene. In it, he warns of crises such as a global spread of infectious diseases, which has already become a reality with COVID-19. His book is currently being translated into German.
The advent of the Corona crisis will not simply displace other challenges humanity is already facing. On the contrary, the virus only intensifies our focus on the profound threats to our highly modern societies posed by the increased use of previously undisturbed animal habitats, the weakening of ecosystems and – likely the most overarching of all threats – climate change. As long as our view of the Earth's natural realm remains one of an inexhaustible resource and waste dump, it will be difficult at best to extricate ourselves from the headlong growth of mutually reinforcing crises. It cannot be ruled out that this continual exposure to crises will ultimately overwhelm our societies.

So from now on, science and research must do more to confront the challenge of contributing to the resilience of our globalized world, and put all of their previously imposed disciplinary boundaries and methodological blinkers behind them. At the present time, when our problems can only be understood from a comprehensive perspective, it is an existential imperative that we investigate the complex interactions between society, technology, the environment and a global system that is in continual overall flux.

The Earth has been radically altered by human encroachments. We are currently leaving a geological epoch behind that, for roughly 11,000 years, has provided human cultures with largely stable climatic conditions, giving them a time window in which to develop and expand around the globe. For our departure from this unusually stable “Holocene” epoch, Paul Crutzen, Nobel Prize Laureate in Chemistry and former Director of the Max Planck Institute for Chemistry, coined the term “Anthropocene,” a term that no longer permits the trivialization of the influence humans have on the Earth system.

In the Anthropocene, humans are no longer acting against the backdrop of an unchangeable natural system, but rather are profoundly intertwined in its structure and impacting both the immediate and distant future. The fundamental revision of our understanding of this planet’s condition can only be compared to the overturning of the physical concepts of space and time that occurred in the wake of Einstein revealing his theory of relativity. In classical physics, space and time seemed to be the fixed stage upon which world events took place. In contrast, according to Einstein’s theory, this stage is no longer an unchanging framework, but rather is itself part of the play. There is no absolute distinction between actors and stage. The changes in the Earth system are confronting us with the similarly radical necessity to rethink our situation: we are not living in a stable environment that serves only as a stage...
We are conducting an experiment on the entire global system, which we still only poorly understand.

and as a resource for our actions. Instead, we are part of a dynamic system in which humans and the non-human world play equal roles. As it is used today, the term “Anthropocene” is also the result of a new type of Earth science, a transition from geology to the science of the Earth system, which views our planet as a complex, nonlinear system with many interactions and feedback loops in which human intervention is playing an increasingly important role.

The concept of the Anthropocene has established a bridge between geological and historical time. It has become clear that the time scale of human history is inextricably linked with the geological time scale. In view of the massive effects of human intervention in the environment, the traditional dividing lines between nature and culture have become problematic. What roles have science and technology played in this transition? Were they the accelerants that will have enabled colonialism and industrial capitalism to eventually destroy the Earth? Or were they our Cassandra, giving us fateful warnings well in advance, but whose advice was tragically ignored? Humans have certainly become a planetary force, but we have yet to develop any sensibility for our planet.

How society, science and our shaping of the future fit together can only be assessed by focusing on the development of the Anthropocene. The question of which processes and dynamics have brought us into the Anthropocene is currently a subject of broad discussion. Suggestions range from the extinction of the megafauna in the late Pleistocene as a result of humans’ new hunting skills and further environmental and climatic factors, to the advent of agriculture and animal husbandry, the early modern era and the Industrial Revolution, to the so-called Great Acceleration since the mid-20th century, which geologists are currently focusing on.

All of these historic interventions have left their traces in Earth’s history: the increasing dominance of domesticated animals and cultivated plants in the biosphere; the transfer of species (and of lethal pathogens) caused by European colonialism between biospheres that had been separated for millions of years; the rapid rise in CO₂ concentration in the atmosphere and oceans since the Industrial Revolution and the exponential increase in consumption of global resources since the Great Acceleration.

All of these interventions have simultaneously changed and reinforced the possibilities for human action: early advanced civilizations would have been
inconceivable without agricultural settlements and animal husbandry. Modern science would probably never have flourished without these advanced cultures, and both colonialism and the Industrial Revolution may have been impossible without the Scientific Revolution of the modern era. This long-term, concurrent development shows how our knowledge and hence our creative power have increased, while the associated, unintentional or consciously accepted consequences have simultaneously been amplified.

Our modern societies are deeply rooted in this interaction between knowledge, cultural technology and intervention in the natural environment. We are currently caught up in an escalation of this interrelationship and are actually in the process of conducting a global experiment on an entire planetary system that we still only poorly understand. The effects of this experiment and whatever measures we take in the future to mitigate these effects will depend profoundly on the available knowledge of the interaction between the Earth system and its human components. In any event, if we are to successfully shape the Anthropocene future, it is essential that we understand the evolution of our knowledge.

But what exactly is knowledge? Individual knowledge is based on the encoding of experiences that enable individuals to solve problems as part of their adaptive behavior. While knowledge enables individual persons to plan their actions and to consider the results, a society or an institution cannot “think” but rather can only anticipate the consequences of its actions within a “knowledge economy.” The knowledge economy represents the sum of the societal institutions and processes that convey, accumulate and propagate the knowledge available to a society – especially the knowledge with which a society can ensure its own preservation and growth. The limits of knowledge economies are likely to have been a critical factor in the collapses of historic societies, like those evolutionary biologist Jared Diamond examined in his book, Collapse. A knowledge history of the Anthropocene therefore includes a history of our knowledge economies, in which knowledge has been produced, distributed and reproduced – or has not been produced or has even been suppressed, ultimately with global consequences.

From an evolutionary perspective, knowledge is one of the structures, along with social institutions, that govern human behavior. At the same time, human activity affects the environmental conditions under which people live. Thus, environmental conditions also embody the structures of human behavior. Conversely, this human-influenced physical environment serves in
turn as the starting point for new knowledge processes and societal formations. This engenders a constant interplay between the material embodiment of regulative structures that govern behavior and the changes in these structures based on new experiences. This interplay determines the general dynamics of cultural evolution.

Under given environmental conditions, societies can reproduce some of these conditions but not others. For example, in the transition to an agricultural society, humans learned to recreate the environmental conditions that enabled them to produce their own food. In this way, naturally given external conditions, such as the local availability of plants and domesticable animals, ultimately became dominant characteristics of further global development.

The transition to the Anthropocene can hardly be traced back to a single cause or moment in time. Rather, it can best be described as a cascade of evolutionary processes, from biological via cultural to an “epistemic evolution.” With this epistemic evolution, human societies – dependent on the use of fossil energy and on infrastructures and technologies that are increasingly science-based – have entered into an interdependency with the Earth system as a whole. What stone tools, hunting and gathering were for the Pleistocene, and arable crops, clothing and dwellings were for the Holocene, science-based technologies are now for the Anthropocene: critical conditions for human life and human survival. This process can be observed at the latest since the Industrial Revolution, and has reached a preliminary peak under the present conditions of digitalization, mobility, global supply chains, technocratic governance and, last but not least, high-performance medical research on an international scale.

While the possibility of reproducing external conditions contributing to livability was once primarily a question of circumstances in times of cultural evolution, it will increasingly have to be a question of knowledge in the age of epistemic evolution. This especially applies to the consequences of our actions for the coupled human-Earth system. Our understanding of this complex system requires new scientific approaches that help to better understand and mitigate systemic shocks in our highly industrialized and extremely fragile age: a “geoanthropology” or human-Earth science of the Anthropocene. The goal of such scientific approaches – which are currently also under discussion in connection with the founding of a new Max Planck Institute – is to effectively combine the necessary adaptation to the systemic risks of the present with the elimination of their causes.
FOCUS

ALL EARS

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Painting with ultrasound: to construct an image with microparticles, Max Planck researchers first calculate the hologram that generates the corresponding sound profile. This simulated hologram is then used to produce an image of Picasso’s “Dove of Peace” using particles.
Ultrasound can be used manipulate tiny particles and even to arrange them in any desired patterns by using acoustic holography. This method has been developed by Peer Fischer’s team of researchers from the Max Planck Institute for Intelligent Systems in Stuttgart. The physicists are already working on medical applications.
"We use ultrasound in many ways in everyday life, such as in medical imaging, in nondestructive material testing and for measuring distances when we park our car," explains Kai Melde. But the postdoc in Peer Fischer's working group at the Max Planck Institute for Intelligent Systems has a completely different use for ultrasound. He causes tiny particles to hover and transports them from one place to another with no apparent physical contact. What sounds like magic has become routine laboratory work for Kai Melde and Peer Fischer. They use a sophisticated method to modify acoustic signals to cause micron-sized particles to move and even be arranged into nearly any pattern required. This method is of interest for medical treatments with ultrasound, for analyses in materials science and for medical laboratory testing of cell cultures in petri dishes, for example.

The team led by Peer Fischer has opened up a promising new research field with this method. But, as so often happens in the field of science, that was not the original plan. Normally the scientists on his team work to develop nanobots and microbots, or they conduct research on functional materials. They arrange the tiniest of components of these materials with the aid of magnetic fields or chemical reactions to form objects such as sensors. “We hit upon the method of manipulating materials with ultrasound while searching for a way to work with biological materials as well,” explains Peer Fischer.

**Acoustic tweezers**

The actual concept of shaping sound and using it as a means of transport in the micro or nano world is not a new one. It goes back to research from the 1980s, which yielded first optical and then acoustic tweezers. Physicists use the radiation pressure of light or sound waves to trap individual microparticles in air or fluids and to position them precisely. In the simplest example of acoustic tweezers, they use a sound source to transmit pressure waves into a vessel filled with air or water. This source is called a transducer – but for inaudible ultrasound. Because it is physically constrained by the vessel, a standing wave forms within the medium that is at rest at its nodes. Microparticles can be trapped at these locations. The sound acts like invisible tweezers.

If two such sources are positioned perpendicularly to each other, the standing waves are superimposed, so that the nodes and the particles trapped within them form a grid. Multiple sound sources can create even more complex patterns from a large number of nodes, which serve as pixels in an image. The phase of the individual ultrasound waves can be adjusted by individually controlling the sources. The phase determines where waves of a specific frequency reach their maximum and minimum intensity. This enables the researchers to actively control the locations where the acoustic nodes form and the microparticles accumulate. In principle, the microparticles could be arranged in any pattern by using this method. However, as the number of sound sources increases, the complexity and effort involved also increase tremendously. In addition, the resolution of the image is limited by the overall size spanned by all sources.

"I find the potential medical applications of acoustic holography particularly exciting, especially for ultrasound therapy.”

Peer Fischer

The team led by Peer Fischer and Kai Melde also included researchers from the University of Stuttgart, and together they worked out a different method to circumvent these problems. They replace the ensemble of multiple sound generators with a specially shaped plastic relief that they irradiate with sound from a single transmitter. This plastic plate is an acoustic hologram. The field of optics brought us holograms, which extend photography into the third dimension. In addition to the intensity of the light, holography also utilizes the phase of the light waves: the reflection of light off a three-dimensional object creates characteristic shifts in its peaks and troughs.
The phase of the light waves therefore transports information about the physical, i.e. spatial structure of the object, which gives holographic images their typical three-dimensional form.

Similarly, an acoustic hologram contains information about the phase of the waves, in this case sound waves. It therefore acts like thousands of tiny sound sources working together. To demonstrate how acoustic holograms can be created and used to manipulate particles, the physicists from Stuttgart arranged microparticles in a liquid to form images such as the “Dove of Peace” by Pablo Picasso. Because the subject is both highly complex and also has a fine structure, the resolution of the hologram must be correspondingly high. To duplicate the dove using particles trapped by sound, the researchers first create a phase map of the image on the computer. Then they simulate the necessary shape of a plastic relief to impose exactly this phase profile on an ultrasound wave. The thicker the material that a sound wave penetrates, the more its phase is shifted. “We use software to calculate the necessary thickness at each of the 15,000 pixels in the hologram,” explains Melde. In this way, each pixel is a tiny independent sound source. Each pixel is approximately 375 microns in size. This corresponds to roughly half the wavelength of the ultrasound signal at 2 MHz in water and therefore the theoretical resolution limit of the sound waves. The researchers then use a 3D printer to create the plastic relief.
For the actual experiment, they fill a chamber with water, to which they add 150-micron silicone spheres. They place the hologram beneath the chamber and irradiate it using a large ultrasonic transducer. The silicone spheres floating in the water then actually arrange themselves into a copy of Picasso’s “Dove of Peace.” To prevent the particles from disengaging from this shape as soon as the sound is switched off, the researchers coat them with a photochemical material. “If we irradiate these coated particles with UV light, they bond in place and the structures can then be permanently retained,” explains Fischer. But creating static images is not the only capability of acoustic holograms. For example, Melde and Fischer use a different, correspondingly structured plastic relief to generate an annular wave on which they can actually get millimeter sized objects to surf.

**Medical applications**

Although the first experiments in acoustic holography sound a lot like clever tinkering, the method could also have a number of applications in medicine and technology. For example, acoustic holograms can emulate multiple ultrasound sources could help simplify the inspection of materials for cracks, such as in aircraft wings. This makes use of the fact that sound propagates differently within intact material than it does in defective material. “But I find the potential medical applications of acoustic holography particularly exciting, especially for ultrasound therapy,” says Fischer. Ultrasound is already in use today to destroy diseased tissue or break up kidney stones. Holograms could now be used to generate customized sound profiles that only target diseased tissue.

“However, acoustic holography also enables the use of ultrasound in the brain,” explains Fischer. “This is a completely new concept, because treatments of this kind have never before been possible.” This is because the thickness of the skull varies so much that it distorts an ultrasound signal to the point that it becomes unusable. A team from the Polytechnic University of Valencia in Spain recently demonstrated that a holographic plastic relief can compensate for these variations. Peer Fischer’s team is working together with researchers from the Fraunhofer Institute for Biomedical Engineering to develop a medical application for this method. To holographically modulate ultrasound waves in the brain, physicians first use X-ray images to determine the variations in skull thickness and then generate a plastic relief that compensates for the differences. This method could help to remove diseased tissue, such as a tumor, from the brain.

Meanwhile, the researchers are also working on an acoustic holography method to specifically structure cells in a petri dish, without having to penetrate the culture and physically touch the cells. In this way, they hope to create artificial tumors or organoids, i.e. laboratory models of organs, with which they can improve drug testing and thereby replace testing on animals. In their experiments, the researchers are working with colorectal cancer cells; primarily because these can be easily cultivated in the laboratory, but also because artificial tumors are one of the possible applications for acoustic tweezers.

To reproduce tumors or organs, the researchers first collaborated with colleagues from the Max Planck Institute for Medical Research to find a way to organize cells into specific patterns in two dimensions. In the next step, they expanded their cellular arrangements into the third dimension, which is crucial for conclusive medical studies. “Cells behave differently in a three-dimensional environment than they do in a two-dimensional plane. And we simply need the third, spatial dimension for certain drug tests, for tumor growth experiments or for organoids,” explains Fischer.

To generate two-dimensional patterns or even three-dimensional forms from biomaterial, the researchers embed the cells in a hydrogel in which they are to continue reproducing later. “The problem here is that cells consist primarily of water,” explains Fischer. “So there is hardly any contrast with the surrounding hydrogel and they are therefore difficult to grasp with acoustic tweezers.” The cells simply follow the movements of the sound waves. But the researchers quickly recognized that the ultrasound not only moves the particles directly through its vibrations, but also indirectly, because it can create flowing currents throughout the fluid. By carefully phasing and synchronizing the various forms of movement, they are ultimately able to position the cells in the intended configurations.

**SUMMARY**

Like optical holograms, acoustic holograms utilize not only the intensity of a sound wave, but also its phase. In this way, many waves can be superimposed to generate complex sound pressure profiles with which particles in a fluid can be manipulated and organized.

Max Planck researchers in Stuttgart produce acoustic holograms by first reverse-engineering how the many thousands of partial waves can be combined to yield a desired pattern and then determining the hologram that produces these individual waves.

The researchers also want to use acoustic holography to produce artificial tumors or organoids upon which realistic medical and pharmaceutical testing can be performed. This may also make it possible to replace some animal experiments in drug development.
Kai Melde’s colleague Zhichao Ma therefore used a computer to simulate how the flowing currents that are induced in the gel by the ultrasound pressure can be optimally combined with the acoustic forces acting directly on the cells to organize the cells into specific patterns. Melde then prepared the suitable hologram. Finally, the physicists positioned the resulting relief underneath the petri dish and irradiated it with ultrasound. Again, the cells organized themselves exactly as planned – in this case, forming Minerva, the Max Planck Society’s logo.

If medical experts are to subsequently work with the cells, the cell cultures cannot be permitted to lose their shape as soon as the ultrasound is switched off. However, in this instance, coating the cells with a...

“If we want to control particles in three dimensions, the sound waves must also act on them from every direction. So we need more than one sound generator.”

KAI MELDE

The first 3D structure: Kai Melde watches as an icosahedron forms in a cubic vessel immersed in a water tank. He and his colleagues used this shape to demonstrate for the first time that two ultrasound transducers and corresponding holograms can also be used to form 3D structures. The transducers are visible as metal cylinders below the cube.
Sounding out a new dimension: the researchers in Stuttgart are attempting to manipulate not only the phase, i.e. the position, of the sound waves, but also their amplitude. For this purpose, they combine materials in holograms, such as various plastics (black hologram on the upper left) or plastic with white foam (to its right). However, they also incorporate air bubbles in a plastic material (hologram on the left edge of the image). This additional degree of freedom makes it easier for them to form 3D structures from particles and cells.
photochemical adhesive is not an option. But the physicists at the Max Planck Institute for Intelligent Systems have already solved even this problem. “We use a hydrogel that is initially a liquid but that gels after a certain period,” explains Fischer. The substance Peer Fischer and his team uses is heat-sensitive and the acoustic pressure slightly warms it. This slight rise in temperature means that, once the cells have taken on the desired configuration, the gel cools and solidifies after a few minutes. So the cells can no longer float away, but they can still multiply. And, what is also important for medical research: “We have demonstrated that the cells survive; they are unaffected by the acoustic treatment,” says Melde. “They can then be further cultivated in the configuration fixed within the gel.”

Three-dimensional cell structures

Having successfully used acoustic holography to generate cellular patterns in two dimensions, the team from Stuttgart is now working on three-dimensional structures. But the transition to the third dimension is anything but trivial. Holograms can in fact be used to generate three-dimensional sound patterns, as Peer Fischer’s team has already achieved in their experiments. However, in contrast to the previous experiments in two dimensions, particles or cells are now no longer confined to a flat surface, but rather are free to move in all directions. It is difficult to control this new-found freedom from only one direction. “If we want to control particles in three dimensions, the sound waves must also act on them from every direction. We therefore need more than one sound transducer,” explains Kai Melde. Melde and his colleagues therefore proceeded to develop concepts and ways to irradiate a contained volume with sound from two or three transducers on various sides, and thereby interconnect the particles in three-dimensional patterns.

The effort of using acoustic holography to structure cells in three dimensions could pay off in the future, such as in the design of organoids, because this method can save a lot of time without damaging cells. Once the holographic plate has been printed, the cells can be arranged in the petri dish in a matter of minutes. It would take hours or even days to produce organoids with a 3D printer, because the 3D printer can only construct a framework one point at a time from a material on which the cells could then grow. In contrast, the cells can all be configured simultaneously with an acoustic hologram.

While the researchers in their team continue working on the right method to generate three-dimensional cellular structures, Peer Fischer and Kai Melde are already sounding out the next potential uses that acoustic holography has to offer. For example, they want to set the sound profiles and therefore the particle arrangements in motion. They are therefore looking for ways to modify the holograms in near real-time. The researchers from Stuttgart are now exploring the field of acoustic holograms – which they themselves developed – in completely new directions, and it likely that in the future, they will explore many other possibilities with ultrasound.

GLOSSARY

**HOLOGRAPHY**
This method uses not only the intensity of light or sound waves, but also their phase. Holograms therefore also contain information about the three-dimensional structure of an object.

**ORGANOID**
An organ-like structure made up of many cells.

**PHASE**
Indicates the point at which a wave is in its cycle at a specific time. Waves that share the same phase have peaks and troughs at the same location. A phase shift between waves results in an offset, which changes the resultant wave pattern when they are superimposed.
Operatic singing. Birdsong. Loud shouting. An off-pitch violin. We instinctively find some sounds pleasant, others unpleasant. But how do we decide whether something sounds good or bad? And how is sound actually processed within the brain? In an attempt to answer these questions, a team led by David Poeppel at the Max Planck Institute for Empirical Aesthetics in Frankfurt is trying to break down speech and music into their most elementary components. And at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, researchers are investigating the secret of super-hits.
Alarm! Screams, including babies’ cries, feature an acoustic peculiarity that we experience as particularly unpleasant. It’s what guarantees their social impact.
“What is the role of neuroscience?” David Poeppel’s response to this question, posed in an interview, was as follows: “Breaking something up into its constituent parts.” This observation reflects both his personal approach as a researcher and that of the Max Planck Institute for Empirical Aesthetics in Frankfurt, where Poeppel has been Director since 2014. However, that’s not where you would have reached him on the day of this interview in April 2020. Instead, you would have had to dial a telephone number starting with +1 – the country code for the U.S. Since 2009, he has held a part-time professorship in psychology and neuroscience at New York University. At the start of the COVID-19 pandemic, Poeppel and his family left the hotspot New York City for Connecticut, where he continues to work from home. In his words, it has been a “blessing in disguise”, he has had the time to pursue ideas that he had previously put on the back burner in his daily work.

Time is also relevant to his research; one of his research interests is how speech and music are processed in time. Poeppel gives an explanation for the layperson: “A sound wave reaches your ear, is converted into an electrical signal and is then split apart at switching points in your brain. The final result is tiny elementary constituents, which – if processed correctly – carry the appropriate information.” His interest, then, is how acoustic signals are processed in the human brain. If he can answer these questions, Poeppel hopes to make advances in linguistic theories and in the aesthetics of speech and music.

Many languages, one tempo

There’s no denying that a conversation with David Poeppel is inspiring. Many of the questions he poses are ones you’re likely to have already asked yourself, while others are very unexpected. Some sound very complex, and others are almost astonishingly simple. For instance, you don’t have to be a linguist to know that words are made up of one or more syllables; surely, the question “what is a syllable?” is, at first glance, banal. But from a scientific and technical standpoint, nothing could be further from the truth. As Poeppel explains, linguists have been discussing for some 70 years whether syllables should be regarded as elementary constituents of speech or whether they are just a type of by-product of smaller acoustic elements, such as phonemes, the individual units of speech sounds.
What is beyond dispute is that syllables play a fundamental role in speech perception and speech production. In one long-term project, Poeppel and his colleagues compared the speed of various languages with the number of syllables uttered. They discovered that the average speed of speech corresponds to the rate of successive syllables. The astonishing thing was that this tempo was almost identical for countless languages. “Our sense that some languages are spoken much faster than others is therefore mistaken,” says Poeppel.

A person can easily speak four to five multisyllabic words in the space of one second. To clearly understand each word, the listener needs to perceive every single sound. Moreover, the sequence of the sounds is crucial. The slightest errors can result in chaos, as any child who’s ever played the popular game of “Telephone” will know. “Wall” quickly becomes “ball”, “shoes” becomes “choose”, while “smell”, “sell” and “sail” can hardly be distinguished when whispered.

To perceive such fine differences in ordinary discussions, the brain has to achieve a temporal resolution of between 20 and 80 milliseconds. “The brain needs to be structured in such a way that it can construct very short intervals of time: ‘samples’, as we refer to them,” says Poeppel. But that would only result in a staccato-like sequence of sounds. Speech is also highly dependent on precise stresses, pauses and intonation. Take the example of the German phrase “München wird modern”. Its meaning depends on whether the last syllable of the word “modern” is stressed (“moDERn”, meaning “Munich is modern”) or the first syllable is emphasized, “MODern”, which changes the meaning to “Munich is rotting.” Speech only becomes interesting and vibrant when it includes such ‘prosodic contours’. The importance of such factors is particularly evident in sarcasm and irony. Whether you are praising someone when you say “well done”, or whether you’re being sarcastic depends completely on your chosen emphasis.

To perceive such nuances, longer time intervals are needed; the brain needs to generate both a temporal and a spectral analysis, and this occurs at frequencies of a few Hertz, corresponding to time intervals of between 200 and 300 milliseconds. “Ultimately, two parallel processes need to take place in the brain,” explains Poeppel. “I can work out the correct order of sounds based on the short time intervals, and the long time intervals indicate the intonation and the speech melody.” If you want to discover how these differing lengths are then precisely analyzed and converted into concrete information, you have to delve deep into neurobiology. That’s where neuronal oscillations play an essential role.

By this, neuroscientists mean the synchronized activity of particular groups of cells. Once a sentence, a melody or a sound reaches the ear as a sound wave and is converted into electrical signals, certain nerve cells in the brain become synchronized, switching on and off in defined cycles. In order to process the aforementioned short time intervals of under...
100 milliseconds, the relevant cells oscillate at a frequency between 25 and 35 Hertz, known as 'gamma waves'. For the longer intervals, a different type of cell becomes active at a frequency between three and eight Hertz, and these oscillations are known as 'theta waves'.

Neural oscillations don’t just play a role in perceiving speech. They also underlie the brain’s ability to process music, as David Poeppel discovered with his colleague Keith B. Doelling from New York University. In their study, the two compared active musicians with at least six years of musical training with non-musicians. The test subjects listened several times in succession to 13-second excerpts from various classical pieces by Johann Sebastian Bach, Ludwig van Beethoven and Johannes Brahms. The pieces were played on the piano in varying tempos – from one note every two seconds to eight notes per second.

We process speech and music in similar ways

For the pieces of music with a faster rhythm than one note per second, the researchers were able to record cortical oscillations in musicians and non-musicians, and these oscillations were synchronized with the speed of the notes in the piece being heard. “The findings show that the presence of these oscillations improves our perception of music and pitch changes,” explains Keith Doelling.

At the same time, they also observed that the brains of the musicians synchronized more clearly with the rhythm of the music than those of subjects with no musical training. In addition, it was only in the musicians that oscillations were recorded that synchronized with unusually slow pieces. This difference indicates that people without musical training may have difficulty recognizing continuous melodies, instead perceiving music as just a series of tones. In the larger context of their research, the findings also demonstrate that low-frequency oscillations enable the brain to decipher speech or music.

Pauline Larrouy-Maestri, a senior researcher in Poeppel’s group, also investigates parallels between speech and music. Given her broad background, she appears predestined to conduct this kind of research. She studied psychology and music, plays the piano and used to work as a clinical speech therapist. In a typical experiment, Larrouy-Maestri asks subjects to listen to music and then rate the performance. She plays them either synthesized or acoustic pieces, both of which have their advantages and disadvantages.

“Synthesized music is very easy to manipulate and control, but it’s not as natural, so it’s not as easy to define how people actually perceive the music,” says Larrouy-Maestri.

In one of her experiments, she asked volunteers to listen to famous chorales by Bach that were altered at certain points in the music. She then analyzed how the subjects’ brains reacted to the altered passages or notes. Listeners, she discovered, were able to recognize harmonic structures and, therefore, precisely identify the places where the music had been altered. Pauline Larrouy-Maestri and Xiangbin Teng’s experiment showed that we analyze music and speech in similar ways. While continuous speech is parsed into linguistic units – sentences, words and syllables – the continuous musical phrases in pieces of music are parsed into musical units – melodies, chords and notes. The more musically trained the subjects were, the better their brains could distinguish the musical units from each other.

Another focus of Larrouy-Maestri’s work is the question of whether musically untrained listeners can recognize wrong notes in songs and which cognitive processes are responsible for this. She found that you don’t have to be a professional musician to detect wrong notes in a piece of music. Nor is it necessary to have an expert ear to know whether a singer is singing off pitch. Almost anyone can hear what’s right or wrong – regardless of the music being played.

Like David Poeppel, the impetus for Larrouy-Maestri’s research often comes from observations of everyday life. People turn on the radio and probably switch sta-

“You don’t have to be a professional musician to hear wrong notes in a piece of music.”

Pauline Larrouy-Maestri
tions a couple of times until they find a song they want to listen to. “Irrespective of what kind of sound we perceive, we can immediately say whether we like it or not. Astonishingly, it’s something we’re all able to do. And so I asked myself, how is that possible?” To answer this question, Larrouy-Maestri has relied on natural acoustic music in her experiments. “We invite volunteers – both trained and untrained musicians – to come into the lab and sing us a song.” Then, we ask other volunteers to judge how well they sang.

In another study, Larrouy-Maestri tried to discover which factors influence whether listeners experience a melody as pleasant or less pleasant. In vocal music, these include how accurately the melody is sung, for instance, how on pitch people sing. However, accuracy is not the only criterion. Interestingly, the speed of the music also seems to be a factor. The majority of people experience neither very fast nor very slow music as pleasant. This might have something to do with how the human brain processes music in general. It is these general mechanisms that Larrouy-Maestri is trying to discover, in order to find out what makes people decide whether or not a piece of music is good or bad. “I’m not trying to crack the code for writing the perfect musical hit that everybody loves,” she says. “I’m more interested in how listeners reach their decisions regarding whether they like a particular piece or not,” says Larrouy-Maestri.

What does a “hit” trigger in the human brain? That’s another mystery that a research team at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig is looking into. Vincent Cheung, a doctoral researcher at the Institute, doesn’t just have a passion for listening to music; he is also a violinist. He asked himself why certain pieces touched both him and other music lovers so deeply. Together with Stefan Koelsch, he set out to discover the recipe for the success of songs like Yesterday by the Beatles.
The scientists then calculated how predictable or surprising the chord progressions in each of the hits were and analyzed the reactions of test subjects to the sound sequences. They found that listening pleasure was greatest when listeners were occasionally surprised, while too much uncertainty was a bad thing. If the listeners were relatively sure which chords would come next, they enjoyed the sensation of being surprised – in other words, if their expectations were not met. If, on the other hand, they were unsure of what was going to come next, they preferred not to be surprised by subsequent chords. These findings were backed up by magnetic resonance imaging studies of the test persons. The nucleus accumbens, the brain structure responsible for anticipating feelings of happiness, only reacted in the test subjects when they were particularly interested in finding out how the music would continue.

But, of course, not everything we hear is pleasant – our auditory system, for example, also exists to warn us of danger. It’s a subject the researchers at the Max Planck Institute for Empirical Aesthetics are also examining. David Poeppel caused a stir with a study in which he explored why screams shake us to the core. “Everyone can recognize a scream, and everyone has a rough idea of what constitutes a scream – they’re loud, high and shrill,” says Poeppel, describing the starting point of his analysis. In several studies conducted with his New York colleague Adeen Flinker together with Luc Arnal, Andreas Kleinschmidt and Anne-Lise Giraud from the University of Geneva, he identified an acoustic peculiarity that is unique to screaming.

The brain analyzes speech at different temporal resolutions to interpret both individual sounds and more complex patterns. The brain processes music in a similar way. It breaks pieces of music down into individual components, such as melodies, chords and notes.

Professional musicians can often recognize musical structures better than people without musical training. But even lay people can recognize wrong notes or manipulated harmonies.

Popular songs are characterized by a mixture of predictable and surprising chord sequences.

**SUMMARY**

The brain analyzes speech at different temporal resolutions to interpret both individual sounds and more complex patterns. The brain processes music in a similar way. It breaks pieces of music down into individual components, such as melodies, chords and notes. Professional musicians can often recognize musical structures better than people without musical training. But even lay people can recognize wrong notes or manipulated harmonies. Popular songs are characterized by a mixture of predictable and surprising chord sequences.
“Screams exhibit a characteristic termed ‘roughness’,” explains Poeppel. “Roughness occurs when sounds acquire a particular temporal structure due to changing amplitude. If such changes occur extremely quickly, the auditory system can no longer resolve them – they are instead experienced as rough and therefore unpleasant.” Normal speech has a modulation frequency of about four to five Hertz, but for roughness that frequency is between 30 and 150 Hertz – the changes are much faster.

In one study, the research team generated a sound database containing a wide variety of human sounds, from screams and sentences to artificial sounds, such as an alarm clock going off. They discovered that both screams and artificial sounds, such as an alarm clock, and dissonant intervals, such as an off-pitch fifth, fall within the frequency range of roughness – a finding that shows that the manufacturers of alarm clocks have done a great job in imitating the modulation of a human scream.

Thus, the sounds that we perceive can be meaningful to us in many different ways. The brain performs an enormous feat in not only distinguishing between different sound sources, but also simultaneously filtering out what is important for us and correctly decoding what we hear. And yet, as David Poeppel points out, even though scientists have made numerous discoveries in recent years, there are still fundamental puzzles that are still unresolved – for instance, the interaction between sound and memory. Finding the answers will require the contribution of many bright minds and visionaries who pose the right questions.

www.mpg.de/podcasts/schall (in German)
Two shadows flit around in the evening light. A bat is chasing after a moth in a wild dance between hunter and prey. For Holger Goerlitz, pursuits like this one are a real thrill. The leader of an Emmy Noether Research Group at the Max Planck Institute for Ornithology in Seewiesen is researching how bats and insects use sound to detect each other.
Many animals have the ability to hear. Sound can carry over very long distances, and obstacles hardly muffle it at all. Nocturnal animals in particular rely on their sense of hearing because, unlike their eyes, their ears are also effective in darkness.

Bats are perfect examples of what extraordinary feats the sense of hearing can accomplish. The animals emit sounds and analyze the echoes that are reflected back by their surroundings. To do this, they usually use ultrasound, in other words, frequencies that lie above the audible range of the human ear. “For us, the sounds bats make are usually inaudible. And we should be glad about this, because the volume of bat calls reaches the level of a jackhammer or even a jet plane,” Holger Goerlitz explains. The bats calculate their distance from an object according to the time that elapses between the moment they emit their call and the moment they hear the echo back. Fluctuations in the frequency – the pitch of the sound – as well as the duration and volume of the echo also inform the animals as to whether the object is large or small, smooth or rough, stationary or flapping its wings. This is how they can identify obstacles, find potential prey and even communicate with other members of their own species. This is not so easy in the natural world, because bats are moving within complex sound environments during their nightly hunting excursions. Other bats of the same or different species are calling, moths are flying about, and leaves shake in the wind.

Goerlitz and his team are observing the animals in their natural environment and in laboratory experiments to study the sensing and orientation strategies used by bats and their prey. The group is operating a small research station in a village in northeastern Bulgaria. Rivers have carved themselves deep into the rocks of the region’s karst landscape and a large number of caves have been created at their edges. This environment provides roosting sites and food for many different bat species. “This is ideal territory for field research and laboratory experiments,” Holger Goerlitz enthusiastically explains.

The researchers capture the winged hunters at night as they fly in and out of the caves, and then fit them with sensors. Since bats are nocturnal, the experiments are usually conducted in the first few hours after sunset. By setting up arrays with four to 22 microphones, the researchers record the calls of passing bats and analyze their flight paths and the direction of their calls. Using the tiny differences in the time that it takes each call to reach all of the microphones, the researchers calculate the three-dimensional location of the animals. On the other hand, microphones placed just next to the prey species measure what they hear from the approaching predators. Then, the researchers have to sit and wait. They’re wrapped up in several layers of clothing, since it can get pretty cold in northern Bulgaria, even in the spring and fall months. “The most spectacular time is just before it gets completely dark, when we are still able to observe the bats and their behavior ourselves,” Goerlitz says.

But some experiments can only be conducted in the laboratory. Both at the station in Bulgaria and at the Max Planck Institute in Seewiesen, the researchers use sound-proofed flight rooms equipped with loudspeakers and microphones. These rooms are of course kept completely dark, in keeping with the animals’ nocturnal rhythm. The laboratory experiments have shown the researchers that the bats constantly adapt their echolocation to the specific environment and task. In the open air they emit regular calls at low frequencies, since these travel particularly far. As a result, they can detect obstacles and prey over longer distances. In contrast, when flying in more confined spaces, when landing or when approaching prey, the bats’ calls get shorter, contain more frequencies and are repeated more often. In this way, the animals optimize different aspects of the echoes to obtain more and more precise information about their environment from the returning echoes. “Thus, with their calls, bats let us know what they are currently interested in,” says Goerlitz.

Recently, the researchers have begun utilizing portable mini-measuring stations to study the strategies that bats use when approaching prey. Fitted with sensors, these devices are attached to the backs of the bats, and throughout the night, they collect data about the natural behavior of the animals in the wild. In this way, Goerlitz and an international team of colleagues have discovered how the bats can differentiate between their prey and other objects in the background. “Just before they attack, the background echoes disappear and the acceleration sensors kick in. In other words, shortly before they attack, the bats turn away from the background and towards their prey. In this way, they fade out the background and focus on the prey,” Goerlitz explains. But the prey insects have their own defense mechanisms against attacking bats. Moths, for example, can hear the echolocation calls made by the bats and react to the predators with sophisticated
Right: In the laboratory, Antoniya Hubancheva replays the hunting calls of a bat to a bushcricket and measures the insect's reaction.

Below: Most bats are very delicate creatures. A young pale spear-nosed bat like this one held by Holger Goerlitz weighs just around 15 grams.
The greater mouse-eared bat can localize its prey even in absolute darkness. To do so, it uses echolocation and its finely tuned sense of hearing.
Lesser and greater mouse-eared bats, common bent-wing bats and long-fingered bats in the Gabarnika Cave. The animals form huge colonies of tens of thousands of bats. They rear their young in the karst caves in northeastern Bulgaria, where they also roost during the winter months.
evasive maneuvers. This is surprising, since the insects have only a very simple ear. It consists of just one eardrum and two nerve cells with different levels of sensitivity. As a result, the moths can perceive a broad frequency range and hear a bat as it attacks, but they are unable to differentiate between individual frequencies.

Jointly with a colleague from the U.S., Goerlitz has discovered that the moths' sense of hearing is adapted to the local bat population. For example, if bat species that call at a higher frequency are living in a region, the ears of the local moths are more sensitive within this frequency range as well. The moths respond to a bat attack with a two-stage evasive maneuver. If the bat is still far away, and its call is relatively faint, they try to escape via the direct route. However, if the predator comes closer and its calls become louder, the insects fly in a zig-zag pattern or in spirals, or they drop to the ground. This variation in evasive maneuvers makes it difficult for the hunters to catch their prey. The researchers want to find out whether moths use different evasive maneuvers and which of these are the most successful. For example, it might be the case that every moth utilizes all available flight strategies. However, it may also be possible that moths only have one of these strategies available, in which case the variety of evasive maneuvers would be a group phenomenon. The researchers have been studying this hypothesis in the laboratory, using highly sensitive technology to measure the reaction of seven species of moths when they hear recordings of bat echolocation calls. The experiments have shown that each species of moth uses different maneuvers. Among some species, there are even differences between individual moths. “Since several species of moth live in one habitat, this diversity provides additional protection against the predators, since a bat is unlikely to differentiate between the various species of moth. As a result, it cannot know how the prey will react,” says Goerlitz.

To date, the researchers only understand the features of the two nerve cells that are activated immediately by the vibrating eardrum. However, they know almost nothing about what happens to this information in the moth’s brain. Therefore, Goerlitz and his team also want to find out more about the neuronal basis for these types of behavior. “For example, how are the sensory inputs to the left and right ear combined? Or how long does it take for a reaction to occur after the sound has entered the ear, and how is hearing influenced by other stimuli, such as light or the pheromones of female moths?” To learn even more about

For their studies, the researchers also investigate bats in the laboratory. The bats are captured in fine-mesh nets, from which they are carefully extricated.
the strategies that evolved in prey species to outsmart their attackers, Holger Goerlitz and his team are also studying bushcrickets. Bushcrickets primarily use sounds to communicate with each other. But this could reveal their location to bats, which not only actively emit echolocation calls, but also passively listen to sounds generated by their prey; so the bushcrickets have to adapt their communication to their nocturnal predators. For this reason, some bushcrickets stop chirping when bats are close by. However, some species don't let themselves get distracted by the hunters flitting around them and continue to sing as before. “Interestingly, these are species that chirp with a fast rhythm and at high frequencies. It is possible that their chirps superimpose the echoes from the surrounding in such a way, that the bats are no longer able to orient properly in their habitat,” Holger Goerlitz explains.

The first laboratory data appears to confirm this idea. When bats hear the songs of bushcrickets via loudspeakers, they are less successful in catching their prey. When several bushcrickets sing simultaneously, it could also create a similar stereo effect to the one we hear from our stereo systems. Although the same sound is coming from two sources (the speakers), we do not perceive them as being separate.

Instead, we localize the sound within the center between them. The bats might experience a similar phenomenon, making it difficult for them to perceive and locate their prey as individual targets.

In summary, the researchers have observed various adaptations of the prey species in response to the hunting strategies used by the bats. Have the bats responded in turn, meaning that a kind of “arms race” is taking place between the hunters and their prey? “For many years, it was thought that this was the case. Bats and moths were considered a textbook example of coevolution between predators and prey,” Goerlitz says. One of his discoveries initially appeared to confirm this view. Barbastelle bats mostly hunt moths that have a sense of hearing. Their calls are ten times quieter than those of other bat species. And the closer they come to the moth, the quieter they become. This enables the animals to outwit their prey's auditory senses and catch the moth. However, the disadvantage of this hunting strategy is that the barbastelle bat only receives faint echoes from its environment, and therefore is almost flying blind. The fact that it is willing to accept this handicap suggests that the advantages of its quiet echolocation for hunting compensate for its disadvantages during orientation.

However, Goerlitz no longer agrees with this idea, and is investigating an alternative explanation. Many close relatives of the barbastelle bat hunt along the edges of forests and bushes and above meadows by listening for the rustling sounds made by insects. At such proximity to the vegetation, loud orientation calls also generate loud echoes from the vegetation. In addition, they mask the quiet rustling sounds of the insects. Possibly the ancestors of the barbastelle bats began to call more quietly to prevent this masking. The advantages of quiet echolocation for hunting prey with ears in open spaces would have been a secondary effect that the barbastelle bats only began to exploit later on. It was also assumed for a long time that the sense of hearing in moths had evolved in response to predation by bats. However, there are now indications that the moths were already able to hear millions of years before bats came on the scene. If that is true, then their sense of hearing evolved to communicate and as a general sense of their environment, and not as a specific reaction to nocturnal predators. “As you can see from this example, it is often difficult to determine the cause of an evolutionary development with any certainty,” Goerlitz explains.

“However, there is a simple reason why moths have adapted in more ways to bats than the other way around,” says Goerlitz. “For the prey, the pressure to succeed is far higher, since for them, it is nothing less than a matter of life and death. For the predator, however, all that is at stake is another meal.”
RACING AGAINST THE VIRUS

Roadmap for new vaccines

START OF TESTING SEVERAL VACCINE CANDIDATES AGAINST SARS-CoV-2 (Status Spring 2020)

Parallel testing of several vaccines in the same study

RESEARCH

20* Search for suitable vaccines

* Estimated number of candidates

PRECLINIC

10* Tests on tolerance and protective effects in animals

PHASE I

5* 20 to 80 volunteers per study

Tests on safety and immune response

PHASE II

3* Tests on safety and immune response

Test in specific target group

PHASE III

1* About 10,000 volunteers per study

Protection from infection/disease

VACCINE APPROVAL

YEAR 0

YEAR 3

YEAR 12

START OF RESEARCH

PARTIALLY OVERLAPPING IMPLEMENTATION OF PRECLINICAL, PHASE I, PHASE II, AND PHASE III STUDIES

YEAR 7+

CLINICAL DEVELOPMENT
New vaccines must prove their worth in time-consuming trials before they can be approved. Only one candidate in 20 passes all tests. The studies make sure that people only receive effective and safe vaccines. In cases of emergency, such as the Corona crisis in 2020, researchers are trying to accelerate the development of candidates.

“Currently, there is no ideal model to study the SARS-CoV-2-Virus.”

Prof. Stefan H. E. Kaufmann
Max Planck Institute for Infection Biology
CAMPAIGNER FOR HUMAN RIGHTS

Mariela Morales Antoniazzi has challenged corruption in Latin America and mobilized its citizens. The Venezuelan-born lawyer is currently conducting research at the Max Planck Institute for Comparative Public Law and International Law in Heidelberg to investigate why human rights are the prerequisite for any democracy – and how to defend them.

“There are indeed enough reasons to despair,” says Mariela Morales Antoniazzi. “But who would that help?” The Amazon rainforest is burning. It’s an issue concerning the pasture land and cultivation areas for an agricultural industry that is expanding ever more rapidly. The areas are so vast that they are visible in satellite photos from space. In Argentina, women fall victim to the culture of machismo. Every 30 hours, the authorities report a murder; the perpetrator is almost always a lover or husband. In Mexico, people are demonstrating in memory of the 43 students who disappeared without a trace in the city of Iguala six years ago. They were not the only ones, and they won’t be the last. Die Zeit quotes one observer as saying that the country is “one mass grave.” Nobody knows how many people have been kidnapped and murdered to date. The estimated figure is around 60,000.

Human rights? An opportunity for education and prosperity, for health, participation, freedom of the press? “There are indeed enough reasons to despair,” reiterates the lawyer. But resignation is just not in her character.

In Chile, police use firearms against demonstrators. The preferred target for the carabineros are the demonstrators’ eyes. In Brazil, President Jair M. Bolsonaro frivolously and cynically plays down the danger of COVID-19. The ‘M’ in his name stands for “Messiah”, but the inhabitants of the densely populated slums of Rio de Janeiro, the favelas, have no chance against the pandemic. In Venezuela, two men are vying for the office of president: the incumbent, Nicolás Maduro, and the opposition leader, Juan Guaidó, who is officially recognized by around 50 states, including the U.S. and the majority of EU countries. Venezuela was once the fifth largest oil exporter in the world. Today it staggers towards ruin; its people are starving. Five million people have already fled, most of them to neighboring countries, where as migrants they are no better off.

TEXT: MARTIN TSCHECHNE
A lawyer with an attitude. Mariela Morales Antoniazzi has set herself the task of utilizing her research to improve the living conditions for people in Latin America.
Protests in Caracas: after Venezuelan President Nicolás Maduro disempowered parliament in March 2017, tens of thousands of Venezuelans demonstrated against an impending dictatorship. The state reacted with reprisals.

Mariela Morales taps her finger on the table to the staccato of her complaints. Colombia, Honduras, Nicaragua. Venezuela is her homeland. She studied there, was politically active, and made a name for herself. She took on the police to break the vicious circle of corruption – quite simply by making them install GPS navigation in patrol cars. From that moment on, civil officials at headquarters would always know where their security forces were patrolling, where they were stopping and perhaps knocking on a back door. She had tough guys in uniforms unburden themselves to psychotherapists about what was weighing on their minds at work. She speaks live on the Internet to 6000 students in Mexico, she distributes her seminars about the human rights system of the Organization of American States online, and she has published books – 24 of them to date – in which she states that political morality in Latin America is in a state of emergency. An entire region devastated by dictatorship and “hyper-presidentialism”, by mismanagement, drug trafficking, and civil war.

Is that really a topic for academic research? “Certainly,” she says. “An urgent topic even!” Her own journey has been protracted. She has been the Minister of the Interior and the Deputy Minister President of the State of Aragua, Chief of Police, lecturer at the Andrés Bello Catholic University and at the Central University of Venezuela in the capital city of Caracas. She is the founder of a citizens’ movement for nationwide change, an advisor to the government, a campaigner, and a coordinator. Yet, for all her determination and almost defiant courage, in person, Mariela Morales is surprisingly engaging, open, and charming. Sporting a sunflower yellow jacket and butterfly glasses in a retro look, she has decorated the table in the conference room of the Max Planck Institute for Human Rights.
Planck Institute for Comparative Public Law and International Law in Heidelberg with flowers and a doily upon which she has placed a self-made flan. “Made with coconut milk,” she explains, beaming. “It’s the secret ingredient that distinguishes Latin American egg custard from its Spanish counterpart. You must try it!”

Time and time again, she has seen that the vicious circle of greed for power and corruption can indeed be broken. She cites the case of Velásquez Rodríguez vs. Honduras – kidnapping and murder by a corrupt regime – and the list goes on: Karen Atala vs. Chile, Maria da Penha vs. Brazil, González and others vs. Mexico. She continues to list the names, each one telling the story of a successful revolt: against the mistreatment and murder of women, against the exploitation of indigenous communities, the destruction of the natural environment, discrimination against homosexuals, African Americans, migrants, and journalists. Against the pervasive practice of kidnapping and killing people, against the lack of rights of homeless children, the suppression of ‘undesirable’ judges. “Something can and must be done,” she concludes. “Always! Just think of Alberto Fujimori;” she says triumphantly. The president of Peru was accused of electoral fraud and corruption, of deploying death squads, and of murder. He was made to stand trial. And he is currently serving time in prison for his crimes.

Born in 1962, Mariela Morales Antoniazzi studied law in Caracas. The stance of Catholic liberation theology proponents regarding human rights and justice dominated the discourse at the time. When Carlos Tablante, then Minister President of Aragua, asked her to join his cabinet, Mariela Morales was 31, a young lecturer, married with two small children, dedicated, educated, and full of idealism. Her appointment as the Minister for Internal Security was a signal to the people – perhaps even an experiment. It might be said that suddenly being placed in charge of the police, civil defense, and fire departments was a bit overwhelming. After two weeks in office, Mariela Morales was ready to throw in the towel. “You need a politician,” she said to her boss, “not a professor!” Her opponents in the old guard were in complete agreement.

But she stayed. She recognized her opportunity and grabbed it. She had tracking systems installed in police cars, banned public officials from having lucrative side jobs as security advisors, and made sure that staff were better trained. Money wasn’t an issue; thanks to state-owned oil production, it was practically on tap. She overcame resistance with her friendly and cooperative approach. No time today? Tomorrow then, any time! The federal structure of her country was a boon. “The power existed right where it could make a difference,” she says. “Decentralized. And that’s exactly what our goal was: to change things! Transformation.”

Carlos Tablante’s time in office ended in 1996, after two terms. Mariela Morales remained in her post more months – but it was during that time that she began to foster a debate on values like plurality and the rule of law in other forums. She founded a non-governmental organization, held public seminars on democracy, and discovered the Inter-American System for the Protection of Human Rights: the Commissions and the Court. She argued that these are powerful instruments to record and publicize the individual stories of suffering and misery being felt from Mexico to Patagonia, to administer justice on the basis of international treaties, and to bring about political change. From human rights policies based on witnesses and analyses to more than 360 judicial rulings – the lawyer in her never tires of citing from the list: Claude Reyes in Chile, Barrios Altos in Peru, Sarayaku in Ecuador...

“There’s a world of difference between the constitutional texts and the reality on the ground.”
When Hugo Chávez ran for the office of Venezuelan president to implement his vision of 21st century socialism, she was skeptical: “A military that a few years earlier had attempted a violent coup d'état cannot govern in a truly democratic manner.” Mariela Morales arrived in Germany with her family on September 30, 1998. A DAAD scholarship gave her the opportunity to obtain her doctorate after years in political office and as an activist. The precise date is significant to her. Three days later, she recalls, she witnessed German Unity Day and was impressed. A democracy that has a reason to celebrate itself. Hugo Chávez did not take office until December 6, 1998, a good two months after her departure. “So I didn’t vote for him,” emphasizes Mariela Morales. She wouldn’t have done so in any case. But she didn’t know at the time that her fears would come true and that she would be unable to return to Venezuela.

After all, hadn’t Hugo Chavez been feted as the shining example of a reformer? “No!”, she contradicts indignantly: “He was no reformer!” Was his successor, Nicolás Maduro, therefore, also a dictator? “Definitely: sí!” Enter stage left Juan Guaidó, would-be liberator of the country, with the support of more than 50 countries, including Germany – but his priority appears to be winning the support, of all people, of the authoritarian Donald Trump. It’s not easy to understand how and why he arrived at his policy. “You don’t understand?” Morales asks sharply. “Neither do I! A year ago, directly after Guaidó’s international acknowledgement, we organized a colloquium in Berlin to discuss the political situation in Venezuela. What’s at stake is the guarantee of human rights. That alone is the basis for my analysis. And I must stress that it is especially difficult for the opposition to make any headway, because the current dictatorship has taken other forms than those in the past. There’s a difference. But it’s still a dictatorship.”

This makes the role of supranational institutions all the more important. So is effective networking with human rights organizations, both regional and international. Constant feedback from state institutions, such as constitutional bodies or courts, is also of great significance. “The principle of democracy is now firmly established in South America,” Morales wrote in the first sentence of her dissertation in 2013. However, six years later, in an article published together with Armin von Bogdandy, the Director of the Institute in Heidelberg, she declared: “The living conditions for many people in Latin America are unacceptable.”

A contradiction? “Only at first glance,” says Morales Antoniazzi. And therein lies the problem. She begins to expound on the concept of transformative constitutionalism, which she and her colleagues see as the goal of their work: “Constitutions are texts that define our rights. However, there’s a world of difference between what they regulate and what they implement in practice. Above all else, the promise is for equality – but we are the most inequitable region in the world!” When reality and constitutional norms drift so far apart, social change becomes an imperative. This marks the starting point for her academic research.

After all, the principle of democracy has a long history in the region. It begins with its independence, back in the 19th century. At that time, the countries of South America were poised for a new beginning. They adopted constitutions that were highly progressive and optimistic. They also enshrined democracy, human rights, and fundamental economic and social rights into law. When the European states followed suit much later, they discovered the South American principles were a valuable template. Similarly, the 1948 Universal Declaration of Human Rights from the United Nations took as its basis the principles of the Pan-American Union founded in 1910 – until everything faded away or was crushed and dissolved in the fury of the military dictatorships in Argentina, Chile, Uruguay, Paraguay, Bolivia, Nicaragua and Peru.

However, unlike in other regions of the world, what remained was a consciousness and a political culture, international connections, vigilant protest movements, and well-established, competent institutions like the Inter-American Human Rights System. “What we are striving for,” says Mariela Morales resolutely, “is an expansive guarantee of the separation of powers, an independent judiciary, and a guarantee of human rights. That applies to elections and freedom of expression and movement, but above all, to health, education, and employment.”

Of course, she sometimes gets a lump in her throat when she hears news from her homeland that shows how far reality is from these lofty goals. But at other times it fills her with righteous fury.
Charming, but tenacious: as Minister for Internal Security in the Venezuelan state of Aragua, Mariela Morales thwarted police corruption in the mid-1990s. Nowadays, the lawyer lives in Heidelberg and follows the developments in her native country with concern.
More than 400 lawyers and scholars throughout Latin America belong to her project network Ius Constitutionale Commune en América Latina, all of whom are connected to citizens’ movements and organizations in their regions. Mariela Morales has organized 211 international colloquia from her home base in Heidelberg, and she considers the availability of online communication platforms – zoom conferences, Skype discussions, webinars – a real blessing. It has never been easier for her to reach so many people and get them talking, to bundle their reports and use them to develop strategies and scholarly concepts.

But it also has never been more urgent. COVID-19 is a disease that first and foremost devastates the poor. 30 percent of the population of Latin America live in poverty, 11 percent live in extreme poverty, and 53 percent work without a fixed contract. The elderly, women, and children are particularly exposed to the threat, along with refugees, marginalized groups, the inhabitants of the slums, and healthcare workers. “The virus doesn’t discriminate,” Morales quotes a World Health Organization (WHO) memorandum, “but its effects vary greatly. If just one community of indigenous people becomes infected, they all perish.”

For politicians, the epidemic frequently provides an opportunity to restrict fundamental rights, virtually at a single stroke. “So we must be vigilant,” warns Morales. Which rights are being curtailed? On what grounds are restrictions being imposed? For how long? “Human rights are the issue,” she says. They must include medical care and access to clean water, the preservation of the natural environment, as well as education, employment, freedom of expression, political participation, and an independent judiciary.

“And don’t assume,” she adds, “that the issues concern only the corona virus and Latin America. We always keep countries like Poland or Hungary in mind as well.”

LATIN AMERICA’S CIVIL SOCIETY IN CRISIS

The organization CIVICUS evaluates whether citizens are allowed to exercise their liberties in the civic space. The category ‘openness’ is a measure of the extent to which citizens of a country are guaranteed freedom of association and assembly, as well as freedom of expression. Many Latin American countries violate these fundamental rights.
RESEARCH DOESN’T HAVE TO BE HEAVY.

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For centuries, their lives were under threat: Europeans considered bears, wolves and ibexes either as a threat, a food source or trophies, and hunted them to extinction. Wilko Graf von Hardenberg, a researcher at the Max Planck Institute for the History of Science in Berlin, studies the ways in which our relationship to iconic mammals has changed over the centuries.
Back on top: following an eventful history, during the course of which Alpine ibexes were sometimes found exclusively in the Gran Paradiso region and even there were only a few hundred specimens, there are now large numbers living in the Italian national park and throughout the entire Alps.
For the first time in more than 170 years, a brown bear came wandering through Bavaria in the summer of 2006, having made its way from Italy to Germany via Austria. Bruno, as he was dubbed, soon became the talk of the town and became a popular topic in press reports. He was even featured in a report in the New York Times. True to his nature, he would prey on sheep and goats and plunder beehives. He soon became a “problem bear” as he began to venture close to residential areas, and caused general merriment when the then Prime Minister of Bavaria, Edmund Stoiber, used the term in a clumsy manner. He was shot dead on June 26, 2006, following weeks of unsuccessful attempts to capture him. The manner in which the 110 kilogram animal was dealt with serves as a good example of the problems associated with human-predator coexistence: no sooner had the intruder crossed into Germany than two implacably opposed factions formed. On the one side were the nature conservationists, who argued that bears are part of the original Bavarian ecosystem and that they should once again be accepted as the uppermost link of the food chain. On the other side stood the livestock farmers, who were concerned for their herds, as well as members of the public anxious about having to coexist with a predator and who were only too happy to talk in terms of “the problem bear.” Following the fatal shot, emotions boiled over among both parties: there were lawsuits and even death threats.

The history of iconic animals

In the case of wolves, which are once again roaming free in some areas of Germany, there is a similar dispute involving conservation on the one hand and the safety of people and property on the other. And such disputes are not new: for many years, environmental historian Wilko Graf von Hardenberg of the Max Planck Institute for the History of Science in Berlin has been looking into how humans deal with iconic animals. In the current context, the word “iconic” refers to animals that have a special meaning for humans. Traditionally, these mainly include the large predators, such as bears and wolves, whose great strength impresses us and which are depicted as heraldic animals on flags and coins. The eagle too belongs in this group. Yet there are also harmless herbivores, such as the ibex, that have been elevated due to their majestic appearance, as well as their importance for hunting. The ibex is depicted in the coats of arms of numerous Swiss cantons. “An irony of history,” says Hardenberg: “of all the heraldic animals there are, this one became extinct in Switzerland for about a century.” The last one was shot there in the first half of the 19th century and the species wasn’t reintroduced until 1920.

Large animals need extensive ranges to survive; in the case of brown bears this is between 100 and 300 square kilometers for females and males respectively, and about half as much for wolves. More often than not, even national parks are too small, as many animals travel long distances. Young wolves and bears will travel hundreds of kilometers in search of new territories. Thus, people have always had to come to some arrangement with the large predators. Until the end of the 19th century, the arrangement was very one-sided: bears and wolves were hunted mercilessly in the Middle Ages and for a long time afterwards, and the hunters were often even paid a bounty. These predators were demonized, which is still evident in many fairy tales, for example when the wolf eats Little Red Riding Hood. The brown bear had already disappeared from the British Isles about 1000 years ago, and it became extinct in Northern Germany towards the end of the 18th century. It was able to survive for another 50 years in Bavaria, but another 100 years later, after the Second World War, all that remained in the Alpine region were a few isolated colonies in Italy and Slovenia.
Had not a new way of thinking taken root in politics and society in the early 20th century when nature conservation began to gain in importance, bears and other iconic animals would probably have become completely extinct throughout Western Europe. The idea was to protect animals rather than hunt them. Hardenberg suspects that this change in thinking was the result of industrialization, as more and more people started living in cities and lost touch with untamed nature.

This enabled a romantic image to take hold, in which even large predators had their place. But this was not a straightforward development and it depended upon many factors. Each region had its own traditions, economic structures and political bias.

The significant effects of centralization: the number of ibexes in the Gran Paradiso National Park was not always determined reliably between 1923 and 1947, partly because the park administration changed their survey method during that period. However, the statistics reveal the trends, the most obvious of which is that when the supervision of the park was entrusted to the National Forestry Militia by the fascist regime and extra-regional militiamen were brought into the region, the ibex population shrank dramatically. It only recovered after the end of this era.
So one has to look very closely at the detail to understand how the relationship between humans and large mammals has changed over time.

This is what Hardenberg has done. He conducted research into the management of the ibex in the Italian Gran Paradiso massif region between the two world wars. The results, from two years spent searching the archives, will be published by the University of Pittsburgh Press in 2021 in a book entitled A Monastery for the Ibex. The book tells the story of how the Gran Paradiso area ensured the survival of the Alpine ibex (Capra ibex). The high alpine region north of Turin became the final refuge for the species during the 20th century. Like the brown bear, it had become almost extinct in the Alps and only survived there. All living members of the species descend from this bio-reservoir. The fact that the ibex did not vanish completely is down to the intervention of the authorities. King Carlo Felice banned the hunting of these rare animals as early as 1821, and King Vittorio Emanuele II established a royal hunting reserve around 30 years later and had it guarded by a dedicated corps of guards. Ultimately, this became the forerunner of the Gran Paradiso National Park, which was established in 1922, shortly after the First World War.

Thanks to the protection this provided, the number of ibexes increased from 2370 in 1922 to 3865 in 1933. But then the development toppled in the opposite direction and the population fell dramatically. Whilst 1564 animals had been recorded in 1942, this number had fallen to just 419 towards the end of the Second World War. The cause was quickly identified: poachers had almost wiped out the population for cheap meat. The fact that they were able to go about their business undisturbed can be explained by the prevailing political situation: following Mussolini’s rise to power, the fascists intervened in the park administration in 1933. Their goal was to present Italy as the final refuge for the species, and their propaganda emphasized the extent to which the fascist regime was committed to the protection of Italy’s natural environment. However, this failed entirely. The fascists established a dedicated forestry police force, the Milizia Nazionale Forestale, which was recruited from all parts of Italy. Prior to that, the gamekeepers had been recruited from the local area. The outsiders were neither familiar with the nature of the region nor with its game passes and secret trails, nor with the peculiarities of the local population. Because many of the militias had been posted to this remote region as a punishment for disciplinary violations, their motivation levels were very low. Their ignorance also made it easy for locals to outwit them. The story is told of one gamekeeper who courted a local woman whose two brothers were well-known poachers, so she was always able to tell them well in advance which routes the various patrols would take. The brothers hunted the ibexes unchallenged and even processed the meat in their own restaurants.

Whilst ibexes are currently protected, this is not always the case for bears and wolves. But was poaching really the only thing responsible for the sharp decline in the ibex population? There are other conceivable reasons, such as particularly harsh winters, frequent avalanches, epidemics and having to compete with chamois for food. And there were indeed some extremely severe winters at that time. However, Hardenberg wanted to know precisely what happened, so he applied modern biostatistical methods to the historical data. He made use of a computer model developed by a research team led by climatologist Andrew Jacobson of Princeton University in New Jersey. The researchers had developed it in 2004 to determine the extent to which the ibex population depended on climate in precisely this Alpine region. Although the period in question was 1956 to 2000, theoretically the model should also work for earlier years. Hardenberg applied it to the interwar years and the results were clear: by no means can the prevailing weather conditions explain the decline in the ibex population after 1933. Outbreaks of disease and avalanches can also be ruled out, as the park administration would have
documented such events. The only remaining cause, therefore, was indeed poaching.

The ibex is no longer endangered in the Alps, where approximately 45,000 animals are currently thriving, of which about 13,000 are in Italy and over 17,000 in Switzerland. There are even a few hundred ibexes climbing around the German Alps, and their numbers appear to be increasing. Whilst the conservation and reintroduction of the ibex is currently supported by all sides and probably owes a large part of its success to this fact, the situation is more complicated when it comes to the large predators that can get into conflict with humans. Protecting bears, wolves or lynxes, for example, is always associated with a considerable amount of conflict. In the book The Nature State, which was published by Routledge in 2017 and which he co-edited, Hardenberg describes how the coexistence of man and bear has developed in Trentino. Ultimately, the story of the problem bear Bruno is also a result of this history. It all started when brown bears became extremely rare in the Alps during the 19th century as a result of several factors: on the one hand, the animals were hunted with a vengeance right up to the first third of the 20th century because they preyed on goats and sheep. Most of the inhabitants of the Alps still lived from agriculture at that time, so they had reason to fear predators.

On the other hand, the Alpine landscape underwent a radical change: forests were cleared, Alpine pastures were established, new settlements were constructed, tourism...
flourished, roads and railways were laid through remote valleys, and industrial enterprises settled there. Bears, which need large ranges, found ever fewer refuges. They were no longer able to move from their summer pastures to their wintering grounds without crossing traffic routes or coming close to buildings. Even in the course of their usual forays they always came across human encroachment. Ultimately, the bears were forced to coexist with civilization; rather than avoiding people, as is their natural tendency, they accepted our proximity. The result, according to Hardenberg, was that: “The number of conflicts between humans and bears rose sharply.” Claiming self-defense, people would reach for their guns wherever bears appeared.

Attitudes towards the brown bear began to change at the start of the 20th century, not least because more people were beginning to adopt a romantic view of nature and no longer simply regarded predators as enemies. Many intellectuals and politicians at that time began to believe that the existence of bears was endangered and demanded protective measures. But the killing continued. Decades passed before a protected area was finally opened in the Adamello-Brenta region. The fascists, of all people, then stood up for the endangered species – again for propaganda purposes.

In 1936, the Italian Ministry of Agriculture and Forestry prohibited the hunting and capture of bears, enacting the first total ban on bear hunting anywhere in the world. However, because there were no gamekeepers and the local population was not supportive, not much changed. Many claimed that not only were farm animals in danger, but also children. Even state compensation for the damage caused could not prevent the trend, though the farmers were happy to take the money. Hardenberg unearthed an incident that took place in September 1954 involving a missing cow. The farmer demanded compensation, claiming that a bear had killed his cow, which however, had just escaped and later reappeared. The bear was innocent.

By the mid-1990s, there were only three bears remaining in the Adamello-Brenta Nature Park – too few to maintain a breeding population. This critical situation finally mobilized the state. To avoid having to abandon this highly symbolic animal and under the auspices of an EU project, the park administration brought in bears from Slovenia, where there are still large populations. The operation was launched on May 26, 1999. A truck struggled up a narrow mountain road in the Tovel valley with a male brown bear from Slovenia in its trailer. Nine additional transports were to follow in the following years, and the population eventually recovered.

Among the imported animals were the parents of “problem bear” Bruno. Joze, the father, was rehomed in Trentino on May 22, 2000, followed by the mother, Jurka, on May 3, 2001. Bruno, a dyed-in-the-wool Italian, was born in 2004. However, none of the family was particularly lucky, which probably has to do with the
idiosyncrasies of the mother. She never behaved aggressively towards humans, but did venture close to villages where she broke into stables and plundered beehives. Basically, she had adapted very well to the dense human settlement in the Alps. Because people refused to accept this, Jurka was captured in 2010 and moved to the “Black Forest Alternative Wolf and Bear Park.” Her offspring, who had all learned from her example, fared worse. Not only Bruno was shot, but also his younger brother, who had strayed into Switzerland, where he would rummage through dumpsters.

Bears only tend to come to Germany en route from other countries, whereas wolves have once again taken up permanent residence here after almost 150 years. “From a human perspective, wolves are more dangerous than bears,” Hardenberg explains. This is because, whereas bears are predominantly herbivorous, wolves are primarily carnivorous. 60 packs, 6 pairs and 6 individuals have found a home here since 1998. The Federal Documentation and Consultation Centre on Wolves (DDBW) keeps meticulous records of this. Discussions about this lupine immigrant are similar to the dispute about bears in Italy. Hunters and livestock farmers would prefer to shoot the wolves. And anxious urbanites would also like to forgo the slight sensation of fear when hiking through the countryside.

On the other side are the conservationists, such as the Nature and Biodiversity Conservation Union (NABU), who have proclaimed a National Wolf Day and are calling for donations. As Hardenberg has demonstrated in his work on other iconic mammals, whether the wolf will be able to survive long-term is no longer a matter of nature: “It’s a political decision,” the researcher explains. This is because man interferes with the environment and species diversity to a profound extent and ultimately determines wildlife populations, species composition and even the vegetation. Today, the notion of an untamed, pristine natural environment is reserved for romantics.

Summary

Humans have hunted bears, wolves, lynxes and ibexes ruthlessly for centuries, until these large mammals were only found in a few remote areas.

Many people’s attitude towards these iconic mammals has changed since the early 20th century, but there have been multiple setbacks in terms of protecting them.

Using the ibex population in the Italian Gran Paradiso massif as an example, Wilko Graf von Hardenberg has reconstructed the eventful history of efforts to protect it. He also used computational modeling to demonstrate that it was hunting, rather than climatic factors that thwarted efforts to protect the animals between the First and Second World Wars.

Man’s relationship with bears and wolves continues to be marked by the conflicting interests of conservationists on the one hand and cattle farmers and the concerned public on the other.
Chimpanzee Kinshasa with her brother Kuba and son Kiriku (from left to right) in the Tai National Park in the République de Côte d’Ivoire. These animals are extremely sociable and live in large groups, which means that pathogens can spread within a community with great ease.
Roman Wittig, who heads up the Taï Chimpanzee Project at the Max Planck Institute for Evolutionary Anthropology in Leipzig, knows what happens when a virus changes its host, and has experienced it several times in the Taï National Park in the République de Côte d’Ivoire, the last time having been four years ago, when a coronavirus that is harmless to humans jumped from humans to chimpanzees. In collaboration with Fabian Leendertz of the Robert Koch Institute in Berlin, he is looking into pathogens that cause disease in chimpanzees and which of them could also pose a threat to humans.

Everything had to happen very quickly when SARS-CoV-2 reached the Côte d’Ivoire: which team members would remain and who would be flying back to Germany? “We weren’t so worried about the staff,” Wittig explains, “as they are isolated and very well protected out there in the rainforest.” Instead he wanted to not only protect the park’s chimpanzees from getting infected but also, as he explains: “If we had all flown home, the chimps would have been left to the mercy of poachers.” Zoonoses, such as SARS-CoV-2, are diseases that can be transmitted from animals to humans, or vice versa. The pathogens involved could be viruses, but also bacteria, fungi, worms or infectious proteins – the so-called prions. Pigs, rodents, birds, and bats, including flying foxes, have been a recurring source and target of such host exchanges in the past. The same is true of our closest animal relatives, the great apes. For example, we share 99 percent of our genetic material with chimpanzees, which are particularly susceptible to respiratory diseases. Many of the chimps in the National Park were repeatedly falling victim to mysterious infections as early as the 1990s. “They started coughing and sniffling, became lethargic and lost their appetites,” says Wittig: “They slept on the ground rather than in the trees – something they never usually do for fear of leopards.” There was a major wave of infections in 1999, which caused severe symptoms in 50 to 70 percent of the animals, almost one in five of which died. Behavioral scientist Christophe Boesch was also at a loss at the time. Together with his wife Hedwige, Boesch founded the chimpanzee project in the Taï National Park in 1979 and, as Director of the Department of Primatology, later transferred it to the Max Planck Institute for Evolutionary Anthropology in Leipzig in 1997. Fabian Leendertz flew out to the national park, which is the last remaining extensive rainforest area in West Africa, and spent 13 months investigating the deaths. This was the start of a close collaboration between the two Institutes that continues to this day.

“There have been several major and minor outbreaks of disease during the past 20 years.” Leendertz explains: “We examined all the sick and deceased animals and collected fecal samples from the sick ones. We performed autopsies on the dead ones under strict safety precautions, as we were aware that there had also been cases of Ebola in chimps.” The analyses revealed that many of the outbreaks were caused by respiratory diseases.
Leendertz was able to identify various common cold viruses as well as a coronavirus known as OC43. The viruses came from humans and cause only mild symptoms in adults. The apes’ immune systems, by contrast, were unable to fight the pathogen, which was new to them. Leendertz also identified Streptococcus pneumoniae bacteria – so-called pneumococci – in the chimpanzees, which can also be transmitted by humans. “We now know that such secondary bacterial infections can contribute to the severity of a viral disease.”

The researchers developed strict handling and hygiene guidelines to protect wild animals from human diseases in the future, which are still in force today. Anyone arriving at any of the four camps in the Tai National Park to carry out research is quarantined for five days. “Handwashing and wearing a mask are also compulsory,” says Wittig. Since that time, researchers have been monitoring the health of the chimpanzees in Tai National Park: the team collects fecal and urine samples and examines them for pathogens in the laboratory.

But humans are not the only ones capable of transmitting pathogens to animals: there is a plethora of unknown viruses, bacteria and parasites slumbering in primeval forests around the world, which could become dangerous to humans. For many years, therefore, scientists have been hunting down mosquitoes, mice and bats and studying the pathogens they carry. Unfortunately, however, this does not enable us to identify which of the pathogens can actually cause diseases in humans. Apes, on the other hand, are susceptible to a spectrum of pathogens very similar to that of humans and often fall ill from the same infections. “So any pathogens we find could be heading our way.” Leendertz explains: “That’s why we now use chimps as indicators of new, potentially dangerous germs.”

“The animals live here in their natural environment and when they fall ill, they help us to identify the causes.”

Thanks to the continuous emergence of new technologies, researchers are even able to reexamine samples that have already been analyzed to shed light on things such as nutritional status or changes to the immune system and intestinal flora. When, for example, they discovered a new, atypical anthrax pathogen known as Bacillus cereus biovar anthracis, in dead chimpanzees, they also analyzed older bone and tissue samples and discovered that of 55 dead animals, 31 had been infected with the bacterium. Subsequent analyses revealed that the pathogen had also been responsible for the deaths of numerous wild chimpanzees, gorillas and elephants in Cameroon and the Central African Republic. “Now there are signs that suggest that humans in the region have also become infected with the pathogen,” said Leendertz.

Over 50,000 fecal and 40,000 urine samples, as well as tissue from autopsies and genetic samples are currently in storage in the cold rooms at the Max Planck and Robert Koch Institutes. In most cases, the researchers even know which chimpanzee a given sample was taken from. “Such long-term data represents a treasure of immense importance,” as Roman Wittig explains: “It becomes increasingly valuable over time because very few studies go back that far.”

Once a month, Roman Wittig’s team collects feces and urine from each of the habituated chimpanzees. Fabian Leendertz and Wittig examine the feces for traces of pathogens.

This photo shows a student of the Tai Chimpanzee Project collecting urine in a plastic bag from a chimpanzee perched in a tree above her. The mask she is wearing protects against a possible infection of both humans and animals.
Chimpanzee mortality rates between 1985 and 2017 in the North and South Group of the Taï Chimpanzee Project. The comparison with the average birth rate shows that significantly more chimpanzees died than were born in many years. In the last 20 years, the chimpanzee population in the park as a whole has decreased by 90 percent. Only in the past few years has the population stabilized to a certain extent.

In samples taken from several outbreaks, the researchers also recently succeeded in detecting the pathogen responsible for monkeypox, a viral disease that is transmissible to humans and can cause a mild illness similar to smallpox, but can also be fatal. The list of currently known zoonoses includes over 200 diseases, ranging from A for Anthrax to Z for Zika. At up to 300,000 new infections per year the Lassa virus, which first appeared in 1969, is among the most prominent examples. This was followed in 1983 by HIV which has so far killed 41 million people around the world. Then it was one thing after another: the H5N1 bird flu has been around since the 1990s, SARS emerged in 2003, the H1N1 swine flu in 2009, Mers in 2011, Ebola in 2014, and Zika in 2015. And now SARS-CoV-2. This does not surprise Fabian Leendertz, who considers it to be only a matter of time until the next pathogen makes the leap to humans, as we are doing everything possible to promote zoonoses: we are encroaching ever further into hitherto pristine regions and coming into closer contact with wild animals. We hunt, trade and eat wild animals on a mass scale. And thanks to today’s mobility, we are able to spread pathogens across the entire globe within a very short time.

The, for the most part illegal, hunting of wild animals is increasing the worldwide risk of pathogens being transmitted from animals to humans. The consumption of “bushmeat” also has a long tradition in Africa. “The people attribute special powers to wild animals and there is a widespread belief that these powers will be transferred to them when they eat the animals.” There is also the fact that many animals have become so rare that prices have soared and, as a
result, wild animal products have become status symbols for the rich. Rhinoceros horn is so sought after in China and Vietnam that it is now worth its weight in gold. Although hunting wild animals is prohibited in many African countries, monitoring is lax and the profits tempting. Leendertz himself witnessed how custom officials at Abidjan airport asked a fellow passenger to open her suitcase: it was full of desiccated monkeys!

To counteract the ever-increasing destruction, Wittig and Leendertz have proposed the so-called “One Health” concept, which is intended to reduce the risk of new pandemics. “It is simply becoming increasingly apparent that disrupted ecological equilibrium favors zoonoses. We need healthy ecosystems for the sake of our own health. Therefore,” Wittig insists, “we ought to do everything possible to put a stop to the deforestation of the rainforests, the illegal hunting of wild animals and climate change.”

The poachers are now focusing on smaller game because the large animals in many regions have been exterminated. Bats, for example, are now being hunted by the hundreds of thousands. However, not only are they sought after as a source of meat, they also harbor a plethora of microorganisms. “Fruit bats and other bats are ideal hosts,” Leendertz explains, “because this genus includes a large number of species, and, for this reason alone, they host a wide variety of pathogens, which, because bats travel long distances in their nocturnal flights in search of prey, can be dispersed rapidly over long distances.” It is no coincidence, therefore, that SARS, Marburg, Ebola and the new coronavirus originated in these flying mammals.

But how does a virus get from a bat to a chimpanzee?

As Leendertz explains, “A fruit bat will chew on a ripe fig one night and leave its saliva behind. The next morning, a chimpanzee will eat the remainder of the same piece of fruit, and the microbes it contains will find themselves in a new organism.” If they then succeed in evading the ape’s immune system, multiply within its body and then go on to infect other chimpanzees, they will have succeeded in changing hosts.
SUMMARY

Pathogens can easily cross the species boundary between chimpanzees and humans, because the two species are genetically closely related: in the past, H1, Ebola- (from ape to man) and coronaviruses (from man to ape) have already succeeded in doing so.

The primary causes of zoonoses are considered to be habitat destruction, the illegal hunting of wild animals, intensive livestock farming and burgeoning mobility.

There are close links between human, animal and environmental health. In the battle against the transmission of the pathogens, researchers are therefore pursuing the “One Health” concept for a healthy environment, humans and animals.

As insectivores, the bats’ diet does not overlap with that of chimpanzees, but their habit of sleeping in hollow trees does result in contact opportunities. “Thirsty chimpanzees often find pools of water in such trees. They then chew up leaves, dip them as a makeshift ‘sponge’ into the pool and suck the water out of them – and a virus or bacterium can find its way into the new host.”

However, demonizing bats because of their “cohabitants”, driving them out of houses or even exterminating them would be a bad idea. Fruit bats, by contrast, are pure herbivores and feed on fruit, pollen, nectar and flowers and are, therefore, important pollinators. They then excrete the pips and seeds of their meals when they defecate far from the original location thus making an essential contribution to the reforestation of the rainforests. “Bats” as Leendertz emphasizes, “also do a lot for us humans, even in major cities such as Berlin.” They can eat up to a third of their bodyweight in insects, including mosquitoes, every night. “Without bats, we would have malaria epidemics in regions in which the disease has thus far been virtually non-existent.” In addition, none of the coronaviruses that are dangerous to humans are found in Central European bat species.

Do chimpanzees actually take care of each another when one of them falls ill? “Yes,” says Wittig, “that happens all the time. For example, we recently saw a leopard attack an adult female and literally scalp her during the struggle. Her offspring and friends kept coming over to her and licking the wound. And she survived it. If a youngster is sick and cannot...
A bushmeat vendor offers his goods for sale at the roadside. The transmission of pathogens is favored by poor hygienic conditions in wildlife markets.

Keep up with the group,” he continues, “the mother will leave it in a fruit-bearing tree. She then returns every other day to check on it until it recovers.”

If an alpha male or an old female dies, the group members gather round, touch the corpse and groom its fur. And some of them give in to their frustration. “When Ravel, a 15-year-old male, died,” Wittig recalls, “Oscar, his best friend with whom he had grown up, tried again and again to lift the corpse up and get it to stand up. But, when that didn’t work, he ran about screaming and flinging sticks around.” Dead chimps are also sometimes covered over with branches or leaves.

Do the researchers help sick chimpanzees? “No!” says Wittig. “We want to observe the animals’ natural lives, which include illness and injury – we don’t want to interfere in that.”

However, there was one exception: “It was when we realized we had infected the animals with our cold viruses and we didn’t yet know how to protect them.” To combat secondary pneumococcus infections, which is also transmitted by humans, Leendertz used a blowgun to inject some of the sick animals – including Sumatra, a female who was seriously ill at the time – with an antibiotic. That was over 20 years ago and, thanks to the therapy, Sumatra is now a very elderly chimpanzee matron.

So chimpanzees are extremely sensitive to respiratory tract infections. The consequences for them could be dramatic if SARS-CoV-2 were to reach the chimpanzees in the Tai National Park. If a vaccine was available, Wittig would probably inoculate at least those of them that have become accustomed to the researchers. “For the chimpanzees of Tai National Park, it’s purely a matter of survival: of the 3000 animals alive in 2000, just 300 are still alive today. We have a moral duty to protect the chimpanzees from an epidemic that we ourselves triggered.”

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The Foundation supports Yingxue Wang at the Max Planck Florida Institute for Neuroscience; she tackles the question how the hippocampus processes information, when our brain integrates past and future into the present.
THE BITTER LEGACY OF SLAVERY

TEXT: STEFANIE REINBERGER

When people find their final resting place in a mass grave, their life stories are often buried along with their mortal remains. Researchers from the Max Planck Institute for the Science of Human History in Jena have succeeded in reconstructing part of the story of three African men who lived in Mexico City in the 16th century: theirs is a story of forced migration and slavery, but also of dangerous pathogens that traveled around the world undetected.

Since the 1960s, the construction of the subway in Mexico City has brought numerous testimonies to the turbulent history of this centuries-old metropolis to light, thus saving them from obscurity. In one example, workers constructing a new subway line in 1992 came across a mass grave in the grounds of the Hospital Real de San José de los Naturales. The hospital was founded in 1530 specifically for the indigenous inhabitants, who were hopelessly vulnerable to diseases introduced by the Spanish invaders. Yet three of the skulls did not fit this scenario at all. Thanks to work carried out by an international research team under the auspices of the Max Planck Institute for the Science of Human History in Jena, the mortal remains of three men are now able to tell part of their story, which is one of slavery and suffering and provide new insights into Mexico's colonial era, but also into diseases that travel the globe alongside a mobile humanity.

The skulls of the three men stood out because of striking modifications to their incisors, which had been sharpened. Something similar had already been observed in African slave remains found in Portugal. And even now, this type of decorative dental modification is still common among certain ethnic groups in West Africa. The most obvious assumption was that the three men were of African origin. Research carried out by Rodrigo Barquera, a doctoral researcher and member of a team headed up by Johannes Krause, Director of the Department of Archaeogenetics at the Max Planck Institute for the Science of Human History, has recently shed light on the situation. Barquera has already had an eventful research career, having been active in everything from pharmacological chemistry to immunology, genetics and anthropology. However, the Mexican scientist has a particular interest in the history of his country and the roots of Mexico's contemporary population. “Everyone talks about the Spanish immigrants and the few survivors of the indigenous population,” Barquera explains. “Yet, this is only a part of the truth: there were also African slaves as well as migrants from Asia and Polynesia, whose genetic heritage is also reflected in modern Mexicans.” But this is hardly ever mentioned.

In 2014, the Mexican researcher, who, at the time, was Laboratory manager at the National School of Anthropology and History in Mexico City, invited Krause to participate in a workshop at which he talked about his field of research. Krause is one of the few experts in the field of archaeogenetics, which involves the analysis of old and ancient DNA, which can, for example, be isolated from skeletal remains. Barquera was so
Rescued: these children were liberated from a slave ship en route to America in 1869, at which point the slave trade had already been prohibited. Human trafficking had been common practice for 300 years. Children and adolescents were preferable “cargo”, as they were more likely to survive the brutal conditions of the ocean crossing and slave owners paid higher prices for them.
excited about this research field that he decided to relocate to Jena as a doctoral researcher. Once there, he got the opportunity to get hands on the putative Africans from the mass grave in Mexico City. He and Krause extracted one molar from each of the three skulls so that they could isolate DNA samples from them. “We can extract incredible amounts of data from very small amounts of biological material using modern laboratory techniques,” Barquera explains. “The range and breadth of information we can currently glean from the analysis of a single tooth is something we could only have dreamt of ten years ago.” So ancient DNA is now able to reveal many things that archaeologists have only been able to speculate about until now: it can be used to help classify people’s origins and track mass migrations; it provides clues about what people ate in the past and discloses the diseases from which mankind suffered in ages past.

The analysis of the teeth from Mexico City identified a genetic signature that points towards southwest Africa. It proved possible to match the three men’s Y-chromosomes to a genetic lineage that is widespread in Africa today and is also prevalent within the African American population. Such matching is possible because the Y-chromosome is inherited virtually unchanged from father to son and, therefore, bears the genetic signature of all male ancestors. An isotope analysis also showed that all three men were born outside of Mexico. The three skeletons show signs of violence and malnutrition. Fractures and deformities point to maltreatment and barbarous, hard labor. Traces of buckshot embedded in his bones prove that one of the men had suffered a gunshot wound at some point and that he obviously lived with it for several years. All three died young – between the ages of 25 and 35. “Together with the evidence that they were born outside Mexico,” Barquera explains, “all of this strongly suggests that the three men were among the first African slaves to be transported from their native land to Mexico.”

In 1518, King Carlos I of Spain authorized the transportation of African slaves to the Viceroyalty of New Spain, which encompassed what is now Mexico. By the time the importation of slaves into this region was prohibited in 1779, some 130,000 to 150,000 Africans had been forcibly resettled there. The reason for this was that the indigenous peoples, who until then had been abused as forced laborers, were dying en masse from diseases imported by the Europeans. Their immune systems were unable to mount a defense against such things as measles, smallpox and typhoid fever. Finally, a law was passed in 1542 that prohibited their use as laborers. Nevertheless, the colonialists still demanded to have slaves to do their household chores, agricultural labor and gold panning, and Africans were deemed to be more resistant to the contagious diseases that had been introduced. “However,” says Barquera, “that might have been a mistake.” One has to wonder, he continues, how the three African men ended up in the mass grave at the Hospital Real de San José de los Naturales, when this hospital was actually reserved exclusively for the treatment of indigenous people suffering from infectious diseases introduced by the Europeans. In all probability, the mass grave was for the victims of an epidemic to which the three Africans may also have succumbed.

But the three deceased also tell a story of pathogens that travel around the world on ships unnoticed – which given the current COVID-19 pandemic could hardly be more topical. Not only did the genetic tests reveal information about the origins of the men, they also showed that one of them had been infected with a strain of hepatitis B that is typically found in West Africa today. Whether this viral disease was rife in Mexico at that time remains unclear. Another of the men had been infected by the bacterium Treponema pallidum pertenue, which causes a painful, infectious disease similar to syphilis known as yaws. Previously, Barquera and Krause had discovered the same strain of the pathogen in Mexico in a 17th century European immigrant, which could indicate that the pathogen originated in Africa and spread among the early colonial populace.

The disease in both men was very probably still at the symptom-free stage, i.e., they were probably unaware of the pathogens, which, like stowaways, had been deported to Mexico along with them. “What this teaches us,” says Barquera, “is that, whether it’s voluntary or forced, human mobility has always gone hand-in-hand with the risk of spreading pathogens.” Still, the fate of the three men is the researchers’ main focus. As Krause summarizes, “We were able to gain insight into the life histories of some of the first African slaves in the Americas by combining molecular biology, isotope analysis and bioinformatics methods with traditional historical, anthropological and archaeological evidence.”
In the future, the team would like to use contemporary African genomes to learn more about the precise origins of the three men. “Unfortunately,” Krause explains, “there have been far fewer genome analyses performed on contemporary Africans than on people outside Africa.” While Africa is the cradle of mankind, he continues, and is home to the greatest genetic diversity in Homo sapiens, there is nevertheless far too little genetic data available from that continent. “Should this change in the future, we would hopefully be able to not only identify the origins of the three individuals from early Mexico, but also to give the many millions of descendants of abducted slaves currently living in North and South America more precise information about the origins of their ancestors.”

Through their work, the researchers in Jena have been able to sketch out the fate of three individuals, who serve as examples of the lives of African slaves in colonial Mexico. Yet, they cannot reflect the full history of these forcibly resettled people who were brutally trafficked from one continent to another. As Rodrigo Barquera states, one thing is certain: “Everyone here at the Institute has been profoundly moved by the fate of these three men. We’re finding it difficult to simply move on to the next research topic.”

A striking find: the sharpened incisors in the three skulls (above), which were discovered in a mass grave in Mexico City, differentiate them from the other interred persons. Genetic analyses revealed an African origin. The Africans’ skeletons show traces of excessive strain, due to heavy physical labor (center) and maltreatment (below): discolorations on the bones, for example, indicate gunshot wounds inflicted with copper shot.
“STRICTER LAWS ARE A SIGN OF HELPLESSNESS”

From Luegde and Bergisch Gladbach to Muenster, the scourge of child abuse cases does not seem to be slowing down. Demands for harsher punishment for the perpetrators are becoming louder than ever. In early July, the Federal Ministry of Justice presented its initial reform proposals. But what effect could stricter laws have? Tatjana Hörnle, Director at the Max Planck Institute for the Study of Crime, Security and Law, is skeptical about this trend. The lawyer has been dealing with the issue of abuse for years.

Proponents of tougher laws are demanding that child abuse should be punishable by at least one year in prison. But hasn’t that been the case until now?

TATJANA HÖRNLE Most of the cases that have recently caught the media’s attention – such as those of Muenster or Luegde – are clear-cut cases of serious sexual abuse. The Criminal Code already stipulates a prison sentence of between two and 15 years. Such acts are thus clearly classified as felonies. However, the legislation also covers less serious cases. For example, when a fleeting physical touch was on the borderline between “sexual” and “harmless”. Overall, the framework is quite broad. This corresponds to the various types of offenses and presents a convincing range of sentences that does not require amendment.

So you do not believe in higher minimum sentences?

I know that when it comes to sexual offenses against children, some people see it as trivializing matters when a distinction is made between serious and less serious acts. But especially the recent extreme cases make it clear: there must be a way to correlate varying degrees of offenses to varying levels of penalties. It is precisely in those cases in which the perpetrators have been particularly brutal and there are many victims that the lower limit in the Criminal Code is no longer relevant. Therefore, the question is: what do we want to achieve? When it comes to deterring offenders, it would be more important to increase the risk of discovery. When it comes to the moral condemnation of sexual violence against children, there is an unusually broad societal consensus. By increasing the minimum penalties, the legislator tends to create new problems.

In what respect?

In the legislation, there is a rigid age limit of 14 years; up to this age, any sexual act is prohibited. Based on surveys of 12- and 13-year-olds, we know that many have their first sexual contact with their peers at this age. But according to the legislation, a French kiss that a 15-year-old gives to his 13-year-old girlfriend is punishable by law. Austria and Switzerland already have an exemption clause for such cases. One positive aspect of the current reform project of the Federal Ministry of Justice is that a similar solution is to be introduced in German criminal law. But there are also lesser offenses in other constellations such as the one-time touches mentioned earlier. These are only just above the threshold of what must be considered “sexual”. For example, briefly caressing the genital region when the child is wearing clothes. The range of sentences should be designed so that even atypical, minor offenses can be punished appropriately.

The Federal Minister of Justice also wants to increase the minimum penalty in connection with child pornography. What do you think about that is?

The problem is similar to the one just discussed: the degree of wrongdoing varies. A continuum of cases ranges from youths wanting to break a taboo and experience the revulsion such images evoke to perpetrators who spread numerous images of rape with child victims. Here too, the range of sentences in the Criminal Code is designed to take the differences into account. When sexual acts with children are filmed and distributed over the Internet, the penalties for the perpetrators are already quite high. Even the mere intent to disseminate pic-
The cases of Muenster and Luedge have caused a great deal of public outcry. Across all political, cultural, and social divides, there is a broad consensus that child abuse must be combated. The outrage is particularly noticeable in our media-saturated society. Politicians are facing increasing pressure to act quickly. The simplest course of action is to change the range of sentences. Ultimately, this is a sign of helplessness. This is because the government and the Bundestag have no influence on court decisions. More effective investigative measures are currently hindered by the fact that data retention is on hold.

What is currently holding up the implementation of data retention measures?

A decision of the European Court of Justice is currently pending. It concerns the complaint of providers and the question of whether the German legislation passed in 2015 violates European data protection regulations. Telecommunications companies, data protection officers, and net activists all criticize the regulation. It is certainly justifiable to question whether (and under what conditions) we should accept the storage of our data – especially without cause. A reasonable compromise that controls and regulates access to retained data without hindering the work of law enforcement authorities would be preferable.
Material design. Damascus steel produced in the traditional way, such as that seen here, is often used for decorative purposes nowadays because of its characteristic pattern. In contrast, producing a material of this kind in a 3D printer involves varying the properties of materials that can be processed using this technology.
In ancient times, it was the material of choice for sword blades. Now, a kind of Damascus steel can be produced in a 3D printer using a technique developed by a team from the Max-Planck-Institut für Eisenforschung in Duesseldorf and the Fraunhofer Institute for Laser Technology in Aachen. Composite materials of this kind could be of interest for aerospace components or toolmaking.
Born out of necessity and destined to become a legend. In the past, blacksmiths were able to influence the properties of iron alloys only by adjusting their carbon content. They obtained either a soft yet tough or a hard yet brittle steel. Especially for swords, a tough and hard material was needed so that the blades would not break or have to be straightened in the middle of a battle.

Celtic smiths combined various iron alloys — perhaps initially only to recycle the valuable iron — and thus obtained the material that later became known as Damascus steel or damask. It owes its name to the trading center through which the composite material of oriental origin entered Europe. While Indian and Arabic damask was created by a sophisticated smelting process, European smiths developed the art of folding two alloys into many thin layers. The layered structure of Damascus steel can usually be recognized by a characteristic stripe pattern.

Although there are currently ferrous alloys that are both hard and tough, they are often not specifically made for the 3D printing process and therefore do not fully exploit the ad-
SUMMARY

A team from the Max-Planck-Institut für Eisenforschung and the Fraunhofer Institute for Laser Technology is developing alloys for use in 3D printing.

The researchers recently presented a technique whereby 3D printing can directly convert a single starting material into a kind of Damascus steel with alternating hard and tough layers.

By fine-tuning various parameters, such as the printer’s pause times, the laser energy, or the speed at which the metal is 3D printed, it is possible to make localized adjustments not only to the hardness but potentially also to other properties.

They developed an alloy consisting of iron, nickel, and titanium. At first, this alloy is relatively soft. “Under certain conditions, small nickel-titanium micro-structures form. These so-called precipitates harden the material,” explains Kürnsteiner.

“The laser beam makes it possible to not only melt the respective material but also to heat the top layer of the already resolidified metal. This is exactly what the team of the Max Planck researchers in Duesseldorf used to specifically change the crystal structure of the steel in individual metal layers. In this way, they can influence the mechanical properties without changing the chemical composition.”
In order to be able to create the nickel-titanium structures, the researchers interrupt the printing process for a certain time after each newly deposited layer. The metal cools down to below 195°C. “Below this temperature, a transformation of the crystal structure occurs in the steel,” explains Eric Jägle, head of the “Alloys for Additive Manufacturing” group at the Max-Planck-Institut für Eisenforschung and, since January 2020, professor at the University of the Bundeswehr Munich. “A ‘martensite’ phase is formed. It is only during this phase that the nickel-titanium microstructures can precipitate.” However, in order to allow
precipitates to form, reheating is necessary. To achieve this reheating the researchers exploit the laser energy used to deposit the subsequent layer.

This additional effect caused by the laser beam of the 3D printer is referred to as intrinsic heat treatment. Layers that have been directly covered with the next layer without interruption remain softer because they are not yet present as martensite at this point.

For the first time, the researchers are able to directly create a composite material consisting of layers with different properties from a single starting material during the production process. Kürnsteiner is impressed by the mechanical properties of the material produced in this way: “The tests confirm an excellent combination of strength and ductility.”

Many different process parameters are suitable for influencing the micro-structures during 3D printing. Jägle explains that in addition to or instead of the pause time, which is varied in this study, martensite formation and subsequent precipitation hardening could also be controlled by varying the laser energy, laser focus, or printing speed as well as external heating and cooling techniques.

In their experiments, the researchers produced cube-shaped or cuboid steel pieces with side lengths of a few centimeters as models for objects with more complex geometries for which computer-controlled 3D printing is of interest. They also emphasize that the Damascus-like steel with its periodically changing layers is only one example of how the micro-structure of an alloy can be locally influenced during the manufacturing process. For example, it is equally possible to create tool components with a continuous soft core surrounded by a hard, abrasion-resistant outer layer. “Thanks to our concept of local control, this was achieved in a single manufacturing step – without the additional process steps previously required for surface hardening such as nitriding,” stresses Jägle. According to the researchers, it might also be possible to use the technology to locally adjust other properties such as corrosion resistance.

“The technology opens new doors for adjusting the local micro-structures in a defined manner during the additive production of even complex work pieces and making post-treatment unnecessary,” says Kürnsteiner. The researcher also suggests a paradigm shift: “Until now, it has been common practice to use conventional alloys in 3D printing. However, many known steels are not optimally suited for additive manufacturing. Our approach is to develop new alloys that can exploit the full potential of 3D printing.”

For alloys designed using additive manufacturing, the Max Planck researchers begin by preparing a powder bed. A laser then produces the desired material directly from the powder – layer by layer – in order to manufacture the components.

Glossary

3D Printing
Also known as additive manufacturing, this technique allows components with complex shapes or custom designs to be built up layer by layer. The method was originally developed for processing plastics but can now also be used for metals and other materials.

Composite
Composites are a combination of materials with various properties. Packaging made of plastic-coated cardboard is one typical example. Damascus steel is made up of iron alloys with differing degrees of hardness and is therefore both hard and tough at the same time.
Mr. González, associate scientist at the Max Planck Institute for the Study of Societies, leads the Max Planck Partner Group for the Study of the Economy and the Public in Santiago de Chile. He reports on the project, talks about social unrest in Chile, and recalls the culture shock he experienced while living in Germany.

Max Planck scientists cooperate with partners in more than 120 countries. Here they write about their personal experiences and impressions. Felipe González, associate scientist at the Max Planck Institute for the Study of Societies, leads the Max Planck Partner Group for the Study of the Economy and the Public in Santiago de Chile. He reports on the project, talks about social unrest in Chile, and recalls the culture shock he experienced while living in Germany.

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Chilean cities were the scene of mass demonstrations that had started back in October 2019. These protests were triggered by an increase in the price of subway tickets. A government minister added fuel to the fire by saying that people should simply get up earlier to make use of the cheaper tickets available at that time. Looking back, this was clearly the straw that broke the camel’s back. However, the social origins of the unrest actually go back some 20 or 30 years.

Almost everything in Chile is privatized, be it education or healthcare. This means that many people cannot afford basic medical care or a college education, which has led to increasing social inequality. When the government raised the ticket prices, the dissatisfaction turned into protest. Thousands of Chileans took to the streets and chanted “Give us our dignity!”

Shortly before the coronavirus pandemic broke out, it seemed as if the protests were proving successful.

Parliament organized a referendum asking whether the constitution written under Pinochet’s dictatorship should be changed. It was this constitution that legitimized privatization, so many people saw it as the source of the inequality. But then the government ordered everyone into lockdown and postponed the referendum until October. Now nobody knows what will become of it. Before COVID-19, the demonstrators had momentum on their side and the politicians were feeling the social pressure. This mood could pass by October, even though the pandemic is revealing the full scope of the inequality in society and the deficiencies in the healthcare system.

For economic sociologists like me, Chile is the ideal place to research the social roots of economics. The country has been ruled by economists ever since the beginning of this neoliberal experiment, and the privatized system means that there are multiple links between the economic and social aspects. Nevertheless, I learned
nothing about economic sociology during the entire time I was studying sociology at university – which is why I conducted my own research into it and came across the Max Planck Institute for the Study of Societies. I couldn’t believe my luck when I was appointed to a doctoral post there.

Once I had finished my doctorate and spent some time doing research at the Institute, I decided to go back to Chile. But I never doubted that I would maintain my links with Germany, Cologne, and above all with the Institute. The Max Planck Partner Group I have been leading since January is therefore the perfect compromise. One of the Group’s goals is to make economic sociology better known in Chile. There is a growing community of young students who are interested in the subject. One of the Partner Group’s goals is to serve them as a meeting place. At the same time, it aims to bridge the gap between Chile and the Max Planck Society – and between Chile and Germany. The cultures of these two countries could hardly be more different – as I experienced first hand when I moved to Cologne in 2011. In Latin America, the people are generally more relaxed, they talk loudly on the streets, and a lot of things are treated more casually. In Germany, on the other hand, there seem to be strict rules for everything: you sort your trash, you walk only on the sidewalk, and you don’t make phone calls on the train! But once I had assimilated the most important customs, I had a sense of almost boundless freedom.

In my view, Cologne even has a certain Latin American flair. That’s partly due to their celebration of Carnival, of course, but the people of Cologne are also very warm-hearted and open by nature. I don’t know how many times I got into conversation with strangers on the bus or on the street! I didn’t have this experience in other parts of Germany, but in Cologne, I formed friendships that I’m sure will last for a lifetime.
FINDING THE BEST

For over a year now, the mission of Peter Haffke, Marion Cerri and Henning Hofmann has been to identify the best scientific talents worldwide. They are the three new Scouting Officers of the Max Planck Society and part of the MPG-2030 renewal process. The Scouting Officers search for the Max Planck Directors of tomorrow. The challenge is to find outstanding researchers and promising talents worldwide, without losing sight of the development of former and existing group leaders. “In addition to groundbreaking publications and renowned research awards, the recognition of their work by their peers and their leadership qualities also play an important role for us,” says Marion Cerri, who is the Scouting Officer responsible for the Chemistry, Physics and Technology Section.

International competition is no longer limited to the most renowned universities and research institutions. Global commercial enterprises also offer attractive opportunities for scientists. “Since there is strong competition for the most exceptional talents in many disciplines in basic research, they can choose the best employer with the most attractive working environment,” says Peter Haffke, who supports the Human Sciences Section in the search process. “The results of the talent search, which is carried out across all sections, are entered into a database that will help the sections in their selection processes,” explains Henning Hofmann, who is in charge of the Biology and Medicine Section. The brightest minds often work on an interdisciplinary basis and can rarely be assigned to a specific field. This data collection is constantly growing. All three Scouting Officers have a research background at institutions outside the Max Planck Society, and are familiar with the structure of research institutions and application processes. This external perspective and their close collaboration between them can only be a benefit. “We are still in close contact with the scientific community,” Henning Hofmann says. “In this new position, we again have the freedom to experiment, and to extend our view across disciplines.”

PRESTIGIOUS EARLY-CAREER AWARDS

In the most recent calls for proposals for the ERC Starting Grants, the Max Planck Society received a total of 13 grants. Only the French CNRS, with 20 grants, and the Helmholtz Association, with 15 grants, were more successful in securing the prestigious funding. Other successful German institutions are the Ludwig-Maximilians-Universität Munich (LMU) and the Leibniz Association (six grants each) as well as TUM, the Technical University of Munich (five grants). The ERC Starting Grants support promising early-career researchers who completed their doctorate between two and seven years ago. The grant enables them to set up their own research group and pursue their own research projects. The projects are evaluated in a two-stage peer review process by independent experts. As in the previous year, the most successful research organizations in Europe come from Germany, with 88 grants. They are followed by the United Kingdom (62 grants), the Netherlands (42 grants) and France (38 grants). Of a total of 3,272 applications submitted, 436 were approved throughout Europe. This represents a success rate of 13.32 percent.

On the lookout for top scientists for the Max Planck Society, in Germany and abroad: Peter Haffke, Marion Cerri and Henning Hofmann (from left to right) have been working as Scouting Officers for 18 months now.

THESE MAX PLANCK SCIENTISTS WERE AWARDED THIS YEAR’S ERC STARTING GRANTS

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STAYING CONNECTED IN TIMES OF SOCIAL DISTANCING

The Max Planck Symposium for Alumni and Early Career Researchers has provided a platform for these members of the Max Planck Community since 2016. Each year, the participants themselves proposed a topic, which they implemented and brought to life together with experts and invited guests. It has been a tradition to enable about 40 of the international and honorary alumnae and alumni to travel to the Harnack House conference venue with the help of travel grants. However, in 2020, long-distance travel has been unthinkable. A completely virtual concept was therefore introduced – a goal which had already been visualized by the participants and organizers before 2020. As Tina Persson, workshop chair, panelist and professional career coach, and Alumna of the MPI for Experimental Medicine argues, digital conferencing “offers the chance for a deeper level of connection to workshop participants who aren’t always heard as much in personal workshops as much as digital ones, such as the introverts.” From 09/17-09/19/2020, 4 hours every afternoon (CET) were dedicated to “Smart Working”. In keynotes, workshops and a panel discussion, alumni from industry, science, organizational psychology, and coaching reported how their companies are adapting to the digital work culture. An important result was that Smart Working is not only technology-driven: using the hive mind of one’s own community in order to find solutions for collaboration even in times of crisis is fundamental during the corona pandemic. “Realizing that you need help and reaching out are the first crucial steps to becoming resilient,” emphasized workshop chair, panelist and resilience coach Ben Hartwig, Alumnus of the MPI for Plant Breeding Research, “when the corona pandemic started I decided to simply hire people who knew more about digital tools to help keep my coaching business going.”

“You definitely need conference tools that allow for spontaneity,” added start-up founder Natalie Tillack, who is an Alumna of the MPI für Eisenforschung. “The Max Planck Symposium managed really well to pick up people where they are and engage them, while also leaving space to reflect.” To that aim, the Max Planck Symposium tested various formats that could be suitable for moving conference participants from a passive to an active role, consciously creating the interactive network atmosphere that is so characteristic for the symposium on site. In the end, “there is no difference between onsite and online workshops, there is only a difference between boring and interactive workshops. In both formats, you have to get people out of their comfort zone, both introverts and extroverts. The really cool stuff usually happens when I am silent as a coach, when they go to the breakout rooms. That’s when they shape their own learning experience,” summarized career coach Alexander Schiller in the panel discussion. A total of 260 active Max Planck employees, doctoral researchers and postdocs, as well as alumnae and alumni of all MPIs, registered and contributed topics. Participants from 36 countries joined the conference platform designed for the MPG, which enabled live polls, direct communication via newsfeed and video chats, as well as a matching algorithm. As the Alumna of the MPI for Human Development, Imke Rajamani of Falling Walls Berlin, noted: “The new technology for this is already out there, but sometimes we just don’t know how to use it. I hope that after COVID-19 we keep up the conversation about which medium is right for which interaction, to make sure that everyone stays engaged and active.”

All lectures, the panel discussion, the opening speech by Vice President Asifa Akhtar and highlight videos are expected to be available on the MPG intranet MAX in mid-October.

A special studio was set up at the MPG Berlin office and served as a professional home base for conference hosts Ilka Schiessler-Gabler and Birgit Adam (left to right) of the MPG headquarters to guide participants through the event program via livestream.
Many highly biodiverse ecosystems are low in nutrients. Mr. Zaehle, does this mean that fertilization has a negative impact on biodiversity?

SONKE ZAEHLE: That’s certainly true of many habitats. Take low-nutrient grassland in temperate climates, for example. Meadows of this kind are among Germany’s most biodiverse environments. A number of studies have shown that biodiversity declines when the amount of nutrients added to the soil increases. Nitrogen and phosphorus play the most important role in this situation. In central Europe, the availability of nitrogen inhibits the productivity of most rural ecosystems, while in the severely weathered soils of the tropical rainforests, this problem is more likely to be phosphorus.

What impact do high nutrient levels have?

Nutrient-rich ecosystems often benefit just a few species that are particularly well adapted to these conditions and can grow more quickly. These highly competitive species take light and space away from other plants. However, if only a small amount of nutrients are available right from the start, many species that are not as strongly competitive have a chance of survival. But you have to remember that other factors, like the climate, play an important role as well. The nutrient content of the plants themselves can also change. Plants fertilized with nitrogen store more nitrogen, for example. Since plant-eating animals are adapted to a particular nutrient content in their food, changes like these can have a negative effect on their metabolism and therefore on populations and distribution.

Are we using too much fertilizer in Germany?

That’s too much of a generalization, but a marked surplus of nutrients has been evident in some regions for quite some time now. This is where we urgently need to take action! The farmers have trouble disposing of the vast amounts of animal excrement that accumulates, particularly in areas where there is intensive pig and cattle farming. More livestock are kept than there is space for the disposal of their waste. However, directly applying manure as agricultural fertilization is not the only way in which nutrients end up in ecosystems. Nitrogen oxides in car exhaust fumes or from industrial plants also have an impact. This is one of the reasons why nutrient levels can actually increase in areas that are not even fertilized. Over the years, this unintentional fertilization can for example lead to very high nitrogen levels in forest soil.

Will the reformed fertilization ordinance passed in Germany in the spring of 2020 have any effect?

The measures it contains are moving in the right direction, but it remains to be seen whether they are sufficient and whether they can be implemented in this form. Generally speaking, fertilizer quantities should be adapted to the actual nutrient requirements of the plants and the location. It’s also important that nitrogen losses caused by fertilization are reduced by employing more efficient spreading methods or adjusting fertilization schedules. This would make it possible to decrease the quantities of nutrients added for agricultural purposes, thus reducing the quantities that infiltrate other ecosystems.

How effective are individual measures of this type?

The fertilizer problem goes far beyond the question of how much fertilizer to use and when. We have to create closed material cycles as quickly as possible. In other words, we should only add nutrients that will be removed when the crop is harvested. Without a paradigm change among consumers and a reduction in the amount of meat we eat, we will never be able to overcome the problem of over-fertilization of entire swathes of land.

Interview: Harald Rösch

Dr. Sonke Zaehle from the Max Planck Institute for Biogeochemistry is investigating how nutrients affect the material cycles of ecosystems.
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