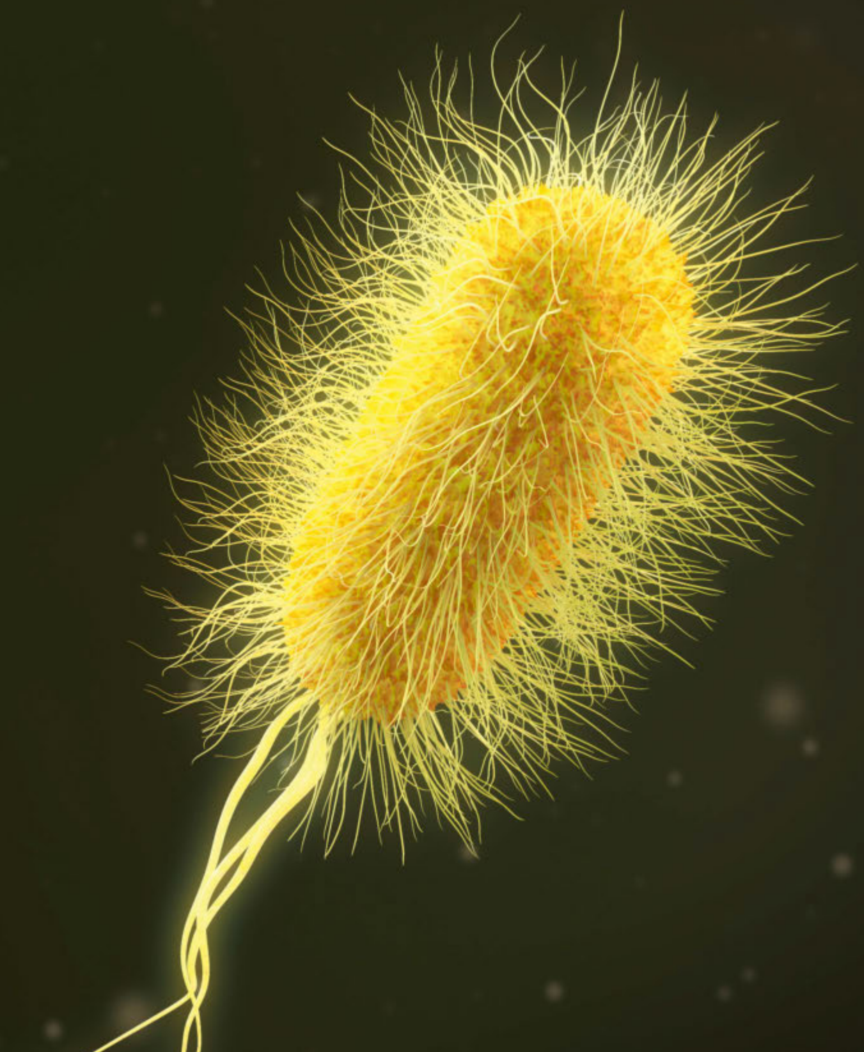
Empa Quarterly

RESEARCH & INNOVATION II #87 II APRIL 2025

FOCUS: MEDICAL TECHNOLOGIES

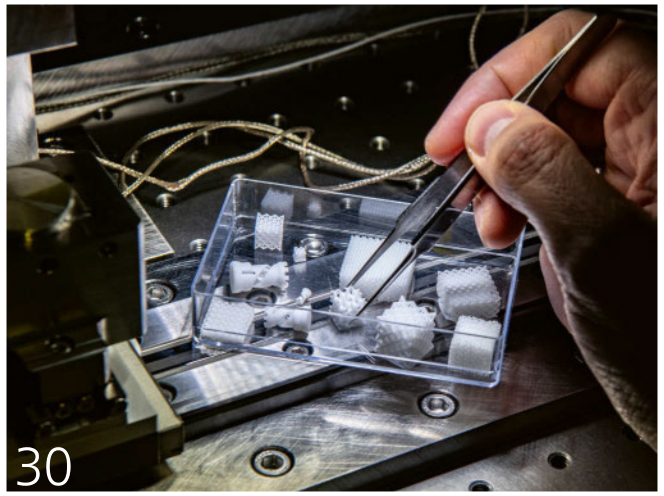
MATERIALS MEET LIFE

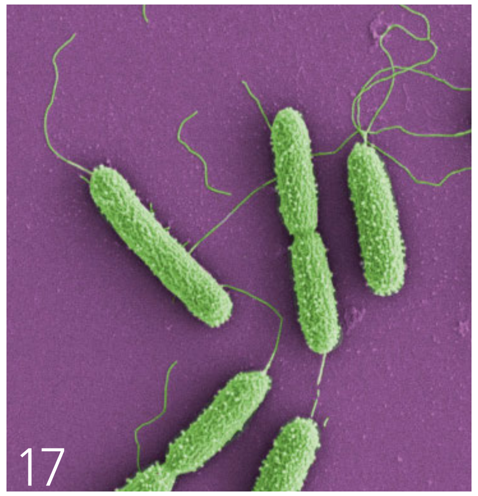


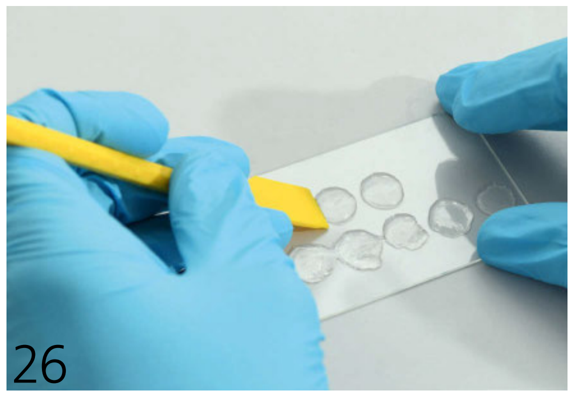
MOVING X-RAYS
GLOWING SENSORS
THERAPEUTIC GOLD PARTICLES

[CONTENT]

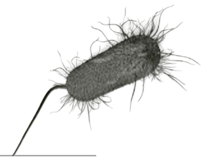
[FOCUS: MEDICAL TECHNOLOGIES]







Photos: Empa; Marion Nitsch; ROK Architects



[COVER]

Despite its fuzzy appearance, this little creature is anything but harmless: some strains of the bacterium *Escherichia coli* are resistant to antibiotics and can cause serious illness. Empa researchers are working on sensors that can be used to detect such multi-resistant superbugs at an early stage (p. 17).
Image: Adobe Stock

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FOCUSING ON PEOPLE

Dear Reader,

Humans are social beings. As such, they interact with their peers in a variety of ways. We at Empa have taken this insight to heart – last year, we engaged and interacted extensively with our stakeholders and the public, be it at the opening of new NEST units (p. 8) or at the Swiss Museum of Transport in Lucerne (p. 11).

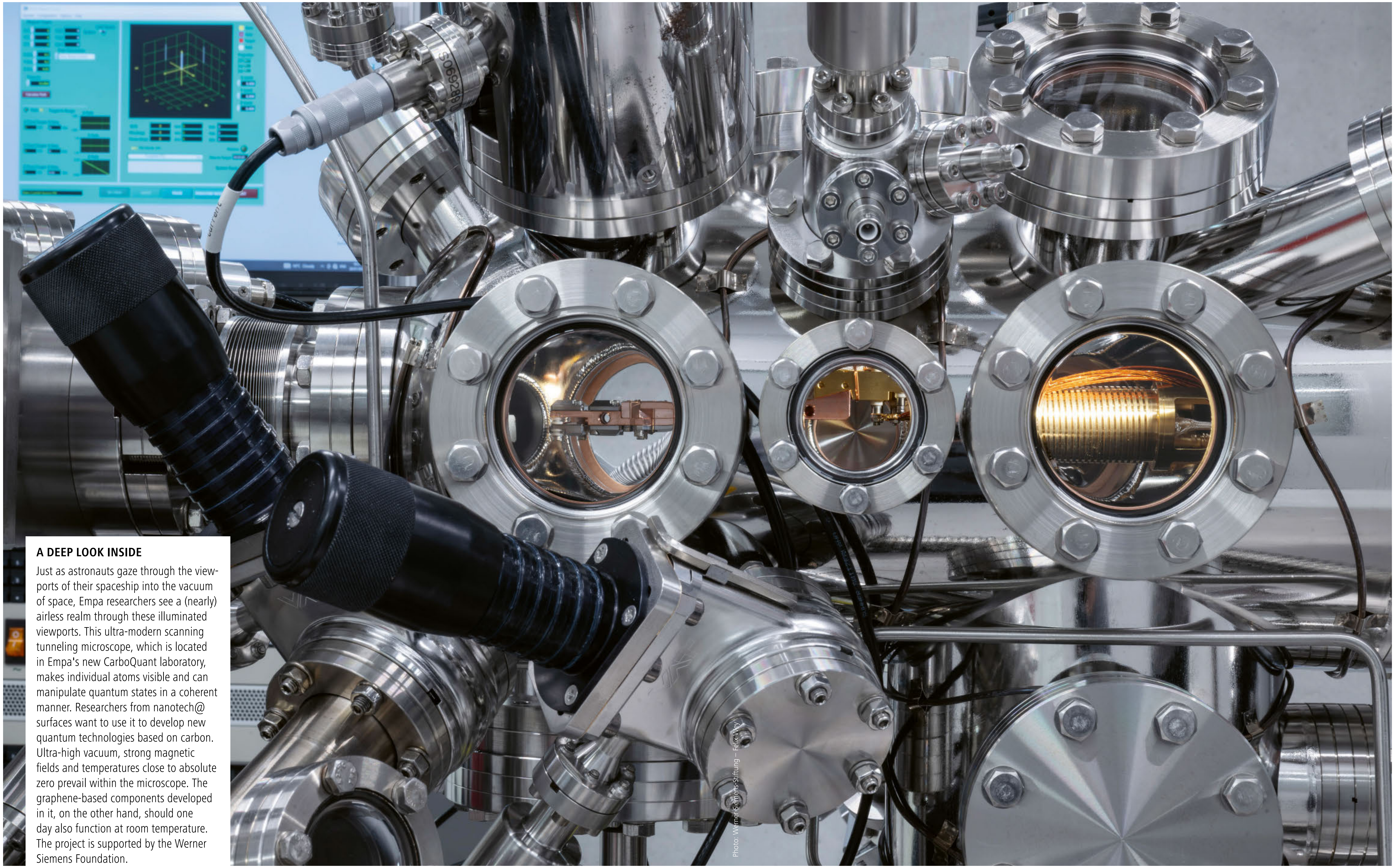
However, humans are also central to Empa on a completely different level: in our research activities in the area "Materials Meet Life", our researchers are developing pioneering solutions for the medicine of tomorrow – precisely where "conventional" materials meet living ones, i.e. cells and tissue (p. 14).

They bring some miraculous – or rather: healing – properties to these meetings. For example, there are polymers that light up when there is an infection with certain, oftentimes resistant germs. Or magnetic nanoparticles that can "fish" bacteria out of urine – all ways to be prepared for the "silent pandemic", the worrying increase in pathogens that are increasingly resistant to (almost) all common antibiotics (p. 17).

Empa researchers are also using tiny gold particles to fight cancer (p. 20), developing nanozymes that help mothers with complications during pregnancy without harming the foetus (p. 22), and using hydrogels from nature to better understand skin diseases (p. 26).

As you can see: Materials are true all-rounders, also and especially in medical technology.

Enjoy reading!
Your MICHAEL HAGMANN



A DEEP LOOK INSIDE

Just as astronauts gaze through the viewports of their spaceship into the vacuum of space, Empa researchers see a (nearly) airless realm through these illuminated viewports. This ultra-modern scanning tunneling microscope, which is located in Empa's new CarboQuant laboratory, makes individual atoms visible and can manipulate quantum states in a coherent manner. Researchers from nanotech@surfaces want to use it to develop new quantum technologies based on carbon. Ultra-high vacuum, strong magnetic fields and temperatures close to absolute zero prevail within the microscope. The graphene-based components developed in it, on the other hand, should one day also function at room temperature. The project is supported by the Werner Siemens Foundation.

Photo: Werner Siemens-Stiftung – Felix Wey

NET ZERO IN THE RHINE VALLEY IS FEASIBLE

DECARBONIZATION
The canton of Graubünden has commissioned Empa to model the energy future for the canton's Rhine Valley.

How can decarbonization be implemented cost-effectively in Graubünden's Rhine Valley? The canton of Graubünden, energy suppliers and leading industrial companies in the Rhine Valley have investigated this question together with researchers from Empa's Urban Energy Systems laboratory using innovative modeling techniques. The results confirm the assessments of the Economic Forum: decarbonization is technically feasible and, what's more, economically interesting. The Empa study provides concrete technical implementation steps and serves as a model example that can also be transferred to other regions.

NEW MODEL FOR THE SPREAD OF INFECTIOUS DISEASES

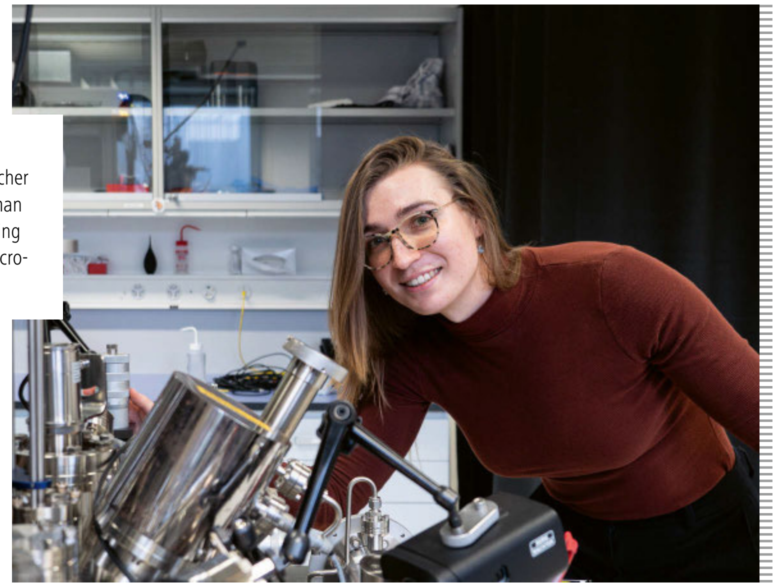
The reproduction number R is often used as an indicator to predict how quickly an infectious disease will spread. However, it disregards the fact that not all groups of people are infected at the same rate. Empa researchers from the Computational Engineering laboratory have developed a new mathematical model that is just as easy to use but enables more accurate predictions than R. Their model is based on a reproduction matrix that takes into account the heterogeneity of society.

HETEROGENEOUS
In an epidemic, not every contagious person infects the same number of people.

Photos: Adobe Stock

Photos: Empa

YOUNG RESEARCHER SHEDS LIGHT ON QUANTUM MOLECULES

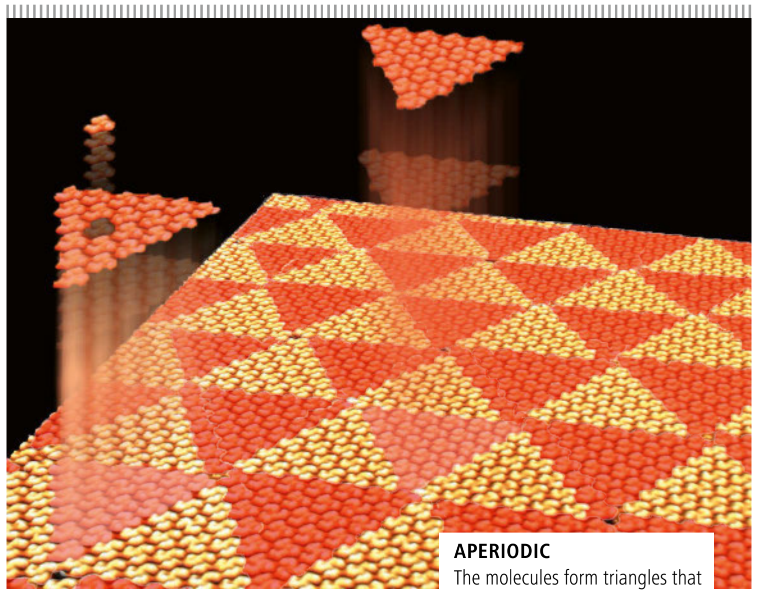


TALENT
Empa researcher Eve Ammerman at the scanning tunneling microscope.

Empa researcher Eve Ammerman from the nanotech@surfaces laboratory wants to bring quantum technologies one step closer to application by combining quantum effects with light – on a molecular level. Such nanocomponents could be used to link future quantum systems and existing fiber optic technologies. Her research project is being supported with a two-year Empa Young Scientist Fellowship.

THE MOLECULAR EINSTEIN

Is it possible to tile a surface with a single shape in such a way that the pattern never repeats itself? In 2022, a mathematical solution to this einstein problem was discovered for the first time. Empa researchers led by Karl-Heinz Ernst have now also found a chemical solution: a molecule that arranges itself into complex, non-repeating patterns on a surface. Novel physical properties have been predicted for such aperiodic surfaces.



APERIODIC
The molecules form triangles that do not fit together exactly due to the chirality of the molecule. This results in irregular defects and misalignments.

A NEST FOR DRONES

The world is currently facing significant environmental challenges and complex demands related to infrastructure and natural ecosystems. To address these issues, viable solutions that are both certified and monitored are needed. Robotics can play a crucial role in overcoming these challenges. Therefore, the DroneHub at the research and innovation building NEST of Empa offers a unique facility in which researchers can test novel bio-inspired drones and robotic technologies capable of living autonomously in the wild, collecting high-quality data, and performing restorative actions in the built environment. Developed in partnership with Imperial College London, the unit is led by Mirko Kovac, who founded the Imperial-Empa partnership in 2019 as Professor in Aerial Robotics at Imperial and as director of the Imperial Centre of Excellence in Infrastructure Robotics Ecosystems. Going forward, the Drone-Hub will support Kovac's new joint professorship in Sustainability Robotics between Empa and EPFL and be a key facility for the continuing partnership with Imperial College London.

Flying robots capable of inspecting and repairing building envelopes, interacting with natural ecosystems, and monitoring climate change and biodiversity are being developed and tested at the DroneHub at Empa's NEST. This cutting-edge facility, recently inaugurated in partnership with the Imperial College London, UK, is dedicated to pioneering autonomous robots that work harmoniously within both natural and man-made environments.

Text: Annina Schneider

Photo: Marion Nitsch

AN AVIARY FOR THE FUTURE
The new DroneHub at NEST, brightly illuminated for its opening ceremony.

"The opening of this new research platform at NEST is not only a significant milestone in drone research but also a strong testament to the importance of research collaborations, such as the partnership between Empa and Imperial College London, which we have officially extended during the opening ceremony," says Empa director Tanja Zimmermann.

The DroneHub is specifically designed to represent a variety of testing environments allowing the validation of life-like robots for infrastructure repair, environmental monitoring, and autonomous ecosystem management.

FLYING ROBOTS TAKING OFF: FROM INFRASTRUCTURE TO NATURE

"Robotics could redefine maintenance, inspection, and reparation practices in the built environments, addressing critical challenges in biodiversity protection and climate change mitigation while reducing human risk and operational costs," says Mirko Kovac. "Our vision is to enable drones to act like an immune system for the environment, capable of performing high-precision tasks such as repairing cracks on structures or engaging in environmental restoration autonomously." Key features of the DroneHub are three innovative elements: a vertical Aerial Additive Manufacturing area for testing drones' infrastructure repair capabilities, a biosphere environment for long-term ecological research and a building façade for testing how drones can be residential systems and act as the building's immune system.

AERIAL INNOVATION FOR THE BUILDING SECTOR

The DroneHub's vertical Aerial Additive Manufacturing area includes a wall with interchangeable surface elements, enabling drones to perform repair tasks via 3D printing on diverse materials, while allowing for detailed characterization, evaluation, and optimization of the printing technology. A unique feature of this space is its outdoor setting within a building structure, which enables drones to operate at various heights and distances from surfaces in adaptable, real-world conditions. This setup provides an ideal environment for validating system performance in realistic scenarios, including exposure to wind, turbulence, and ground effects.

TECHNOLOGY INSPIRED BY NATURE TO PROTECT NATURE

The biosphere for environmental sensing will enable robots to operate autonomously, employing biodegradable materials for testing novel robotic platforms. There, bio-inspired robots will be able to fly through the air, climb, or move across the ground, to gather important data using advanced sensors. What makes the biosphere truly innovative is its focus on sustainable materials and on offering a testbed for sensor placement and biodiversity monitoring. One focus lies on robots made from biodegradable materials, which are tested to see how they biodegrade over time. This ensures that once these robots have completed their tasks, they won't harm the environment. In addition, part of the biosphere is being used as a greenhouse to grow bio-hybrid robots – robots that combine living plants or other organic materials in combination with robotics technology.

AN IMMUNE SYSTEM FOR THE BUILT AND THE NATURAL ENVIRONMENT

The façade of the DroneHub is designed to demonstrate how the robots can be integrated into the building itself and function like its immune system by providing autonomous data collection and interaction capabilities. It features modular components that can be exchanged, enabling new innovations in the collaboration between robots, buildings, and humans to meet the needs of residents and building services. One key focus lies on emergency response, where drones, for example a fire drone, can take on tasks in dangerous situations, such as during a fire, that are too risky for humans. This will allow researchers to develop robots that can seamlessly work alongside humans, making life easier, more efficient, and more sustainable. The goal is to create robots that not only perform tasks but also adapt to and enhance the way we live, helping to shape a future where technology and daily life are more connected.

RESEARCH AND REALISATION PARTNERS
Empa
Imperial College London
EPFL
ROK
Geobrugg

The DroneHub will accelerate the realization of Sustainability Robotics systems that work in harmony with nature and contribute directly to our sustainability goals. By fostering a space where robots are tested in tandem with dynamic ecosystems and infrastructure, the DroneHub transforms how we understand sustainable, autonomous technology and its applications in mitigating pressing environmental crises. ■

YOUR CLIMATE BALLOON

Net zero: the goal that moves our society at all levels. But what can we as individuals contribute to achieve it? Answers are provided by the Emission Explorer, the new exhibit developed by Empa as part of Energy Science for Tomorrow (ES4T), a joint initiative of the ETH Domain institutions and the Swiss Museum of Transport. Visitors can playfully calculate their CO_2 emissions and find out in which areas of life they can make a concrete contribution to a more sustainable society.

Text: Oliver Süess

INDIVIDUAL FOOTPRINT
With only five questions, visitors can determine their own CO_2 footprint.

Photo: Empa

When you enter the Experience Energy! exhibition at the Swiss Museum of Transport, the first thing you notice is the large globe hanging from the ceiling. It shows in an impressive way how mankind consumes energy worldwide, emits greenhouse gases and thus heats up our planet. The main message of the exhibition quickly becomes clear: In order to preserve our livelihoods, we must restructure our energy supply as quickly as possible so that we make careful use of renewable energy sources.

> **ES4T**
> The Emission Explorer is a result of the joint initiative Energy Science for Tomorrow (ES4T) funded by the ETH Board. Together, ETH Zurich, EPFL, PSI, Empa and the Swiss Museum of Transport are entering into a dialog with the Swiss population in order to identify and address ways to achieve a sustainable energy future with the goal of net zero. By the end of 2026, further exhibits, events and regular workshops on energy and sustainability topics will be developed with the involvement of the public at the Swiss Museum of Transport.

A few steps away from the globe, children and adults are fiddling with colorful hand pumps. A balloon inflates on the large screen in front of them. Welcome to the Emission Explorer, the latest exhibit at the Swiss Museum of Transport, which has enjoyed great popularity since its installation at the end of 2024. "When developing the Emission Explorer, our goal was to make the content and design as tangible as possible for the public. Our audience encounters a diverse and high-quality offering at the Museum of Transport. It is therefore all the more important that we also have attractive exhibits on the topics of energy transition and sustainability," says Alexander Manuzzi, Team Leader Education and Communication and the main person responsible for the Emission Explorer at the Museum of Transport.

ONE BALLOON PER MINUTE

What seems funny and entertaining at first glance has a serious background: The Emission Explorer calculates how much CO_2 each individual lifestyle causes. Five simple questions on the topics of living, nutrition, consumer behavior, everyday mobility and flying, each with five possible answers, are enough to provide information on how large your own CO_2 footprint is, how you compare to the rest of Switzerland as well as to the rest of the world and in which areas of life you have the greatest leverage to reduce your personal emissions.

"The balloon symbolizes our own greenhouse gas emissions," says Manuzzi. "On average, every Swiss person emits as much CO_2 per minute as there is room for in a larger balloon. By answering the questions on the Emission Explorer, you inflate your own CO_2 balloon. After the last question, the balloon pops and air flows towards you. This makes your own emissions not only visible but also tangible."

WE ARE THE "SYSTEM"

Another key goal of the Emission Explorer is to make not only personal CO_2 emissions tangible, but also the so-called system share of greenhouse gas emissions. This is because, in addition to individual emissions in the five areas of life, large quantities of CO_2 are produced in Switzerland that are beyond our direct individual control. This "system", which includes industry and infrastructure, for example, produces around 46 million tons of CO_2 per year. That's around 5.4 tons per person per year.

"We need to act on all levels of society in order to achieve the energy transition. The faster we decouple our entire energy system from oil and gas, the sooner our individual footprints will shrink. Of course, this requires cooperation and coordinated action from many people," says Empa researcher Marcel Gauch, who accompanied the development of the exhibit together with his colleague Martin Gasser and worked out the scientific basis for it.

> **EMISSION EXPLORER ONLINE**
> The online prototype of the Emission Explorer allows you to easily calculate your own CO_2 footprint:

"As an individual, the best way to exert influence here is by regularly voting on energy and climate issues, for example, or campaigning for environmental issues. At the same time, you can immediately and directly reduce your own CO_2 emissions by choosing low-CO_2 activities and behaviors in the five areas of life covered by the Emission Explorer. In the context of the climate crisis, every kilogram of CO_2 avoided counts."

SCIENCE IN THE MUSEUM

The Emission Explorer originates from a joint initiative funded by the ETH Board called Energy Science for Tomorrow (ES4T) (see box). The scientific basis of the exhibit is MatCH – a comprehensive analysis of the Swiss economy that Empa carried out on behalf of the Federal Office for the Environment (FOEN) in 2016. The researchers from Empa's Technology and Society laboratory, Marcel Gauch, Cecilia Matasci and Heinz Böni, analyzed all material and energy flows in Switzerland and were thus able to precisely determine the economic sectors and areas of life in which greenhouse gas emissions are generated. In a follow-up scientific publication, they showed the extent to which the various sources of emissions in Switzerland are under the direct or indirect control of an individual.

PLAYFUL LEARNING
Top: the finished exhibit at the Swiss Museum of Transport. Bottom: a prototype built at Empa.

Photos: Verkehrshaus der Schweiz; Empa

This complex data was prepared in a summarized and simplified form for the exhibit. "The work on MatCH was very intensive and comprehensive. Since publication, the reports have been cited in various contexts, from the federal administration to industry, science and society," says Gauch. Now this research is reaching an even wider audience. Since opening at the end of 2024, the Emission Explorer has already registered more than 10,000 interactions. "We hope that this interactive exhibit will continue to be used so enthusiastically over the next three years and inspire many people to find their way to a more sustainable lifestyle," says Gauch. The Emission Explorer will remain at the Swiss Museum of Transport until 2027. ■

SEEING THE BIG PICTURE
René Rossi is Co-Head of the Empa department Materials Meet Life and the Research Focus Area Health.

Photo: Marion Nitsch

INTERDISCIPLINARY BY NATURE

René Rossi, Co-Head of Empa's Materials Meet Life department and the Research Focus Area Health, explains in an interview what is special about research in the health sector at Empa, what this has to do with materials and which topics Empa's research will be tackling.

Interview: Michael Hagmann

Why does a materials science institute like Empa actually conduct biomedical research?
According to an EU study, around 70% of all innovations are materials-driven. There are thus numerous important fields of application for new materials, including the healthcare sector and the life sciences. Take an implant, for example: It should last as long as possible, infections should be avoided, and the surface properties should ensure a solid integration into the bone tissue, for instance in an artificial hip – all highly complex topics that require an enormous amount of knowhow in materials science.

What characterizes Empa projects in this area – what is special about them?
When working with our clinical partners, we often see a push-pull process that is triggered by an intensive dialogue. The most successful projects are those that arise directly in the clinical environment in a direct exchange with our hospital partners. We demonstrate the technological possibilities of new materials, and our partners tell us about their pain points in everyday clinical practice. Although they know exactly where they face problems, they often don't know that there might already be solutions for some of them. These intensive interactions are absolutely crucial – and you have to take your time to build trust and mutual understanding. Even for us, that was a learning process at the beginning.

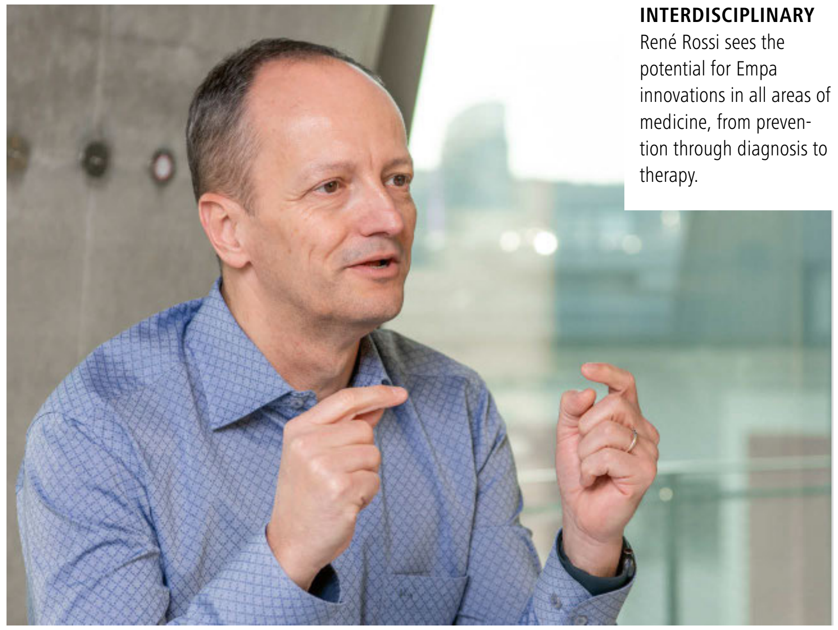
Moreover, many of our partnerships, particularly in the clinical area, are long-term. This allows us to develop technologies across different levels of maturity, known as the technology readiness levels (TRLs), from the first prototype in the lab to market-ready solutions that our partners can use and implement. This is why we maintain strategic partnerships with selected centers, such as the Cantonal Hospital of St. Gallen and the university hospitals in Zurich and Bern. And thirdly, our projects are highly interdisciplinary.

What do you mean by this and how is interdisciplinarity practiced at Empa?
For us, it means approaching a problem from very different angles, which is the only way to recognize the potential for something truly novel. As Empa, with all the natural and engineering sciences under one roof – from nanotechnology and surface analysis, textile and fiber technologies, molecular and cell biology to biomechanics and modeling – we are interdisciplinary by nature, if you wish. On the other hand, modern biomedical technologies are by their very nature systems sciences that combine countless disciplines.

> "Intensive interactions with our clinical partners are absolultely crucial to our work."

You have to understand the entire human system in order to develop effective solutions in the medical sector – from the molecular level to the physiology of the human body, including psychological and sociological aspects as well.

What is a typical Empa product for clinical applications?
One example is "smart" wound dressings. Wound healing processes ▶



INTERDISCIPLINARY
René Rossi sees the potential for Empa innovations in all areas of medicine, from prevention through diagnosis to therapy.

are extremely complex and take place in different phases; the wound dressing must – ideally – support the different phases in the best possible way, especially when infections are likely to occur. These must be diagnosed and treated at an early stage. Above all, we must prevent a wound from becoming chronic. And later on, the dressing should support and accelerate the healing process.

A related and very topical issue is the worldwide increase in antibiotic resistance. In order to prevent this from spreading any further, we should only ever use antibiotics when they are absolutely necessary – we must therefore detect infections as quickly as possible, for instance via sensors, which indicate a bacterial infection by changing the color of the dressing, for example. At the same time, we are working on new, alternative therapeutic approaches, such as "living" materials like bacteriophages – bacteria-killing viruses that are harmless to humans – or probiotics, i.e. "good" bacteria. And we should only "activate" these when the wound is actually infected, for instance by encapsulating them in certain polymers that only release

RENÉ ROSSI

BIO: René Rossi heads Empa's Materials Meet Life department together with Manfred Heuberger. He is also the head of the Biomimetic Membranes and Textiles laboratory. Rossi and his team develop intelligent textiles as the basis for innovative, digital health technologies. In addition to his professorship at ETH Zurich, he is a visiting professor at the Université de Haute-Alsace in France.

their contents when, say, the pH value in the wound rises, an early indicator of infection. A wound dressing that combines all these different "abilities" would be a prototypical Empa product.

Health is always associated with costs. Where do you see opportunities to get healthcare costs under control?
Primarily in prevention and early detection. Especially in the last years of life, healthcare costs rise sharply. One possible approach would be to use digital twins in combination with wearable sensors to optimally accompany and support older patients. The digital twin could – if necessary – suggest personalized therapies based on the transmitted sensor data. In addition, various studies have found that up to 50 % of all therapies are not applied correctly. If we could improve therapy safety as well as compliance through improved health monitoring – and thus ultimately the success of the therapy –, that would be a step in the right direction.

Looking into the future: What would you like to have achieved with your research in five to ten years' time?
Since 2023, we have launched three booster programs at Empa, for example, for improved cancer treatment, combating antibiotic resistance and one on the field of wound treatment. A wound dressing that could prevent wound infections and, above all, chronic wounds, for example in paraplegics and bedridden people, but also in newborns who are in intensive care for any reason – that would be wonderful.

And in dementia research, to name just another example, it would be a huge step forward if we could detect the first signs of the disease at an early stage with the help of simple diagnostics, for example by analyzing movement patterns, vital parameters such as heart and respiratory rate, body temperature, blood analyses, etc. The earlier we can detect degenerative diseases, the better. Because the earlier we intervene – which is unfortunately not yet possible –, the sooner we could at least slow down the progression of the disease. ■

Photo: Marion Nitsch

Photo: Empa

SENSORS FOR SUPERBUGS

Antibiotic-resistant bacteria can cause life-threatening infections that are almost impossible to treat with existing medication. As a result, common illnesses such as urinary tract infections or skin wounds are becoming a health risk. Empa researchers are therefore working on sensors that quickly identify resistant germs and recommend efficient treatment.

Text: Andrea Six

SENSITIVE
Empa researchers are working on antibiotic resistance sensors whose dyes react to certain bacteria.

▶

The spread of antibiotic-resistant superbugs is plunging health care worldwide into a crisis. It is estimated that the number of victims of multi-resistant bacteria in 2028 will be as high as before the discovery of penicillin 100 years earlier, with costs running into the billions. The World Health Organization (WHO) calls the "silent pandemic" one of the greatest threats to global health.

The development of resistance is fueled by the hasty use of antibiotics without the underlying pathogen having been identified beforehand. This is not entirely incomprehensible: Precious time is lost during diagnosis using time-consuming methods, so that in emergency situations, for example, it is often decided not to wait for the relevant laboratory results. The possible outcome: The treatment remains ineffective, and the risk of further resistance development increases. Empa researchers are therefore working together with clinical partners on innovative diagnostic tools such as sensors that can detect resistant pathogens faster and allow customized treatment in good time.

LIGHT SENSOR INDICATES PNEUMONIA

Multidrug-resistant bacteria are particularly common in hospital-acquired infections such as pneumonia. One pathogen that can cause such pneumonia is *Klebsiella pneumoniae*. Empa researcher Giorgia Giovannini from the Biomimetic Membranes and Textiles laboratory is currently working with the Cantonal Hospital of St. Gallen to develop a sensor for this superbug that emits fluorescent light when a *Klebsiella* infection is present. The sensor reacts to the enzyme urease, which the bacteria produce. In the Doorstep project, the researchers are working on polymer particles that surround a fluorescent dye. If the bacterial urease decomposes the polymer, the dye can develop its luminosity. The diagnostic method should work with a throat swab or a sputum sample. This would make it possible to identify the pathogens causing pneumonia within a few hours instead of several days.

PLASTER WARNS OF WOUND GERMS

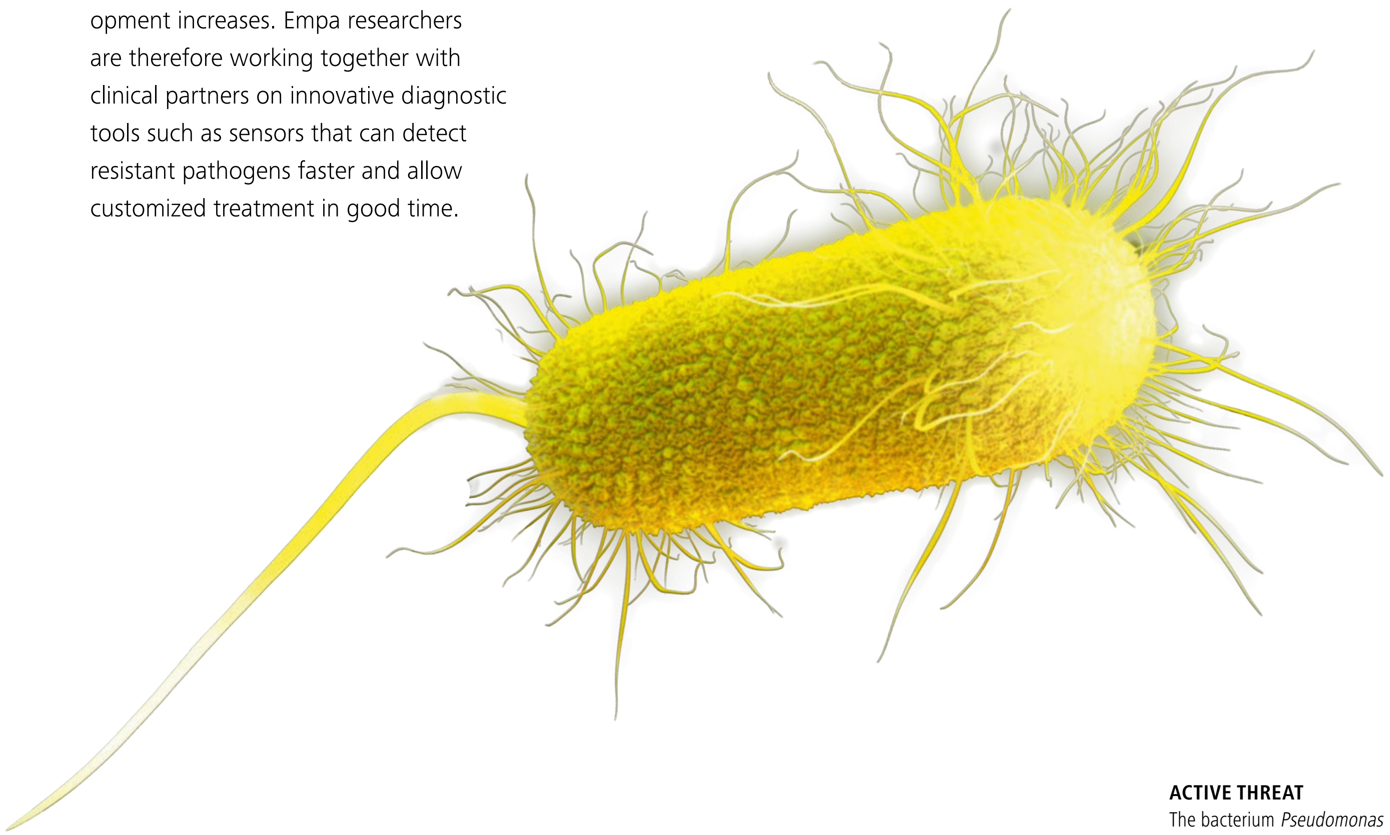
Infected wounds are also an important area of application for the rapid and precise diagnosis of resistant pathogens. They not only cause pain and tissue damage – they are also a breeding ground for antibiotic-resistant superbugs. A team led by Empa researchers Luciano Boesel and Giorgia Giovannini is now launching a project together with the Cantonal Hospital of St. Gallen in which they want to develop a multi-sensor wound dressing. It is based on silica nanoparticles embedded in a resistant hydrogel made from biocompatible polymers. The sensor technology is to be integrated directly into the dressing material. The nanoparticles are functionalized with substances that can specifically indicate the metabolites of certain bacteria.

The sensors are designed to react to particularly dreadful wound pathogens such as *Staphylococcus aureus* and indicate a change in the acid-base balance in the wound. Moreover, they should indicate the risk of antibiotic resistance. As highly pathogenic wound germs are equipped with a specific enzyme, beta-lactamase, which they use to inactivate certain antibiotics, the sensor contains dyes that are broken down by this enzyme. If resistant bacteria in the wound produce the enzyme, the sensor gives a clear warning by glowing under UV light. In everyday clinical practice, the wound sensor thus enables rapid, cost-effective diagnosis and personalized wound treatment. The project could be launched thanks to generous donations from the Philipp and Henny Bender Foundation, the Blumenau-Léonie Hartmann Foundation, the Hans Groeber Foundation and the Räschle Foundation.

EASY DETECTION IN URINE SAMPLES

Another nasty member of the bacterial kingdom is *Pseudomonas aeruginosa*. This rod-shaped bacterium can cause various diseases, including infections of the urinary tract, for example via urinary catheters during a hospital stay. And these pathogens are often resistant to various antibiotics. A team of researchers from Empa and ETH Zurich has therefore developed a method using magnetic nanoparticles that detects the bacteria quickly and precisely. As the magnetic particles are coupled to protein building blocks that react exclusively with *Pseudomonas aeruginosa*, the bacterial cells can ultimately be specifically "fished" out of urine samples using a magnetic field.

In the next step, the sensitivity of the pathogens to various antibiotics is analyzed using a chemiluminescence method. If there are resistant bacteria in the test tube, the sample emits light. However, if the germs can be killed with antibiotics, it remains dark. "All in all, the resistance test takes around 30 minutes – compared to several days for a classic cultivation of bacterial cultures," says Qun Ren, group leader at Empa's Biointerfaces laboratory in St. Gallen. This makes it possible to determine the appropriate antibiotic therapy within a short time – and thus prevent the development of further resistance. ■



ACTIVE THREAT
The bacterium *Pseudomonas aeruginosa* is resistant to many antibiotics.

Photo: Adobe Stock

Graphic: Empa

Dangerous increase: Antimicrobial Resistance (AMR)

Facts about a silent pandemic – and how to fight it

POCKET FACTS 01

Empa
Materials Science and Technology

POCKET FACTS #1

Empa launches a new series of short leaflets, Pocket Facts, on "hot" topics. The first one provides information and useful tips on antibiotic resistance and how to detect, prevent, and treat the "silent pandemic".

NEW RESEARCH BOOSTER

Antibiotic resistance affects people all over the world. Fewer and fewer effective drugs are available to combat resistant bacteria. This is why Empa is researching new therapies and diagnostic methods. In the recently launched Research Booster Antibiotic Resistance, several Empa laboratories are working together with hospital partners on an interdisciplinary basis in the fight against the "silent pandemic" in order to advance the diagnosis, treatment and prevention of infections with antibiotic-resistant germs.

FOCUS ON BACTERIA

The number of multi-resistant bacterial species is constantly increasing. Bacteria that lead to deaths due to antibiotic resistance include *Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae, Streptococcus pneumoniae, Acinetobacter baumannii* and *Pseudomonas aeruginosa*. Incorrect and excessive use of antibiotics accelerates the spread of superbugs. In 2019, such pathogens were linked to around five million deaths. The World Health Organization (WHO) has therefore declared them a priority for research and development.

GOLD PARTICLES AGAINST CANCER

If tumors spread in the abdomen, it is difficult to detect and fight these metastases. Researchers at Empa, ETH Zurich and the University of Zurich are therefore developing an efficient and gentle therapy using gold nanoparticles. Applied directly into the abdominal cavity, the gold particles are designed to detect tumor cells, penetrate them, and kill them with heat.

Text: Andrea Six

FOCUSED
Empa researcher Oscar Cipolato uses long-wave infrared (IR) light for the development of gold nanoparticles to kill metastases.

Photo: Empa

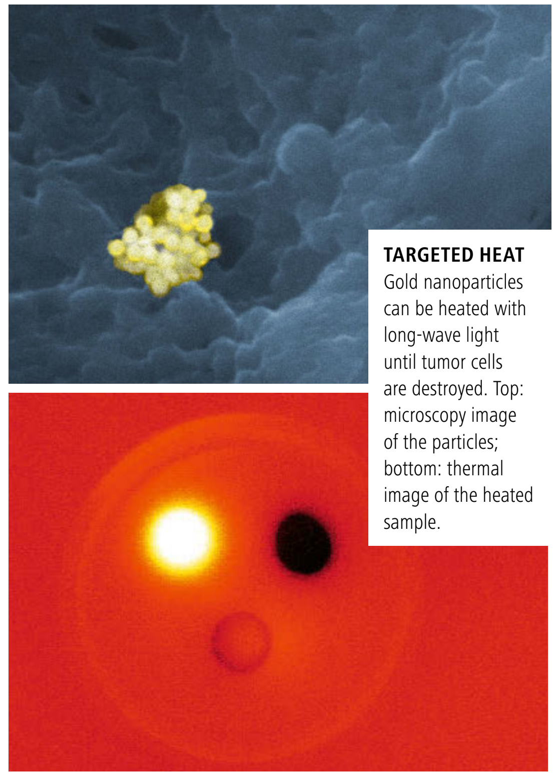
If organs in the abdomen are affected by cancer, tumor cells can spread into the abdominal cavity from affected organs such as the bowel or the ovaries, for example. Despite medical advances, these metastases in the peritoneum are still difficult to diagnose and combat. The chances of recovery are thus rather small, as successful treatment depends on being able to detect and remove every cancerous cell. A team of researchers from Empa, ETH Zurich and the University of Zurich is therefore developing nanoparticles made of gold that specifically attack and eliminate metastases in the peritoneum. Initial laboratory results on the efficient and gentle treatment, which is applied directly into the abdominal cavity, are promising.

TROJAN HORSE AGAINST CANCER CELLS

The researchers chose a highly biocompatible material as the starting material for the nanomedical cancer therapy: gold. If, however, the precious metal can be introduced into cancer cells, very much like a Trojan horse, it turns out to be a highly effective weapon. As gold particles absorb light from the infrared (IR) range and convert it into heat, they can destroy the tumor from the inside using hyperthermia.

The team led by Inge Herrman from the laboratories of Empa, ETH Zurich and Balgrist University Hospital is developing and analyzing the nanoparticles together with the Department of Visceral and Transplant Surgery at the University Hospital Zurich and the University of Fribourg. The aim of the project is to synthesize nanoparticles that effectively and gently eliminate metastases.

The researchers are taking a new approach to delivering the nanomedicine to the site of action – i.e. the tumor: While conventional therapies are administered as an infusion via a drip, the nanoparticles are to be applied directly into the abdominal cavity during a minimally invasive procedure in order to increase efficiency. This also makes it possible to reduce the amount of chemotherapy drugs administered at the same time, which should reduce harmful side effects. "In laboratory experiments with tissue samples, we have already been able to show that the direct administration of gold nanoparticles into the abdominal cavity leads to efficient and selective uptake into the desired tissue," says Empa researcher Oscar Cipolato from Empa's Nanomaterials in Health laboratory in St. Gallen. To further improve this, the researchers are now optimizing the shape, surface structure and size of the nanoparticles. Further experiments are currently underway to determine whether gold spheres up to 400 nanometers in size or gold rods just a few nanometers thick are better suited for this purpose.



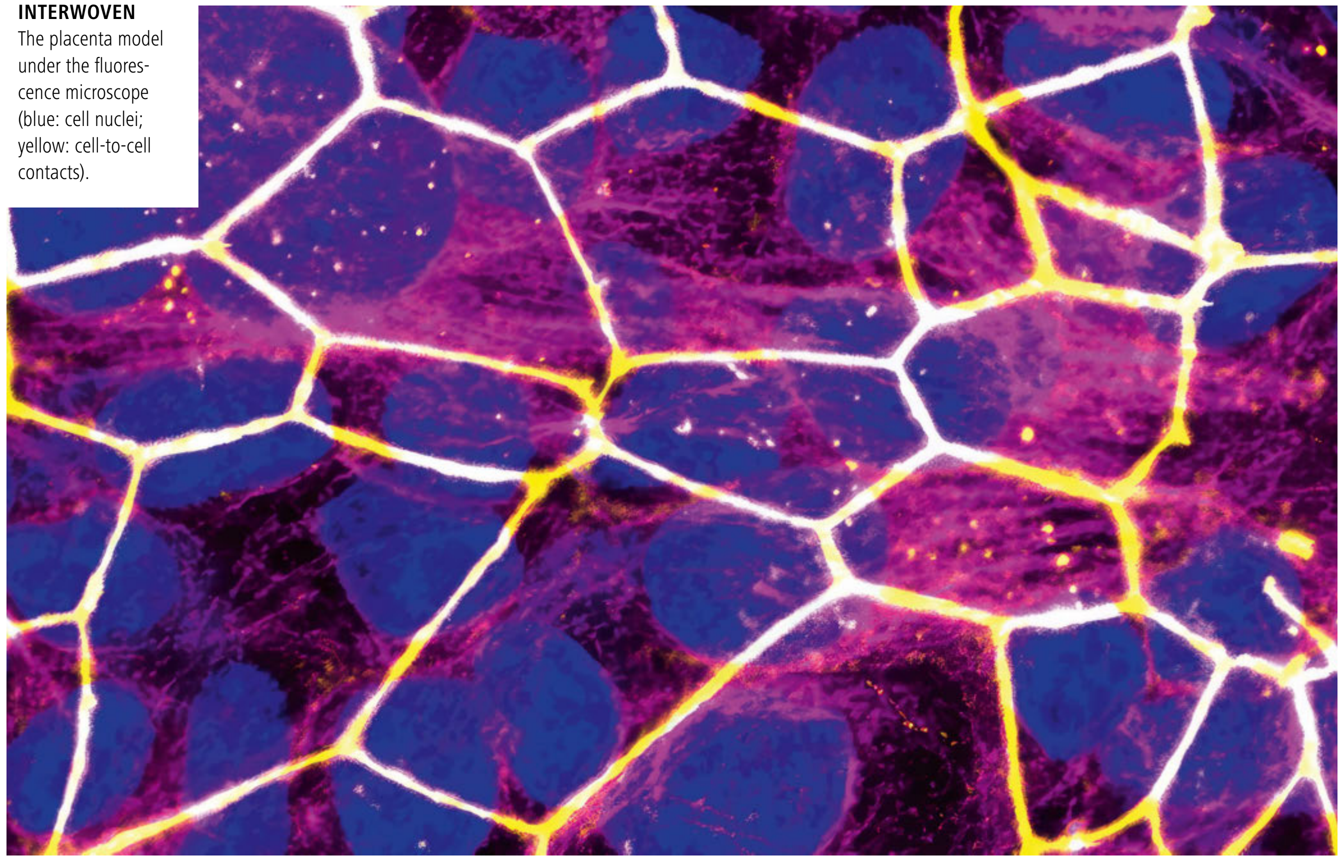
TARGETED HEAT
Gold nanoparticles can be heated with long-wave light until tumor cells are destroyed. Top: microscopy image of the particles; bottom: thermal image of the heated sample.

Photos: Empa

A SLEUTH MADE OF GOLD

To ensure that only metastatic tissue heats up to over 42 degrees when patients are irradiated with near-IR light, the nanomedicines are to be equipped with antibodies against tumor tissue. In this way, the nanoparticles exclusively detect cancer cells. Such a customized therapy is therefore less stressful for the patient, as less surrounding healthy tissue is damaged.

The nanogold-based combination therapy should be used in everyday clinical practice as soon as possible. This requires basic information on the effect of nanoparticles and their distribution within tumors and within the human body. To close this gap, the researchers have optimized imaging techniques so that nanomaterials can be analyzed at the level of individual cells. Thanks to a combination of light and electron microscopy, they can precisely determine the interaction of the nanoparticles with the cells and their distribution in the tissue. The researchers hope that this better understanding of nanoparticles will help to drive forward new developments in nanomedicine for more effective and gentle cancer treatment. ■



INTERWOVEN
The placenta model under the fluorescence microscope (blue: cell nuclei; yellow: cell-to-cell contacts).

Photo: Empa

EFFECTIVE FOR MOM, SAFE FOR THE BABY

Special care must be taken with illnesses during pregnancy, as not all drugs are compatible for mother and child. This is why an international research team involving Empa is now developing nanomedicines that will enable safe and effective treatment of inflammatory processes during pregnancy. Pregnancy complications are frequently caused or accompanied by inflammation, but the treatment options are often not sufficiently effective or are suspected of interfering with the development of the foetus.

Text: Andrea Six

When complications occur in the course of a pregnancy, it is not only the mother's life that is at risk, but also that of the unborn child. But what can be done when medication against widespread infections and other pregnancy complications such as pregnancy poisoning, diabetes or the threat of premature birth is either ineffective or too risky? Medical research has a possible answer: nanozymes. The tiny synthetic particles could help treat inflammatory processes in the placenta without harming mother or child. A team of researchers from Empa, ETH Zurich, the Cantonal Hospital of St. Gallen and the Chinese Zhejiang University is now developing novel nanozymes in a project funded by the Swiss National Science Foundation (SNSF). The development process is accompanied by comprehensive studies on drug safety.

A MODULAR TOOLKIT FOR SAFE THERAPIES

Nanozymes are tiny synthetic compounds in the nanometer range with enzyme-like properties that are already being investigated in other medical fields, such as cancer therapy. They are made up of a nanostructured core (e.g. metal atoms or metal oxides), which determines the particle's enzymatic activity, and surface modifications that increase the stability of the nanozymes and improve their specificity. "In this way, we want to enable customized use for different areas of application," explains Empa researcher Tagaras.

The activity of the nanozymes changes depending on the prevailing disease processes in the area of application: From a stealth mode, a kind of inactive state, they can become active in order to capture reactive oxygen species (ROS) in inflammatory processes, for example, or to destroy bacteria in the event of an infection.

REALISTIC LABORATORY MODELS

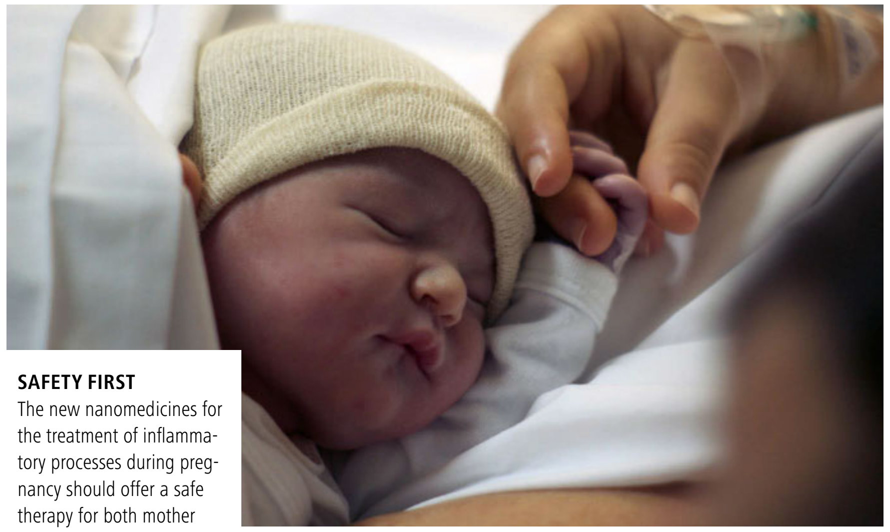
The development of the nanozymes is accompanied by laboratory experiments on the safety of the new drugs. Here, the researchers in the Empa laboratories use established models that faithfully reproduce what happens in the placenta and in the organism of both mother and child. "The structure, metabolism and interaction of maternal and fetal tissue are unique in humans," says team leader Tina Bürki from Empa's Nanomaterials in Health laboratory in St. Gallen. It is therefore necessary to investigate the effect of the nanozymes on laboratory models with human cells and tissues. The established placenta model is used here, for which the team uses fully functional human placentas that were made available after Caesarean sections. "Only thanks to human placental tissue can we obtain meaningful results on the transport and effect of the nanozymes," says the Empa researcher.

A PROMISING START

A further step towards safe nanomedicines is the so-called placenta chip, a finger-length polymer chip on which human cells grow that represent the placental barrier and the embryo in conditions that are as close to reality as possible. In addition to transport processes at the placenta, the direct and indirect effects of the nanozymes on early embryonic development can also be investigated in this way.

The project to develop the chip is funded by the Zurich-based ProCare Foundation.

The initial results are promising. "The nanozymes do not impair the placental barrier and have so far shown no negative effects on the models studied," says Empa researcher Tagaras. Next, the team will analyze the anti-inflammatory and antibacterial effects of the nanozymes. ■



SAFETY FIRST
The new nanomedicines for the treatment of inflammatory processes during pregnancy should offer a safe therapy for both mother and child (top). Empa researchers Nikolaos Tagaras and Tina Bürki are working on comprehensive safety studies on the newly developed nanozymes (bottom).

Photos: unsplash; Empa

DYNAMIC IMAGING FOR STRONGER SHOULDERS

Shoulder instabilities are difficult to diagnose as they usually only occur when the shoulder joint is in motion. A time-resolved 3D analysis now makes it possible for the first time to precisely capture these dynamics. Empa researcher Ameet Aiyangar combines X-ray videos with virtual 3D models of the joints to detect these instabilities with millimeter precision.

Text: Manuel Martin

After a shoulder injury has been treated, patients are often left with a feeling of insecurity – many of them report that their shoulder "doesn't hold" or "slips out easily". When diagnosing shoulder instabilities, doctors often have to rely on these subjective assessments. The reason: Conventional imaging methods do not capture the movement of the shoulder. In contrast, the newly developed 4D analysis by Empa researcher Ameet Aiyangar goes beyond static imaging: "We combine high-precision X-ray videos from two perspectives and use them to reconstruct a four-dimensional motion analysis – in other words, a 3D image while the shoulder is moving."

OPTIMIZED THERAPY INSTEAD OF UNNECESSARY SURGERY

The shoulder is the most mobile joint in the human body and is therefore particularly susceptible to injury. It is true that only around two percent of people dislocate their shoulder joint at some point in their lives. After treatment, however, many patients return to the clinic because they continue to have complaints or are dissatisfied with the result. According to Aiyangar, every other affected person suffers another dislocation of the shoulder joint. "This is particularly problematic with surgical procedures – up to two thirds of patients who have undergone surgery dislocate their shoulder again and come back to seek help. This shows that there is great potential for optimization in diagnostics and treatment planning."

Currently, the stability of the shoulder joint is tested manually – a method whose accuracy heavily depends on the experience of the physician or physiotherapist. Static imaging procedures such as X-rays, magnetic resonance imaging (MRI) or computer tomography (CT) are only useful as a supplement, as they do not capture dynamic movement sequences. With the new technology, the Empa researchers can quantitatively measure and specifically analyze instabilities for the first time. This provides doctors with a more precise basis for deciding whether physiotherapeutic treatment is sufficient or whether surgery is necessary. "This avoids unnecessary surgical interventions or does not unnecessarily delay sensible ones, thus enabling individually optimized therapy," says Aiyangar.

MEASURING SHOULDER INSTABILITIES WITH MILLIMETER PRECISION

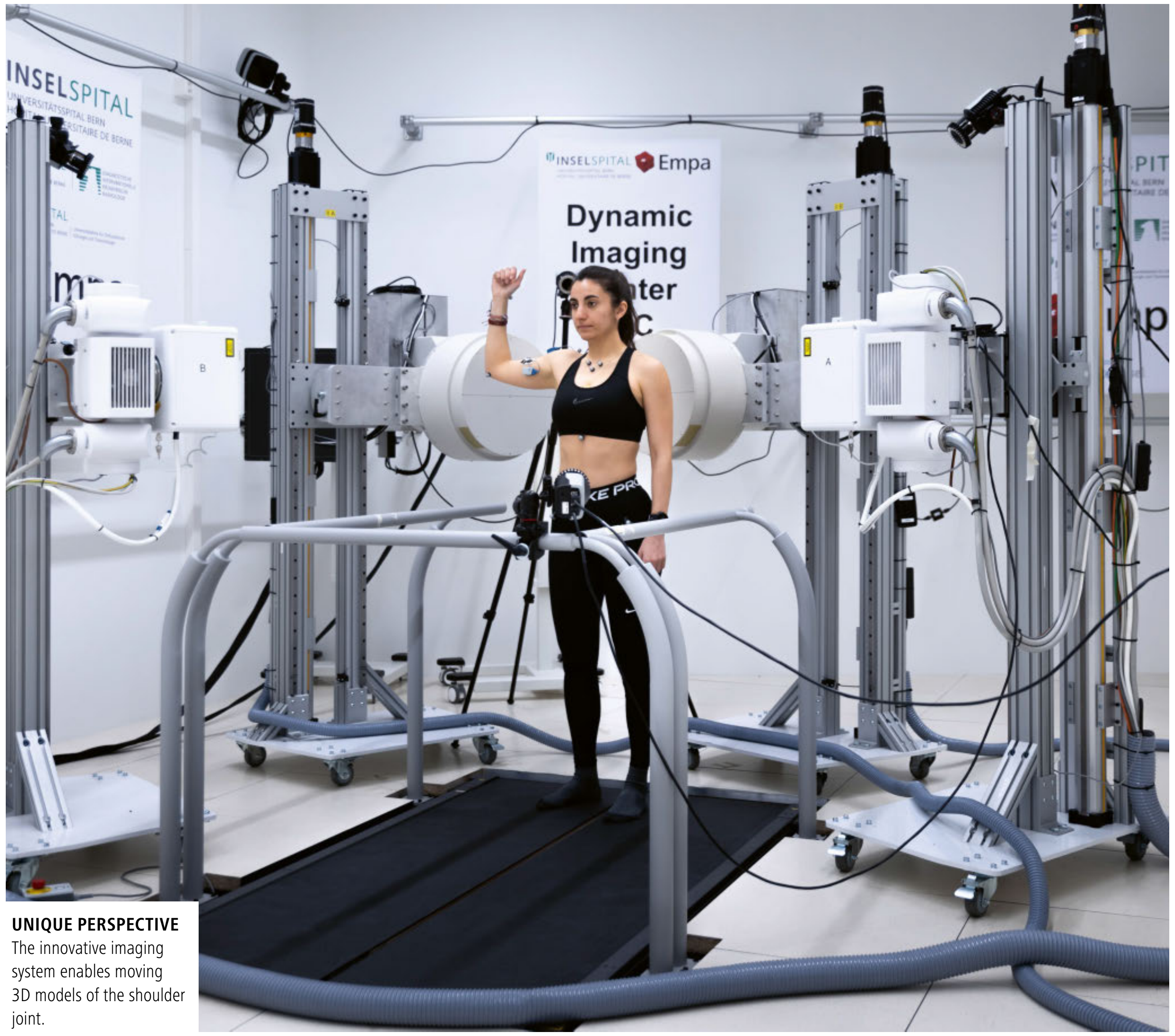
A biplanar radiographic imaging system (DBRI) installed at sitem-insel, the Swiss Institute for Translational and Entrepreneurial Medicine in Bern, is used for the dynamic 3D images of the shoulder. It was developed in close collaboration with Empa and Inselspital Bern. First, the test subjects perform specific shoulder movements, which are recorded from two different perspectives using synchronized X-ray images. Additional CT scans are used to reconstruct detailed 3D models of the bones with anatomical landmarks. A tracking procedure based on this determines the exact position of the shoulder joint. Finally, optimization software calculates the movement sequences of the shoulder.

This enables the researchers to record not only the rough movement patterns of a joint, but also the smallest rolling and sliding movements that are crucial for stability – with an accuracy in the range of 0.1 to 0.5 millimeters. "This is a decisive step forward, because conventional motion sensors with infrared cameras and markers on the skin are inaccurate by 20 to 40 millimeters – far too imprecise to reliably detect instabilities," says Aiyangar.

AIMING FOR DIAGNOSIS WITHOUT RADIATION-BASED IMAGING

The next step will be a joint study with Inselspital in Bern, with which there is a long-standing research collaboration. Around 40 patients with untreated shoulder instability are being sought to be examined before and after targeted muscle strengthening. Individual musculoskeletal models will play a central role to analyze the interactions between muscles, joints and forces. "In the long term, we hope that our four-dimensional movement analysis will find its way into clinical practice. This is because the problem with treating joint instability lies mainly in the dynamics," explains Aiyangar. Based on the biomechanical study data, the Empa researcher also wants to develop force-controlled kinematic models that take into account muscle forces and joint loads in addition to movement. In future, these should enable a patient-specific dynamic analysis of shoulder instability – and thus a comprehensive clinical diagnosis without radiation-based imaging. ■

Photo: Empa



UNIQUE PERSPECTIVE
The innovative imaging system enables moving 3D models of the shoulder joint.

ARTIFICIAL SKIN OUT OF THE OCEAN

Growing cells in the laboratory is an art that humans have mastered decades ago. Recreating entire three-dimensional tissues is much more challenging. Empa researchers are developing a new material based on fish gelatin that makes it possible to engineer artificial skin tissues, which can serve as living models of human skin for better understanding and treating skin diseases.

Text: Anna Ettlin

FROM NATURE TO THE LAB
Doctoral student Tobias Hammer prepares samples of the new hydrogel.

Photo: Empa

The skin is the largest organ in the human body. It makes up around 15 percent of our body weight and protects us from pathogens, dehydration and temperature extremes. Skin diseases are therefore more than just unpleasant – they can quickly become dangerous for affected patients. Although conditions such as skin cancer, chronic wounds and autoimmune skin diseases are widespread, we often still don't fully understand about why they develop and how we can treat them effectively.

To find answers to these questions, Empa researchers are working together with clinical partners on a model of human skin. The model will allow scientists to simulate skin diseases and thus better understand them. This is not a computer or plastic model. Rather, researchers from Empa's Laboratory for Biomimetic Membranes and Textiles and its Laboratory for Biointerfaces aim to produce a living “artificial skin” that contains cells and emulates the layered and wrinkled structure of human skin. The project is part of the Swiss research initiative SKINTEGRITY.CH (see box).

In order to recreate something as complex as skin, suitable building materials are needed. This is where Empa researchers have recently made progress: They have developed a hydrogel that meets the complex requirements while being easy to manufacture. The basis: gelatin from the skin of cold-water fish.

MORE THAN JUST CELLS

Like most tissues, the skin consists of cells that are embedded in a so-called extracellular matrix: a network of proteins and other biomolecules that provides the tissue with shape and structure and sustains the cells. The extracellular matrix differs from tissue to tissue – in the case of the skin even from layer to layer. It is crucial to use a suitable substitution for this matrix to engineer a representative skin model. One way to simulate the extracellular matrix is to use hydrogels: special polymers whose chains are cross-linked in a way that allows them to absorb large quantities of water and other fluids. They are particularly suitable for simulating skin extracellular matrix that contains a large amount of water and other fluids. Another advantage: Many hydrogels can be processed using a 3D printer. “3D printing is powerful for skin model development. The skin cells can be embedded in the hydrogel matrix in specific patterns and not at random,” says Kongchang Wei, group leader of the joint research group Tissue-Regenerative Soft Materials. “3D printing allows us to combine multiple materials and cell types into a single structure – just like real skin.”

SKINTEGRITY.CH

SKINTEGRITY.CH is a collaborative and interdisciplinary research network. It aims to better understand what happens in the skin at the molecular level during injury, healing, or disease; to improve diagnosis and treatment; and to provide interdisciplinary training for young skin researchers and clinicians. The initiative is supported by the University Medical Center Zurich (UMZH) and various research institutions. The Empa laboratories Biointerfaces and Biomimetic Membranes and Textiles are part of the consortium.

However, due to their ability to absorb water, most hydrogels swell considerably when they first come into contact with liquid after 3D printing. The swelling changes their shape and makes them different from the designed layered skin model. Although non-swelling hydrogels exist, they are usually very challenging to produce, or 3D print. “We have discovered that nature already has a much simpler, more elegant solution,” says Wei. Gelatin from cold-water fish such as cod, pollock and haddock can be cross-linked in just a few steps to turn it into a non-swelling hydrogel, which can be printed with skin cells.

“For our skin model, the goal is to include not only the dermis and epidermis layer but also the epidermal-dermal junction (also known as the base membrane) between these two skin layers.” says Wei. “With the cold-water fish gelatin hydrogels and another polymer processing technique, electrospinning, we are getting closer to this goal.”

FROM SKIN RESEARCH TO WOUND HEALING

What's more: Without the addition of living cells, the hydrogel could also be used as a dressing material. Much like hydrogels made from animal gelatin, the resulting material is biologically compatible with human skin cells and can be 3D printed. However, it has a crucial distinguishing feature: As fish are evolutionarily further removed from humans, fish gelatin causes fewer immune reactions and carries a lower risk of disease transmission than comparable materials based on mammalian gelatin. “Fish skin is currently being researched as a promising tool for wound healing,” says Wei. “Our hydrogel is more homogeneous, safer and can be tailored precisely to the patient's needs, for example with different shapes, thickness and firmness. Even the integration of medication would be conceivable,” explains the researcher.

For these reasons, the researchers have applied for a patent for their fish gelatin-based hydrogel. In the next step, they plan to finish developing the living skin model and make it available to other scientists. “We hope that this will promote a better understanding of the development and treatment of skin diseases,” says Wei. The Empa researchers are also aiming to take a closer look at the unusual swelling properties of their hydrogel. ■

BLACK IS THE NEW GREEN

Empa researchers want to use the pyrolysis of biomass to rid the atmosphere of excess CO_2. Carbon stabilized and bound in this way can be used in a wide variety of areas, from construction to therapeutics. Initial research on building materials at Empa has already demonstrated the technology's potential. A larger pyrolysis reactor is now to be built to bridge the gap to industry.

Text: Anna Ettlin

What humans can only achieve with complex technical systems, nature can do effortlessly: removing CO_2 from the atmosphere. Plants bind atmospheric carbon as they grow. When they decompose or are burned, they release the same amount of CO_2 again. But what if we could prevent this re-release?

PRESERVED
Pyrolysis is used to stabilize the carbon from the biomass.

Photo: Empa

Empa researchers led by Jannis Wernery from Empa's Building Energy Materials and Components laboratory are looking into this. They are stabilizing the bound carbon so that it can be stored permanently or even processed into new materials. The method of choice for this is called pyrolysis. The plant material is heated with a reduced oxygen supply and carbonized in the process. As long as the resulting biochar is not burned, this process removes excess CO_2 from the atmosphere – the vision of Empa's research initiative Mining the Atmosphere, in which Wernery and his team are involved.

The removal of CO_2 from the atmosphere is absolutely crucial to achieve Switzerland's climate target of a maximum temperature increase of 1.5 °C by 2100. Initial projects at Empa, for instance as part of the joint initiatives «Speed2Zero» and «SCENE», show that biochar can be used to produce competitive insulating materials or as an additive to concrete, for example.

To ensure that this CO_2-negative technology finds its way out of the laboratory and into industry, the researchers are planning to purchase a larger pyrolysis reactor based on a flexible, easily scalable technology. "This will enable us to establish a platform for further research into the production and utilization of biogenic carbon on a larger scale, also for other Empa labs," says Wernery. The new reactor will also enable researchers to take a closer look at the other two products of pyrolysis, pyrolysis oil and pyrolysis gas. These mixtures of different carbon compounds are potential sources of synthetic fuels or raw materials for the chemical and pharmaceutical industries. ■

ZUKUNFTSFONDS
The Empa Zukunftsfonds is looking for private donations for outstanding research projects, talents and infrastructure – such as the pyrolysis reactor – that are not (yet) supported elsewhere. Further information can be found here:

THE MATERIALS ARCHITECT

Engineer, mechanics expert, bone researcher, materials scientist: Jakob Schwiedrzik has a multifaceted research profile. For several months now, he has been at the helm of Empa's Laboratory for High-Performance Ceramics. With his interdisciplinary expertise, his thirst for knowledge, and his drive for action, he wants to help both his laboratory and ceramics as a material to reach new heights.

Text: Anna Ettlin

Faced with the obligatory question about the correct pronunciation of his name, Jakob Schwiedrzik responds with equanimity. "Schwirzik" is close, he says. "The first syllable comes from German, the second from Polish. As a result, neither the Germans nor the Poles can pronounce it correctly," laughs the tall scientist.

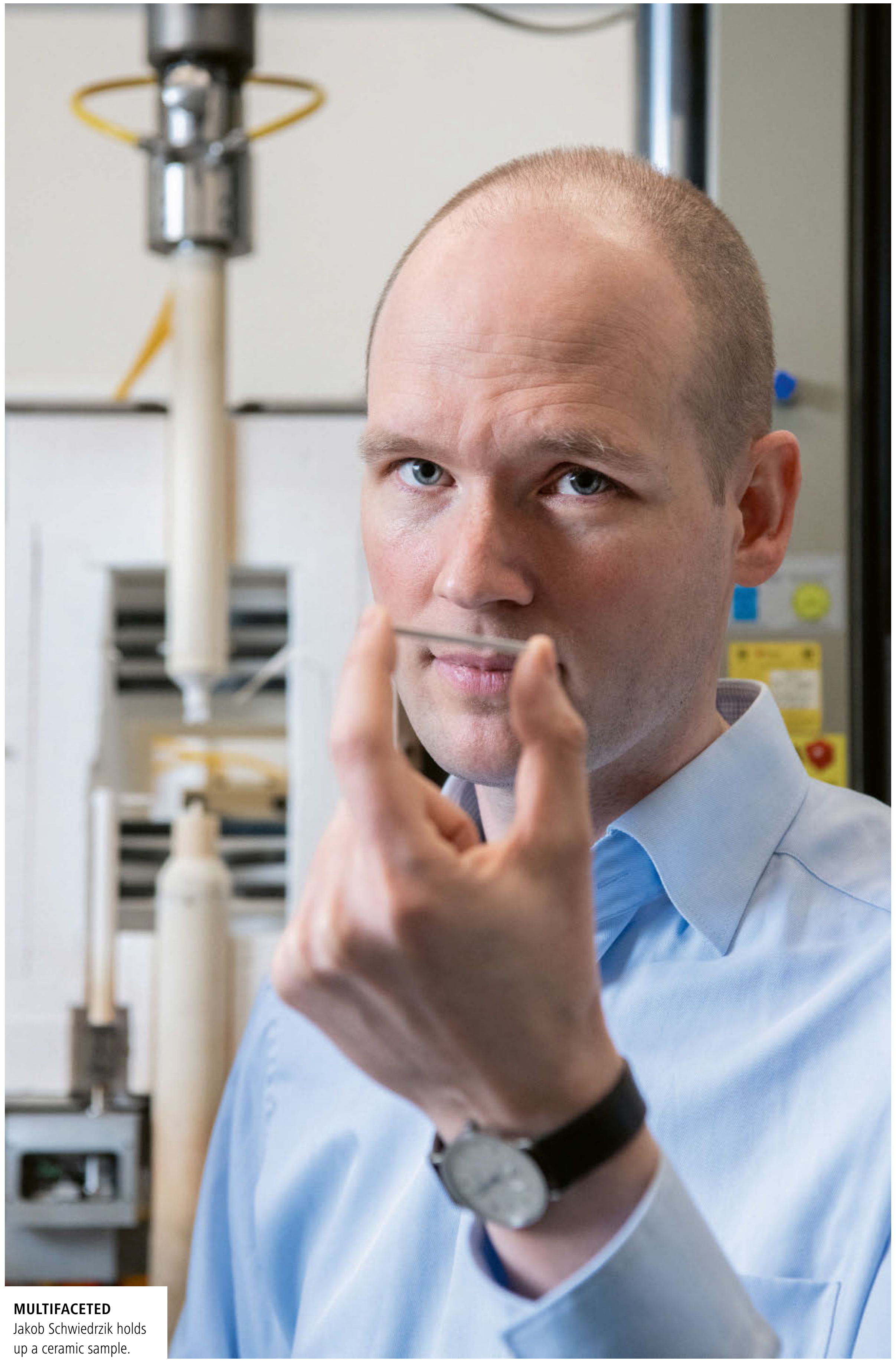
Much like his name, Schwiedrzik himself moves between different fields: materials science, engineering, mechanics, medicine, mathematics. Since August 2024, the scientist has been leading Empa's Laboratory for High-Performance Ceramics. He joined Empa ten years earlier, first as a postdoctoral researcher and later as a group leader in the Laboratory for Materials and Nanomechanics in Thun, where he conducted research into thin film and small scale mechanics. One of the focal points of his research activities during this time was a special material: bone.

CERAMIC IN OUR BODIES

From bone to ceramics – a long leap? Less than you might think, says the 39-year-old. "Bones are a composite material. They consist of a biopolymer, collagen, and a mineral component, hydroxyapatite, a bioceramic." Many ceramics are therefore considered promising materials for biomedical applications, such as implants. Other specialty ceramics promise breakthroughs in lightweight construction, chemical catalysis, energy storage and CO_2 capture from the atmosphere. "Ceramics are great: light and stiff, chemically resistant and biocompatible, temperature-resistant and with interesting catalytic properties," Schwiedrzik lists. The weakness of the "super material" lies in its mechanical properties: Ceramic is brittle and prone to fracture.

But in this weakness, Schwiedrzik sees great potential for innovation. The materials scientist in him knows that the composition of a material is only half the story. Its structure is just as important.

Photo: Marion Nitsch



MULTIFACETED
Jakob Schwiedrzik holds up a ceramic sample.

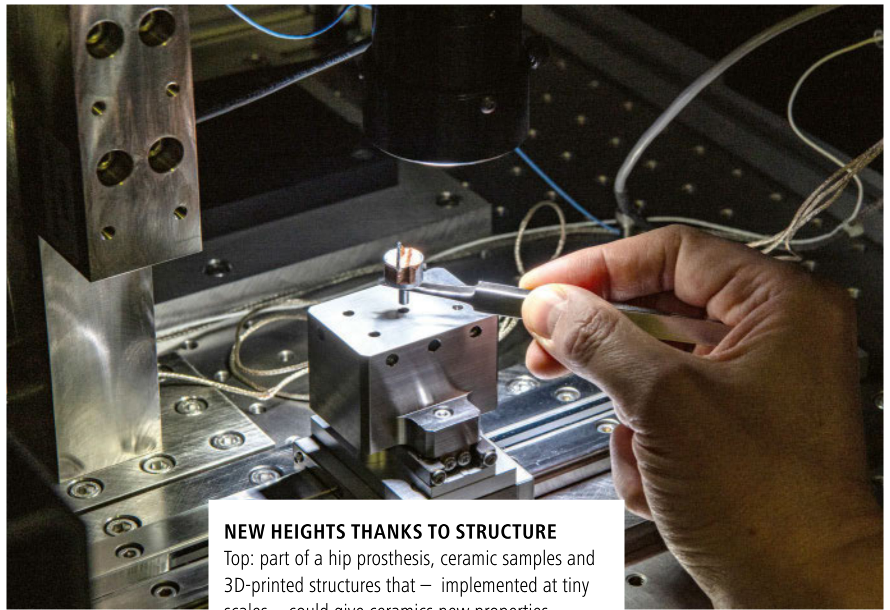
"If you structure ceramics correctly in the micro- or even nanometer range, they can become ductile and behave almost like a metal," he says. This is still a vision of the future – but not an unattainable one, the newly appointed lab head is convinced. He and his Architectured Materials research group at Empa in Thun have investigated and developed precisely such microstructured materials.

This expertise is now at the full disposal of the Laboratory for High-Performance Ceramics – a good addition, says Schwiedrzik. "The development of new materials has three components: manufacturing process, structure and functional properties," explains the researcher. "Thanks to my predecessor Thomas Graule, our laboratory is very strong in the area of process development and 3D printing of technical ceramics. Now we can complement this focus with my expertise in researching the relationships between structure and mechanical properties in particular. We combine simulation and experimental approaches to do this." The laboratory is gaining a broader portfolio with its new head. At the same time, Schwiedrzik is also broadening his horizons. "Interdisciplinarity has always motivated me," he says.

THE COURAGE TO EXPLORE

A glance at his CV confirms this. Schwiedrzik originally studied mechanical engineering at the Vienna University of Technology. "As a teenager, I was enthusiastic about science and technology, especially aviation," he says. "Studying mechanical engineering seemed to me like becoming a jack-of-all-trades: It offered a broad overview of a great many topics."

His plan worked. In addition to thermodynamics and fluid dynamics, mechanics, materials science, electrical engineering and computer science, the inquisitive student discovered a



NEW HEIGHTS THANKS TO STRUCTURE
Top: part of a hip prosthesis, ceramic samples and 3D-printed structures that – implemented at tiny scales – could give ceramics new properties.
Middle: a coated bone sample is placed in the nanoindenter for mechanical tests.
Below: Schwiedrzik with postdoc Kevin Both.

Photos: Marion Nitsch

lecture on tissue biomechanics during his Master's degree. "That was the most difficult lecture I've ever had in my life," laughs Schwiedrzik. "Not only did I have to understand the anatomy of all tissues, but I also had to describe them mathematically. It felt like there was enough material for two years in just one semester." Where most of his fellow students gave up, he accepted the challenge. "It was very demanding, but also very interesting. I was often the only student who finished the exercises. As a result, I also had one-to-one discussions with the professor," he recalls.

JAKOB SCHWIEDRZIK

VITA: Jakob Schwiedrzik (*1986) leads the Laboratory for High-Performance Ceramics at Empa in Dübendorf since 1 August 2024. He studied mechanical engineering at the Vienna University of Technology and then completed his doctorate at the University of Bern in the field of bone micromechanics. He completed his doctorate in 2014 summa cum laude. Schwiedrzik came to Empa as a postdoc in the Laboratory for Mechanics of Materials and Nanostructures in Thun, was promoted to scientist in 2017 and won an Ambizione Grant from the Swiss National Science Foundation (SNSF) in the same year. In 2021, he became group leader for Architectured Materials, also at the Laboratory for Mechanics of Materials and Nanostructures. In addition to his scientific work at Empa, he is also a lecturer at ETH Zurich, EPFL and the University of Bern.

This tenacity became Schwiedrzik's stepping stone to an academic career; the professor, Philippe Zysset, became his doctoral supervisor. He completed his doctorate in the field of bone biomechanics. When Zysset moved from TU Wien to the University of Bern in 2011, the young doctoral student followed him to Switzerland. Shortly afterwards, he met Johann Michler, head of the Mechanics of Materials and Nanostructures Laboratory at Empa in Thun, at a conference. The two researchers began an interdisciplinary collaboration. After completing his doctorate, Schwiedrzik joined Michler's team and entered the world of materials science. A common thread in his life as a researcher: "Every step in my career was also a jump in at the deep end," he smiles.

Fortunately, he finds such jumps refreshing – both in research and also literally, in the swimming pool, which he enjoys visiting with his two children, aged seven and nine. "For me, family time is the best way to balance out my job," says Schwiedrzik. Balance is needed, because the demands on a lab head are many and varied. "I have to consciously schedule time to think instead of just rushing from one meeting to the next," says Schwiedrzik.

BRIDGES TO SUCCESS

Schwiedrzik faces his new administrative tasks with the same curiosity and motivation as the new research topics. He had already taken on additional roles at Empa Thun, such as the vocational training of physics laboratory technicians and leading the local first-aid team.

At heart, however, Schwiedrzik remains a researcher. He is continuing to lead his own research group Architectured Materials, now as part of the ceramics laboratory. "We are also strengthening the collaboration between the Empa sites in Dübendorf and Thun, which I am very pleased about," says the laboratory head. He sees the uncomplicated cooperation between the different laboratories and research areas – the team spirit – as one of Empa's greatest strengths. The other is its bridging function between research and industry.

"We conduct excellent basic research that is also applications-oriented – and we aim to implement it with our partners from industry," says Schwiedrzik.

Ceramics especially is drawing great interest from industry, in particular in the fields of environmental technology, energy and medicine. "The climate crisis, the energy transition and an ageing society are important societal challenges to which we can make a direct contribution," emphasizes the laboratory head. Despite the multitude of problems that our society is currently facing, Schwiedrzik is optimistic about the future: "A challenge is always an opportunity to grow and to develop." ■

RENEWABLE ENERGY AS AN OPPORTUNITY FOR THE ECONOMY

EXPERT
Nathalie Casas, Head of Empa's Energy, Mobility and Environment Department, will speak at Green Day 2025.

On 9 May, the Green Day 2025 will take place at the Switzerland Innovation Park Ost in St. Gallen. The event aims to highlight the opportunities that renewable energies and the circular economy offer innovative Swiss SMEs. Nathalie Casas, member of Empa's Directorate, will be among the speakers. She will talk about Empa's large-scale research initiative Mining the Atmosphere and how we can use atmospheric CO_2 to produce plastics, medicines, fuels, and much more.

A SIP OF KNOWLEDGE

Many people associate science with bad memories from their school days. That doesn't have to be the case, researchers at Empa in St. Gallen are convinced. For the third time now, they are organizing the St. Gallen edition of the global science festival Pint of Science. Scientists from various institutions, universities and companies in and around St. Gallen go to bars and coffee shops in the city and talk to a wide audience about their research in a relaxed atmosphere. Pint of Science will take place from 19 to 21 May. The topics and venues can be found on the festival website:

UNUSUAL
Instead of seminar rooms and conference halls, researchers speak in bars and cafés during a Pint of Science.

Photos: Marion Nitsch; Empa

INNOVATIONS FOR A HEALTHY MUSCULOSKELETAL SYSTEM

Graphic: Empa

To transfer research results from Empa's labs into clinical practice more quickly, Empa is inviting experts from the healthcare sector to another Technology Briefing on 27 May 2025. Empa researchers will present their latest findings on musculoskeletal health and show how innovative imaging, biomechanics, and related technology development can improve the diagnosis and treatment of musculoskeletal disorders. From multi-scale imaging techniques to patient-specific models – science and practice jointly open up new avenues in musculoskeletal medicine. Further information on the program and registration can be found here:

EVENTS
(IN GERMAN AND ENGLISH)

28. – 30. APRIL 2025
URBAN SOUND SYMPOSIUM
Zielpublikum: Wissenschaft und Fachleute
urban-sound-symposium.org
Empa, Dübendorf

12. MAI 2025
Topical Day of Imaging and Image Analysis
Zielpublikum: Wissenschaft und Industrie
www.empa-akademie.ch/imaging
Empa, Dübendorf

22. MAI 2025
Kurs: High-Tech-Keramik
Zielpublikum: IngenieurInnen, TechnikerInnen, KonstrukteurInnen
www.empa-akademie.ch/keramik
Empa, Dübendorf

27. MAI 2025
Technology Briefing: Innovationen für einen gesunden Bewegungsapparat
Zielpublikum: Industrie und Wirtschaft
www.empa-akademie.ch/technologybriefing2025
Empa, Dübendorf

11. – 13. JUNI 2025
Aerogel Industry-Academia Forum 2025
Zielpublikum: Industrie und Wissenschaft
aia-forum.empa.ch
Empa, Dübendorf

24. JUNI 2025
wissen2go
Zielpublikum: Öffentlichkeit
www.empa.ch/web/w2go
Online

You can find all our current events here:

THE PLACE WHERE INNOVATION STARTS.

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