TUM Magazine
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MAGAZINE

THE RACE FOR WATER
Research for sustainable water management

SEVEN CLUSTERS OF EXCELLENCE
Successful start to the funding competition

EPFL'S NEW PRESIDENT
Portrait of Alumna Anna Fontcuberta i Morral

Cover: Verena Stammberger (l.) from the Chair of Landslide Research, here together with her colleague Maike Offer, examines the condition of the permafrost inside the Zugspitze every month. Climate change is melting the "eternal ice," which has consequences for the water cycle in the Alps and beyond.

Back cover: Student excursion to Environmental Research Station Schneefernerhaus at the Zugspitze in summer 2024. The traces in the snow are from Saharan dust.

Groundbreaking research, innovative start-up ideas, inspiring alumni, exciting news from teaching, studying, and campus life: This is what our new TUM Magazine offers you every six months as a print edition, and online at any time at: www.tum.de/magazine

Dear Readers,

PROF. THOMAS F. HOFMANN
President of TUM

I enjoy spending my spare time biking in the Alps. I constantly find that as I come down one slope, I can already see the next climb looming ahead. And that is what our current situation at TUM feels like; we have hardly achieved one great success together before the next mountain is already in view.

Our university is up there with the very best in this key funding line, too, with seven approved Clusters of Excellence—three new applications and four extensions of existing Clusters (see page 24). These team efforts do not just happen. They are the result of hard work and perseverance, and they demonstrate the powerful impact of our interdisciplinary network and our pioneering spirit.

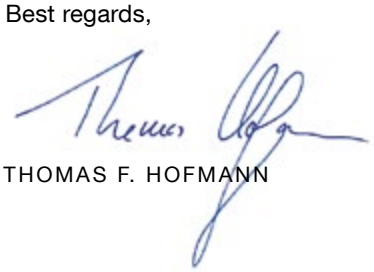
But we are well aware that we need to press on to the next summit. In October, we must defend our future-focused concept in order to retain our title of "University of Excellence." This accolade is more than a competition: It is a strategic compass. Here, too, our goal is to set groundbreaking standards as an internationally prominent entrepreneurial university with a philosophy that consistently brings together science, innovation, and social responsibility.

In May I was appointed President of TUM for a second term. I accepted this demonstration of confidence by the university's Supervisory Board with all appropriate humility, but also with enormous pride in continuing to shape our university's successful trajectory. This confirmation spurs me on to work with you all on developing our vision: a TUM that pursues top-flight research, while also providing guidance through a world in turmoil.

We take this mission very seriously. One example is TUM's new AI strategy, with which we look to the future, building on AI-assisted research and teaching, but also on ethical responsibility, transparency, and social impact (see page 42). Artificial Intelligence is not an end in itself. It has to serve humanity. With this in mind, we are making targeted investments in open platforms, new professorships, and structured engagement with the social and political spheres. This dialogue is essential. Particularly in times when academia and science are coming under increasing political pressure, we must take up a clear-cut position on the freedom of research and teaching. It is the bedrock of our success, and it requires protection and commitment from us all.

Climbing our next summit may be a challenge, but we are confident we have the team, the compass, the determination, and the energy to conquer it.

Best regards,



THOMAS F. HOFMANN

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The 2025 Leibniz Prize winner, Prof. Daniel Rückert.

Most prestigious German research award

Computer scientist and AI researcher Prof. Daniel Rückert has been awarded the 2025 Gottfried Wilhelm Leibniz Prize. The professor of Artificial Intelligence in Healthcare and Medicine receives the accolade in recognition of his research on AI-assisted medical imaging. The award, worth EUR 2.5 million, is presented by the German Research Foundation (DFG). Supported by the Alexander von Humboldt Foundation, the eminent scientist joined TUM from Imperial College London in 2020.

Third victory for tunnel boring team

Students from TUM won the Not-a-Boring Competition.

Student club TUM Boring has scooped its third win at the international Not-a-Boring Competition in the USA, where teams of students pit their self-made tunnel boring machines against each other. The overall goal is to advance technologies for subterranean transportation systems such as the Hyperloop. The winning students also set a new length record of 22.5 meters.

App to record urban trees

Trees play a vital role for climate protection and quality of life. But which trees are growing in our cities? And how many? Answers are provided by “Mein Baum” (My Tree), a new smartphone app that enables local residents to identify and record the trees in their vicinity and thus make an active contribution to research. The app was developed by German nature conservation organization BUND Naturschutz in partnership with TUM and Weihenstephan-Triesdorf University of Applied Sciences.

Data on local tree populations is collected in the app — a valuable source of data for researchers.

Top international placing

TUM regularly attains high positions in prestigious rankings.

TUM has once again moved up the QS World University Ranking, reaching 22nd place worldwide. This marks the first time that the university has reached the top 25 in one of the three most prestigious university ranking systems. UK higher education service provider QS Quacquarelli Symonds draws on surveys of academic institutions and employers to compile its university quality rankings, and applies indicators including the faculty-student ratio and the success of graduates.

Education to improve health

Three-quarters of adults in Germany experience significant difficulties in obtaining, understanding, processing, and applying healthcare information. These findings are the result of a representative study conducted by the WHO Collaborating Centre for Health Literacy at TUM School of Medicine and Health in partnership with the magazine *Apotheken Umschau.* The problems are particularly prevalent among young people, irrespective of education, income, or migration background. Prof. Orkan Okan and his research team are calling for higher investments in health literacy, particularly in schools and other educational institutions.

Heat, dry periods, torrential downpours, melting glaciers—in the Alps, climate change is already very clear to see. High time to adapt, warn TUM researchers. A matter for all disciplines.

The race for water

TEXT—— *Undine Ziller*
PHOTOS—— *Jürgen Merz, Astrid Eckert*

Michael Krautblatter goes ahead into the Kammstollen tunnel, a cable drum on his back. Running deep within the Zugspitze mountain, the tunnel was originally built for skiers almost a century ago, and is now part of Environmental Research Station Schneefernerhaus (UFS). After first passing through utility ducts, the path reaches a bend and we can only progress by crouching. The tunnel walls here are clothed in ice crystals that sparkle in the light from our head torches. But how much longer will they be here?

Professor Krautblatter unrolls the cable and clips it to one of the electrodes that are screwed into every few meters of the rockface. The geoscientist and his team from the TUM Chair of Landslide Research come here to check the condition of the permafrost—the permanently frozen rock. They use electrical resistivity tomography (ERT) to collect information about the expansion of this permafrost almost 100 meters below the peak of the Zugspitze. 40 thermometers set into the rock simultaneously measure its core temperature. In this area of the

Anthropogenic climate change is causing glaciers and permanent ice to melt—as seen here at the Northern Schneeferner in the Zugspitze massif in the summer of 2022. The impact on the water supply throughout the entire Alpine region is enormous.

Prof. Michael Krautblatter conducts research into Alpine natural hazards. Once a month, his team descends into the interior of the Zugspitze to assess the condition of the permafrost, using methods including electrical resistance tomography.

»The Alps are warming twice as fast as the global average. It's like a time machine showing us the future.«

——*Prof. Michael Krautblatter*

tunnel, it has risen by half a degree to –0.7 degree Celsius since 2007. The permafrost in the limestone of the Zugspitze begins to thaw above the equilibrium freezing point of –0.5 degree Celsius.

Permafrost acts as an adhesive and fills tiny cracks and crevices in the rock, stabilizing the mountains. Without this "cement" the Alps will start to crumble and rockslides, rock falls, and mudflows will become increasingly frequent, as seen on the Fluchthorn in Tyrol in 2023. As Krautblatter explains, lower snowfalls and higher temperatures also cause greater volumes of water to flow from the mountain peaks to the rivers in the spring snowmelt, a phenomenon that has been observed over decades. However, this is set to change within the foreseeable future. When the glaciers and permafrost shrink, the water reservoirs in the Alps will dwindle with them. Because of this, rivers will carry less and less water in hot and dry years, the very times when the need for water is at its most urgent—for example, for agricultural irrigation. "The Alps are warming twice as fast as the global average. It's like a time machine showing us the future," says Krautblatter.

Given this, one aim of his research is to develop geophysical and chemical methods that can distinguish and quantify glacial and permafrost meltwater, and thus enable him to more accurately estimate the levels still remaining in these frozen reservoirs in the Northern Alps. "This is the only way for us to predict how much water will flow down from the mountains in the future, and forecast what that will mean for the rivers over the next 30 to 40 years," says Krautblatter. "Permafrost water will be available for longer in summer than glacier meltwater."

Environmental Research Station Schneefernerhaus at the summit of the Zugspitze is the starting-point for the permafrost measurements.

Environmental Research Station Schneefernerhaus

Environmental Research Station Schneefernerhaus (UFS) is on the south face of the Zugspitze, immediately below the summit at an altitude of 2,650 meters. TUM is a consortium partner. Our researchers work in fields including ecoclimatology, environmental medicine, geodesy, and Alpine natural hazards. Here, at Germany's highest research station, they conduct measurements or work on research projects. Prof. Michael Krautblatter is among them, as director of the Virtual Alpine Observatory, which links UFS with other European Alpine high-altitude research observatories.

Jörg Drewes is Professor of Urban Water Systems Engineering at TUM and advises the German government as co-chair of the German Advisory Council on Global Change (WBGU).

With less water, but more stones and sediment washed into the valleys, how will that change the rivers' flow rates and affect the habitats of fish and other water wildlife? What impact will this disrupted water cycle have on agriculture, hydropower, and public water supplies? "These are questions that require interdisciplinary expertise to provide the answers," advises Krautblatter.

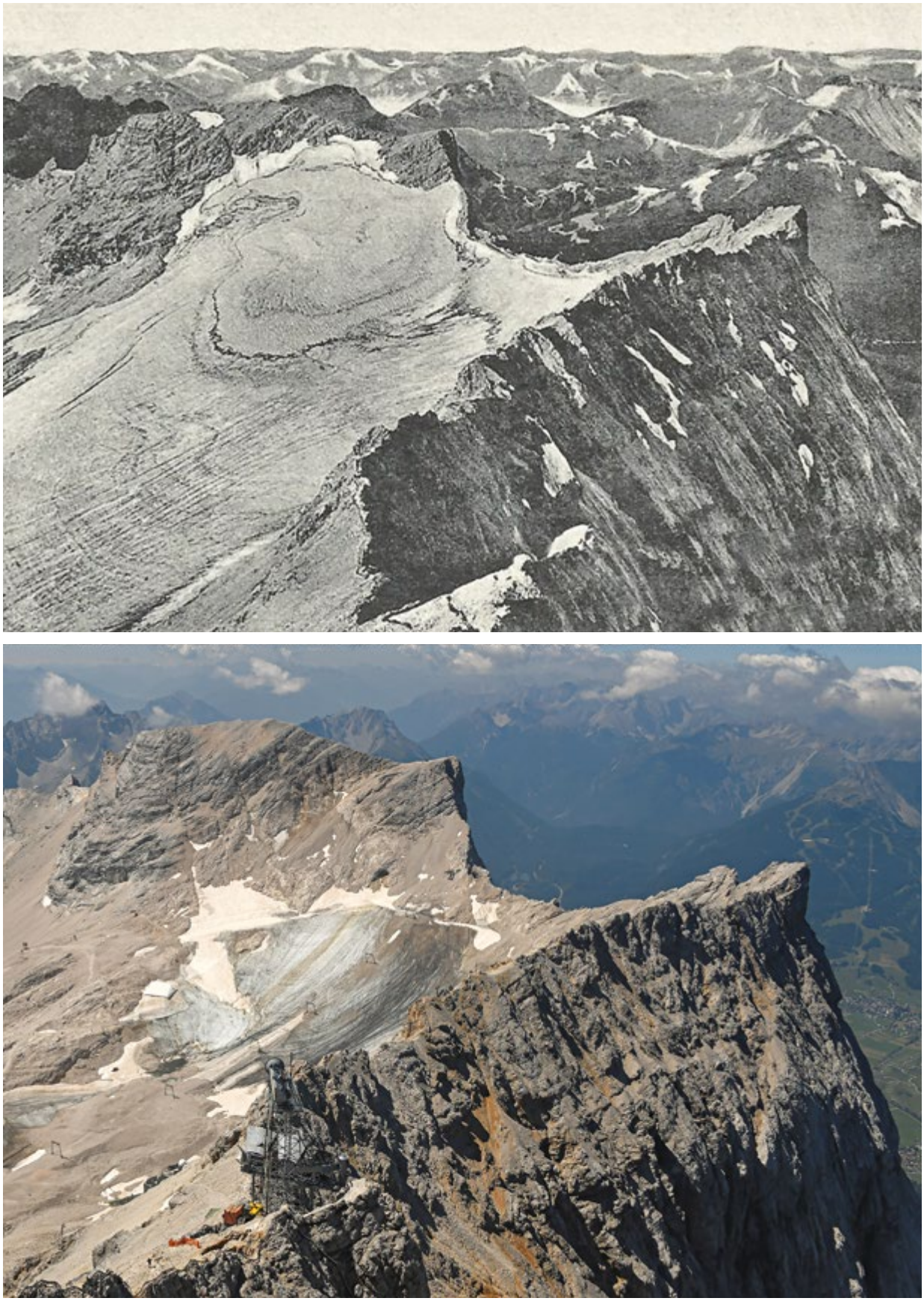
A group of researchers in science and engineering, life sciences, economics, and social sciences has formed the TUM Water Cluster with precisely this aim in mind. The topics covered by the cluster span water science, optimization of hydroelectric power stations, and the importance of water for ecosystems and agriculture, but also extend to analyses of international climate policies. More than 15 different chairs are involved, working together on devising solutions for resilient water systems and rapid adaptation strategies to combat the impacts of climate change. Krautblatter warns that it may take at least ten years before concrete measures can be implemented, "so we need to start right now."

Instability: the new normal

"Time is running out for us," agrees Prof. Jörg Drewes from his office at TUM's Garching campus. The Professor of Urban Water Systems Engineering points out, "For decades, we have been able to base the planning and operation of our water infrastructures on long-term empirical data for aspects such as precipitation patterns, water runoff, and natural groundwater recharge. But this assumption is not valid anymore." Extreme events that used to occur once a century are now occurring ten times more frequently. As Drewes puts it: "Instability is the new normal."

The expert on water systems co-chairs the German Advisory Council on Global Change (WBGU) and advises the German government. In January, he and a group of researchers from various universities published the WBGU flagship report "Water in a Heated World." The council warns that the global water cycle is changing at an accelerated pace, resulting in longer and more frequent periods of flooding and drought, water shortages in urban areas, and rising water pollution—to name just a few of the consequences.

"These threats are by no means confined to specific regions; they represent patterns on a global scale," says Drewes. Hence, international cooperation over climate change must be equally widespread, "to maintain an appropriate distance from



The Northern Schneeferner around 1900 (top) and in the summer of 2022.

Dr. Maria Vrachioli from the Chair of Production and Resource Economics coordinates the EU research project RETOUCH Nexus at TUM's Weihenstephan campus.

the limits of controllability," as the report states. The goal must be to establish a climate-resilient water management with a long-term perspective that can respond flexibly to change. In Jörg Drewes' view, the role of science is to provide fast, robust data as a basis for developing and supporting adaptation strategies while ensuring affected and interested stakeholders are actively involved.

The value of water

In Upper Franconia, around 300 kilometers north of the Zugspitze, TUM researchers are investigating ways of putting those aims into practice. The largely agricultural region around the Upper Main river has some of the lowest rainfall levels in Bavaria. Climate change, accompanied by increasingly frequent torrential rains and flooding, is exacerbating the situation.

»New political and business approaches are required alongside new technological solutions.«

——*Dr. Maria Vrachioli*

When water supplies become scarcer and more unstable, what does that mean for the sectors that depend on them? For households, industry, power generation, and agriculture, to say nothing of ecosystems such as riverscapes, grassland, and forests? This is one of the topics under investigation by Dr. Maria Vrachioli, a senior researcher at the TUM School of Management and coordinator of the European research project RETOUCH Nexus, which includes a case study on the Upper Main. "Our goal is to develop sustainable water management strategies and structures for everyone," she affirms.

One option that can ensure the increasingly scarce resource of water is efficiently distributed and avoid conflict is to place a price on it. "To date, river or groundwater has been used for irrigation free of charge in Bavaria. We are investigating whether it is possible to place a price on irrigation water, in order to achieve more sustainable use while ensuring food crop cultivation remains profitable," says the economist. This can only succeed by bringing all stakeholders together, from government and local policymakers to professional associations and grassroots initiatives: "Our aim is to include everyone in the debate and convince them that new political and business approaches are required alongside new technological solutions."

The vital data for the Upper Main case study is provided by a team at the TUM Chair of Hydrology and River Basin Management. A web of colored lines fills Dr. Jingshui Huang's computer screen: blue for river water, green for wells, and red for water consumption by households, agriculture, and industry. What happens when drought necessitates more frequent irrigation? What impact does reforesting have on the regional water balance? To answer these and similar questions, the researchers are using the database to develop an array of scenarios for RETOUCH Nexus. This data then informs decision-making by the local responsible parties.

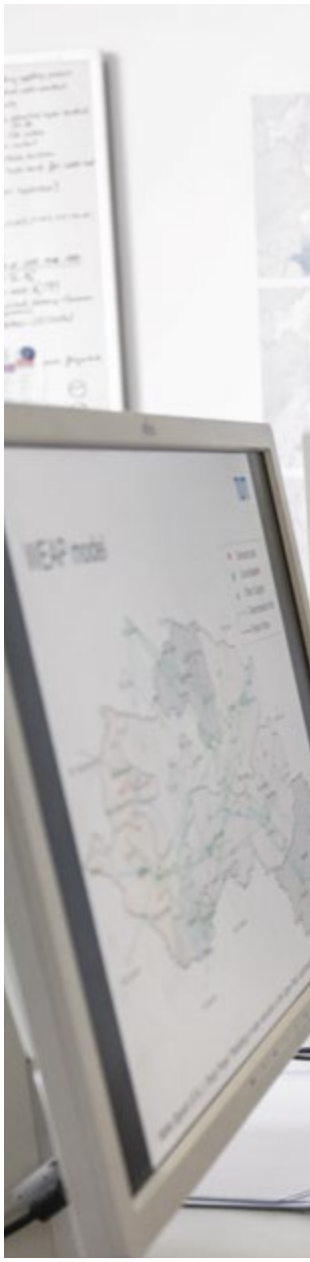
But data of this kind is also sought after outside Germany as climate change and economic and population growth cause water shortages in many regions around the world. An international team in the EU project WE-ACT is thus working on a decision support system (DSS) for the border region between Kyrgyzstan and Uzbekistan. Here too, data on water availability and consumption is collected and integrated. "With our system, we provide in-depth knowledge about how the water resources in the region will develop," says Jingshui Huang, who is coordinating the project. "In this way, we can help decision-makers to respond better to challenges and develop sustainable strategies across borders." The aim is to avoid conflicts and reduce water stress for communities, the economy and the environment.

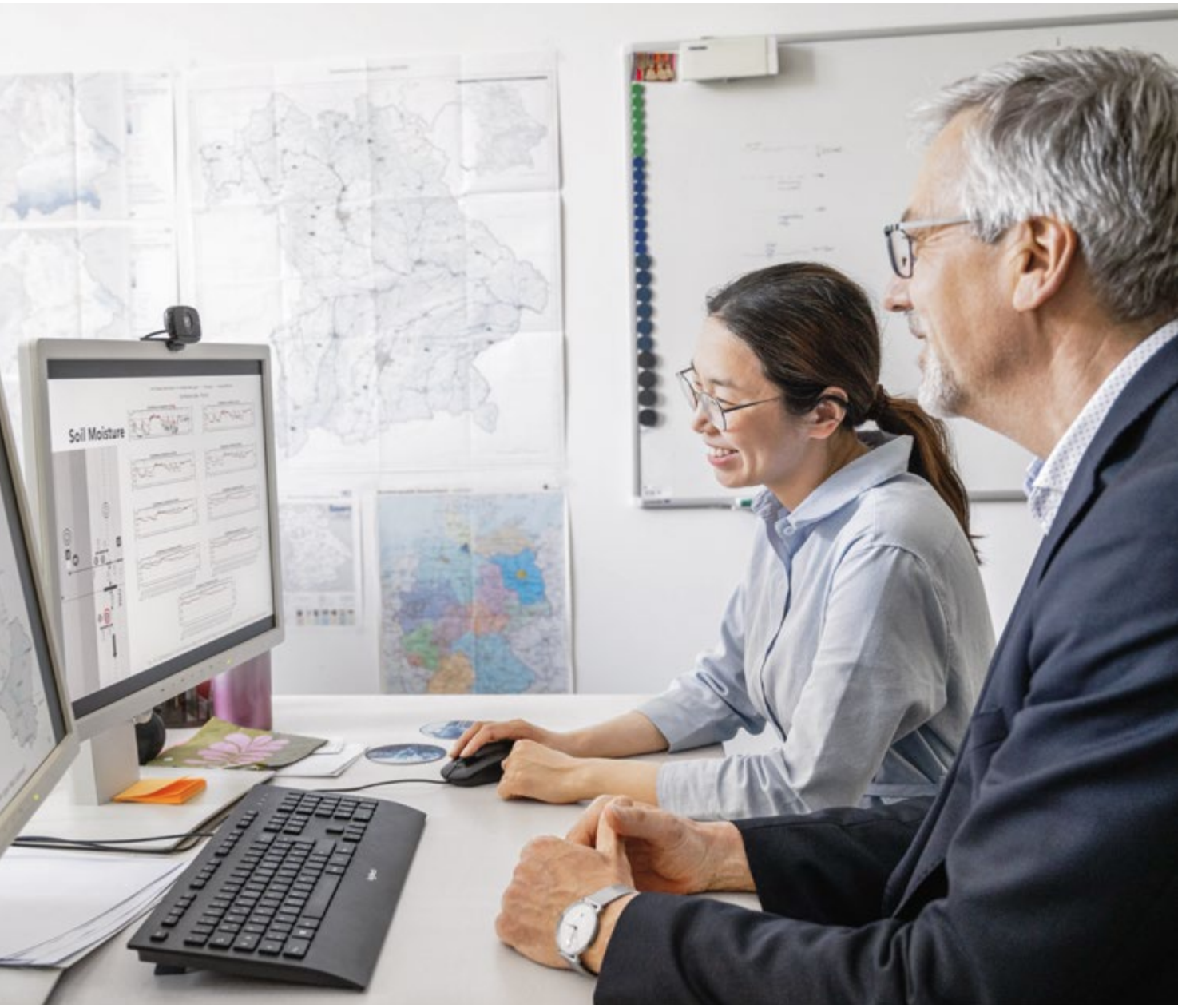
"In the past, the focus has often been on how to divert excess water as fast as possible," says Markus Disse, Professor of Hydrology and River Basin Management. Given this, there is already ample research data on flood protection technologies such as dams and polders. "To combat heat and dryness more effectively, we are now working on solutions that provide more efficient local water retention," he says. Disse is working on decentralized, near-natural measures for restoring soil water retention and improving groundwater recharge. The key here is "green water"—in other words, naturally occurring soil water and rain water, which is absorbed by plants and evaporates.

Ways out of the crisis

One of the Chair's projects, for example, examines ways of using existing drainage ditches as interim storage capacity to take up excess surface water runoff during heavy rainfall, and then return the water to the land in dry periods. Moors and bogs as natural temporary storage have likewise been a focus of Disse and his team. A further collaboration project with researchers from the TUM School of Life Sciences is examining the ecosystem of the River Isar and its riparian forests. The team is investigating how water availability impacts on plant growth, and how the vegetation in turn affects the water cycle. "It's the cross-disciplinary nature of the work that makes the research environment at TUM so exciting," says Disse.

Back at the Zugspitze, Michael Krautblatter shoulders his cable drum once more and heads back to daylight. In the cable car down to the valley, he reminisces about seeing concerned faces among his student audience at a conference. Instead of holding the third talk on the consequences of climate change as planned, he spontaneously decided to outline the available possibilities of rapid adaptation. "By focusing on solutions in this way, we can encourage young people to play a part in shaping their future. If we're smart about it, we then have a good chance of preserving an environment that is worth living in."





Prof. Markus Disse and Dr. Jingshui Huang from the Chair of Hydrology and River Basin Management are developing databases to serve as the basis for a variety of water research projects.

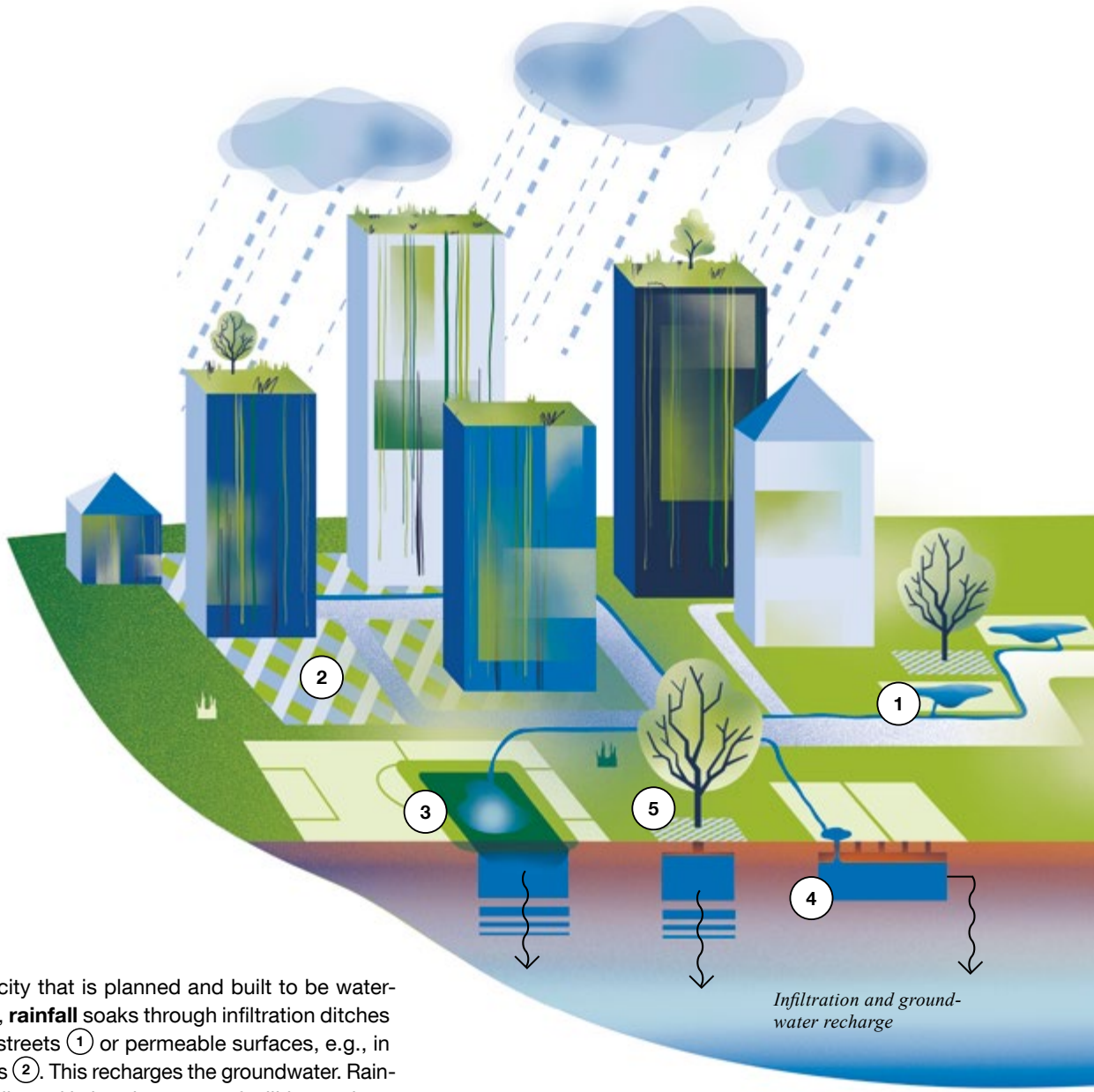
For more information and articles on sustainability, visit: www.tum.de/sustainability

TUM Water Cluster

As TUM's focus program for water research, the TUM Water Cluster coordinates research and teaching activities on water-related issues. The cross-disciplinary program involves over 15 chairs engaged in developing future-facing solutions for establishing resilient water systems.

Water for the city

Due to climate change, torrential rains and periods of drought are becoming increasingly frequent. TUM engineering and life science researchers are developing solutions to prepare cities for climate change and harvest local rainfall. Here's how the water-conscious city (or "sponge city") works.



Infiltration and groundwater recharge

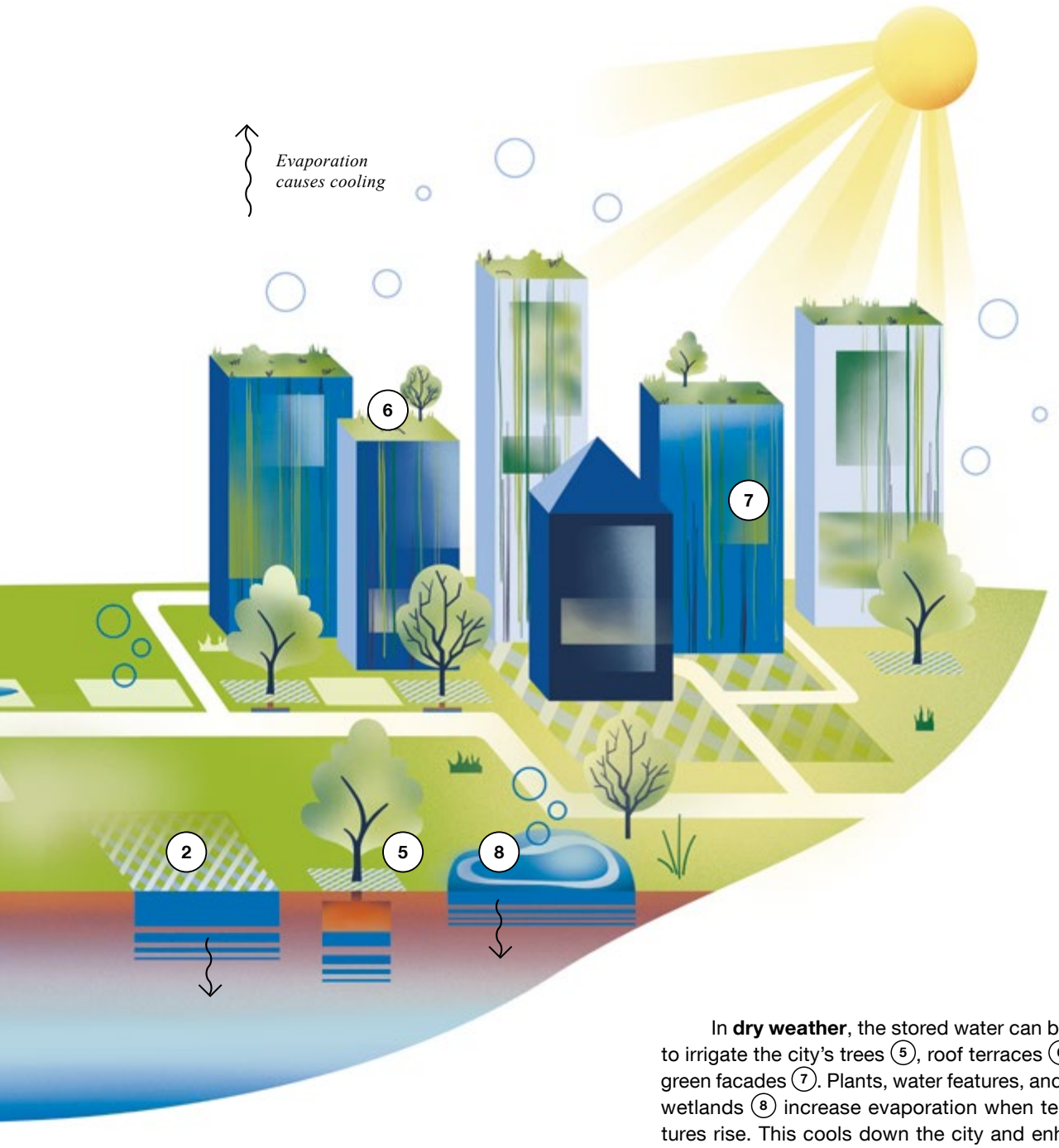
In a city that is planned and built to be water-conscious, **rainfall** soaks through infiltration ditches along the streets (1) or permeable surfaces, e.g., in parking lots (2). This recharges the groundwater. Rainwater is collected in interim storage facilities such as sports fields (3) or underground cisterns (4).

(1) Emergency storm drains and infiltration swales

(2) Water-permeable surface

(3) Multifunctional area/ emergency storm drain

(4) Underground cistern/swale



In **dry weather**, the stored water can be used to irrigate the city's trees (5), roof terraces (6), and green facades (7). Plants, water features, and urban wetlands (8) increase evaporation when temperatures rise. This cools down the city and enhances quality of life and biodiversity.

(5) Optimized tree location with/without interim water storage for tree irrigation

(6) Green roofs with/without interim water storage

(7) Green facades

(8) Wetland

In recent years, the Moon has once again become the focus of space travel. Numerous agencies have launched exploration missions. The long-term goal is the extraction of resources. We spoke with Philipp Reiss, Professor of Lunar and Planetary Exploration, about this topic.

Resources from the Moon

INTERVIEW—— *Moritz Müller*
PHOTO—— *Sebastian Kissel*

Professor Reiss, everyone—whether government space agencies or private companies—wants to go to the Moon or is already there. Where is this renewed interest coming from?

Unlike the Apollo era, when the motivation was clearly political, the current motivation is primarily scientific exploration. The topic of water on the Moon is particularly important. There are still many questions to be answered, such as: Where does the water come from, and in what quantities is it present? These usable resources could be sold in the future, representing economic potential. We can also conduct a lot of scientific research on the Moon. For example, we can study impact processes and learn about the age and geology of the lunar surface, the solar system, and the formation of celestial bodies. These topics were not the focus of the Apollo missions and were only partially pursued afterwards. Moreover, our knowledge of water on the Moon is only about 25 years old. Prior to that, it was assumed that there was no water on the Moon.

The race seems to be on again, this time between China and the United States. Is this impression due to the current political situation?

China's lunar program has been very successful, and its recent robotic Moon landings have demonstrated the country's ability to reliably land on the Moon and return samples to Earth. Over the next decade, China plans to launch crewed missions and build a research station

Prof. Philipp Reiss's research aims to improve our understanding of volatile materials and resources on planetary bodies.

The Moon has recently returned to the focus of space travel. One goal is the extraction of resources.

on the Moon with other nations. Meanwhile, the U.S. is pursuing the extensive Artemis program, which is currently behind schedule due to technical and political challenges. As part of the CLPS (Commercial Lunar Payload Services) program, several private U.S. companies have been flying to the Moon since last year, with various customers, including the European Space Agency (ESA), contributing payloads. Overall, the nature of the race to the Moon is certainly not as distinct as it used to be. Above all, it is no longer just about two competing nations. India has undertaken several successful Moon missions in recent years as part of its Chandrayaan program, and Japan is now among the five nations that have safely landed on the Moon.

The Moon is expected to provide raw materials, serve as a transit hub for journeys to distant planets, and be colonized. Which of these goals is realistic, and when might they be achieved?

The first issue to be tackled is fuel. It holds the greatest economic potential, yet we are making enormous efforts to transport fuel from Earth into space. Propellant production on the Moon would open up new possibilities for long-distance flights. Additionally, it would save costs and emissions when launching from Earth. I expect the first demonstration flights will occur within the next ten years. This means that the first devices on the Moon will extract oxygen from regolith and treat water. The next step will be utilizing the raw materials. However, colonization of the Moon will take much longer.

Will it be possible to extract and process resources without humans?

Most of these processes will be robotic. For example, humans will remotely control processes and machines on the Moon from the planned Lunar Orbital Platform-Gateway space station. However, humans will play an important role in prospecting, or finding resources. They can perceive objects and resources on the lunar surface better than robots with their sensors can. This is why both humans and robots are needed on the Moon. Robots will then take over extraction and processing.

What will happen after we extract resources from the Moon? Will we move on to other planets?

There is still much to discover and explore on the Moon. For instance, setting up telescopes on the far side of the Moon would enable new discoveries because there would be no interference from Earth. At the same time, we will also be heading towards Mars. However, I think using the Moon as a stepping stone to Mars and a testing ground for Mars missions is too short-sighted. Although there are naturally many synergies, the technological requirements and environmental conditions are very different. Additionally, we can fly to the Moon much faster and more flexibly than to Mars. For this reason, I believe it makes more sense to develop missions to both celestial bodies simultaneously.

However, for long-distance interplanetary missions, the space between Earth and the Moon could become more important. Larger spacecraft could be sent from Earth or the Moon in separate parts and assembled and refueled in the lunar region.

Cutting-Edge Research in Aerospace

TUM is one of the leading research institutions in aerospace in Germany and Europe. Combining excellent basic research with practical development, it collaborates closely with industry. With several specialized locations in the Munich region, including Garching, Ottobrunn, and Munich Airport since 2024, TUM covers a broad spectrum of innovative aerospace technologies, from materials and propulsion systems to satellite and robotic systems.

Our university has once again gotten off to a successful start in the new round in the German federal and state governments' excellence competition. End of May, the German Research Foundation announced that seven Clusters of Excellence at TUM and its partners will receive funding—three more than before.

Funding for seven Clusters of Excellence

TEXT—— *Ulrich Meyer*
PHOTO—— *Andreas Heddergott*

From biosynthesis to innovation research, the seven Clusters of Excellence at TUM cover a wide range of topics.

In the two-stage review process of the German Research Foundation, four existing clusters proved themselves. They will receive funding for seven more years, focusing on energy conversion, quantum technologies, neurological diseases, and the origin of the universe. Additionally, three new Clusters of Excellence were selected based on their leading research approaches in nucleic acid research, biosystem design, and societal transformation through technologies.

"Our outstanding scientists and their strong partners once again underline the leading position of science in Munich. This has created the conditions for us to be able to compete for the title of University of Excellence for the fourth time in a row since 2006," says TUM President Prof. Thomas F. Hofmann. "Our team spirit and the trust-based cooperation between the two Munich universities of TUM and Ludwig-Maximilians-Universität München (LMU Munich) with the Max Planck Institutes and Helmholtz Munich, which is tailored to their respective strengths, has once again proven to be the right strategic approach for achieving excellence in research," says Hofmann.

Here are the Clusters of Excellence at TUM:

Cluster for Nucleic Acid Research and Technologies (NUCLEATE)

The cluster aims to accelerate the rapid progress in nucleic acid research and enable groundbreaking discoveries and therapeutic breakthroughs in biomedicine. Applying interdisciplinary approaches, NUCLEATE focuses on fundamental questions about new functions and key mechanisms of modification and homeostasis of nucleic acids, through to the development of new nucleic acid technologies and applications in medicine.

In addition to Julius-Maximilians-Universität Würzburg, LMU Munich, and TUM as joint applicants, the Max Planck Institute of Biochemistry, Helmholtz Munich, and the Helmholtz Institute for RNA-based Infection Research are involved in NUCLEATE.

Biosystem Design Munich (BioSysteM)

This cluster aims to develop self-organizing molecular and cellular systems with programmable, life-like properties. The focus of BioSysteM ranges from biomolecular machines for biosynthesis and intelligent materials to biomedical microrobots, pattern-based therapeutics, and the control of cell differentiation and organ formation as the basis for a new generation of revolutionary applications in biomedicine.

In addition to TUM and LMU Munich as joint applicants, the Max Planck Institute of Biochemistry and Helmholtz Munich are involved in BioSysteM.

Munich Center for Transformative Technologies and Societal Change (TransforM)

While transformative technologies are seen as the key to significant challenges such as climate change, energy, mobility, and healthcare provision, they are causing increasing skepticism concerning innovation and public controversy. As an interdisciplinary social science cluster, TransforM aims to rethink theories, methods, and practices of participation, legitimacy, responsibility, security, and resilience in relation to transformative technologies for dynamically changing societies. At the same time, the cluster seeks to research how these social concerns can be anchored more effectively in innovation processes in order to harmonize technological progress and economic opportunities with future social, ecological, and political interests.

In addition to TUM as applicant, LMU Munich, the Max Planck Institute for Innovation and Competition, the ifo Institute, Munich, the Munich School of Politics and Public Policy, and the Leibniz Center for European Economic Research are involved in TransforM.

Fundamentals of Energy Conversion Processes (e-conversion)

The cluster researches the fundamental processes of converting and storing renewable energies, which are at the heart of the energy transition. The aim is to further develop fundamental findings from the first funding phase in order to combine transformative energy concepts, energy conversion, and energy storage into innovative bridging technologies. The focus is on multi-particle systems, complex materials, and dynamic interfaces, as well as AI-supported automation and high-throughput methods to accelerate the development of innovative energy concepts and materials many times over.

In addition to TUM and LMU Munich as joint applicants, the Max Planck Institute for Solid State Research, the Fritz Haber Institute of the Max Planck Society, and the Deutsches Museum are involved in e-conversion.

Munich Center for Quantum Science and Technology (MCQST)

MCQST researches the scientific foundations of complex quantum systems and creates the technological basis for quantum technology, a key future technology of the 21st century. The researchers address important fields of application, ranging from quantum computers, powerful quantum information systems, and quantum sensors to novel quantum materials. In the second funding phase, the Cluster of Excellence aims to expand basic research into the phenomenon of quantum entanglement and use it for innovative applications in the fields of data processing, communication, metrology and sensor technology, materials science, chemistry, and medicine.

In addition to TUM and LMU Munich as joint applicants, the Max Planck Institute of Quantum Optics, the Walther Meissner Institute of the Bavarian Academy of Sciences and Humanities, and the Deutsches Museum are involved in MCQST.

From the Origin of the Universe to the First Building Blocks of Life (ORIGINS)

The cluster researches the formation and development of the universe and its structures - from galaxies, stars, and planets to the building blocks of life. ORIGINS investigates the path from the smallest particles in the early universe to the emergence of biological systems. In the second funding phase, the researchers aim to make groundbreaking discoveries in nuclear and particle physics, astrophysics, astrogeophysics, cosmology, and biophysics. Examples include research into conditions for possible extraterrestrial life and a deeper understanding of dark matter.

In addition to TUM and LMU Munich as joint applicants, the Max Planck Institutes for Astrophysics, Biochemistry, Extraterrestrial Physics, Physics, and Plasma Physics, the European Southern Observatory, the Leibniz Supercomputing Centre, and the Deutsches Museum are involved in ORIGINS.

Munich Cluster for Systems Neurology (SyNergy)

The cluster investigates how complex neurological diseases such as multiple sclerosis, stroke, and Alzheimer's develop. Using systems neurology as a new interdisciplinary approach, researchers can map the many underlying processes of neurodegenerative, neuroimmunological, and neurovascular diseases and develop strategies for novel therapies. In the new funding phase, the Cluster of Excellence aims to research the effects of the brain's energy supply, investigate immune reactions in more detail, better understand the resistance of neurons to disease, and develop repair mechanisms for damaged cells, among other areas.

In addition to TUM and LMU Munich as joint applicants, the German Center for Neurodegenerative Diseases, Helmholtz Munich, and the Max Planck Institutes of Biochemistry, Biological Intelligence, and Psychiatry are involved in SyNergy.

Excellence Strategy

Through the Excellence Strategy, the federal and state governments support outstanding scientific achievements, research collaborations, and the development of German universities' profiles. The funding program consists of two lines of funding: the Clusters of Excellence, in which universities and research institutions conduct joint research, and the Universities of Excellence, which aim to expand their leading position in research. Only universities that have been successful with at least two Clusters of Excellence can apply for additional funding as a University of Excellence.

TUM has been successful in all funding lines of the competition since 2006. The decision on the title of University of Excellence will be made in 2026.

www.tum.de/excellence

Stefan Guldin is the new Professor of Complex Soft Matter at the TUM School of Life Sciences and Scientific Co-Director of the Proteins4Singapore project. His research is located at the point where materials science and life sciences meet.

New approaches to future nutrition

TEXT—*Anja Lapac*
PHOTO—*Andreas Heddergott*

Prof. Stefan Guldin conducts research in Singapore and Weihenstephan.

A slight fluctuation in temperature, a deviating pH value, a touch of moisture—subtle changes and low-level stimuli are all it takes to cause changes in the structure or function of soft matter. A key principle in this is molecular self-organization, a process where tiny nano-scale building blocks such as proteins or polymers automatically aggregate into ordered structures, flexibly aligning themselves to their environment.

The process may sound abstract but has a host of practical applications, from medical diagnostics and sustainable water purification to the development of plant-based meat alternatives. As Guldin explains, "At my Chair, for example, we are developing biosensors that bind very specifically to certain viruses and bacterial components, allowing the reliable detection of diseases and contaminants," Guldin explains. "In environmental engineering, we are working on membranes that purify water of salts, pollutants, and heavy metals. At the intersection with food technology, we are developing new approaches to future nutrition."

Meat alternatives for Singapore

Guldin is currently juggling active roles at two TUM locations; alongside his chair at the Weihenstephan campus, he is Scientific Co-Director at TUM-CREATE in Singapore. In the Proteins4Singapore project based there, he is researching into processing plant-based proteins to create sustainable and convincingly flavorful alternatives to meat.

From a global perspective, the significance of plant-based proteins extends far beyond individuals' personal decision to stop eating meat. Amid the progress of climate change and continued population growth, nutritious and sustainably produced foods are becoming increasingly important. "Agriculture is responsible for a significant part of greenhouse gas emissions. If we can manage to replace at least some animal proteins with plant-based protein sources, we can reduce the industry's ecological footprint significantly," urges Guldin.

Although the market for meat analogues has grown over recent years, plant-based protein alternatives are not yet widespread. "The products on the shelves are often heavily processed," warns Guldin. "Anyway, flavorful food involves a whole lot more than simply the right seasoning."

For an all-round taste experience, a food must combine various factors: aroma, flavor, and the sensory experience on the tongue. "Our goal is to develop plant-based meat alternatives that are as natural as possible and barely distinguishable from meat in terms of flavor." The Singapore-based team is working on removing undesirable flavors from the plant proteins, using methods including fermentation and enzyme treatment. At the same time, Guldin is drawing on his expertise in order to make targeted improvements to the consistency of meat alternatives by generating controlled formation of micro- and nanoscale structures.

"My priority is to pursue open, bold issues with determination. That line of action may not always pay off, but from a long-term perspective, it would be a shame to squander genuine innovative potential merely making minor adjustments," says Guldin.

NewIn

What attracts scientists to TUM? What applications do they see for their work, and how has their career progressed so far? In the "NewIn" video series, we introduce our newly appointed professors and reveal what they are passionate about—both in and outside of work: www.tum.de/newin

Researchers at TUM and Imperial College London have developed a new method to identify bacteria with unprecedented speed by searching not for the pathogens themselves, but for their metabolic products. Bacteria can thus be identified within minutes and treatment can commence immediately.

Diagnosis within minutes instead of days

TEXT—— *Ulrich Meyer*
PHOTO—— *Astrid Eckert*

Harmless infection or serious disease? Effective diagnosis depends on speed and reliability. Traditionally, bacterial diseases are diagnosed using the complex method of isolating pathogens and creating bacterial cultures, with waiting times of several days as the rule. Only then can targeted treatment of the disease begin.

The team led by Nicole Strittmatter, Professor of Analytical Chemistry at TUM, and Dr. James S. McKenzie (Imperial College London) uses mass spectrometry to eliminate this time-consuming step. The researchers' method enables them to identify bacteria directly in tissue and stool samples. "Our approach is not to look for the pathogenic bacteria directly, but only for their metabolic products. This allows us to detect them indirectly, but much more quickly," says Wei Chen, PhD student at the Department of Bioscience at the TUM School of Natural Sciences in Garching.

Expanding the bacteria database

At the heart of the process is a database in which 232 medically important bacterial species and their metabolic products have been recorded to date. Biomarkers—measurable parameters for biological processes—are derived from this database and can then be used to directly detect specific bacteria. Among the bacteria that can be identified using the

Prof. Nicole Strittmatter (l.) and PhD student Wei Chen use mass spectrometry to identify pathogens within minutes.

new method are pathogens of high clinical relevance that, for example, can trigger stomach cancer, are responsible for certain pneumonias and meningitis, are associated with premature births, and can cause septicemia.

Strittmatter also sees great opportunities for using mass spectrometry in personalized medicine, in which the treatment is precisely tailored to the individual patient, explaining: “This is one of the most important future topics in biotechnology and medicine. Targeted interventions can dramatically improve the chances of successful treatment. As analytical chemists, we develop modern tools and methods for doctors to do this.” In 2024 she received an ERC Starting Grant from the European Research Council (ERC) for her work.

The biomarker database will now be further expanded to enable the new method to be used regularly in clinical practice. According to the researchers, a total of over 1,400 bacterial pathogens are already known and described, and their specific metabolic products will now be identified and added to the data.

Living architecture

PHOTO—— *Kristina Pujkilović*

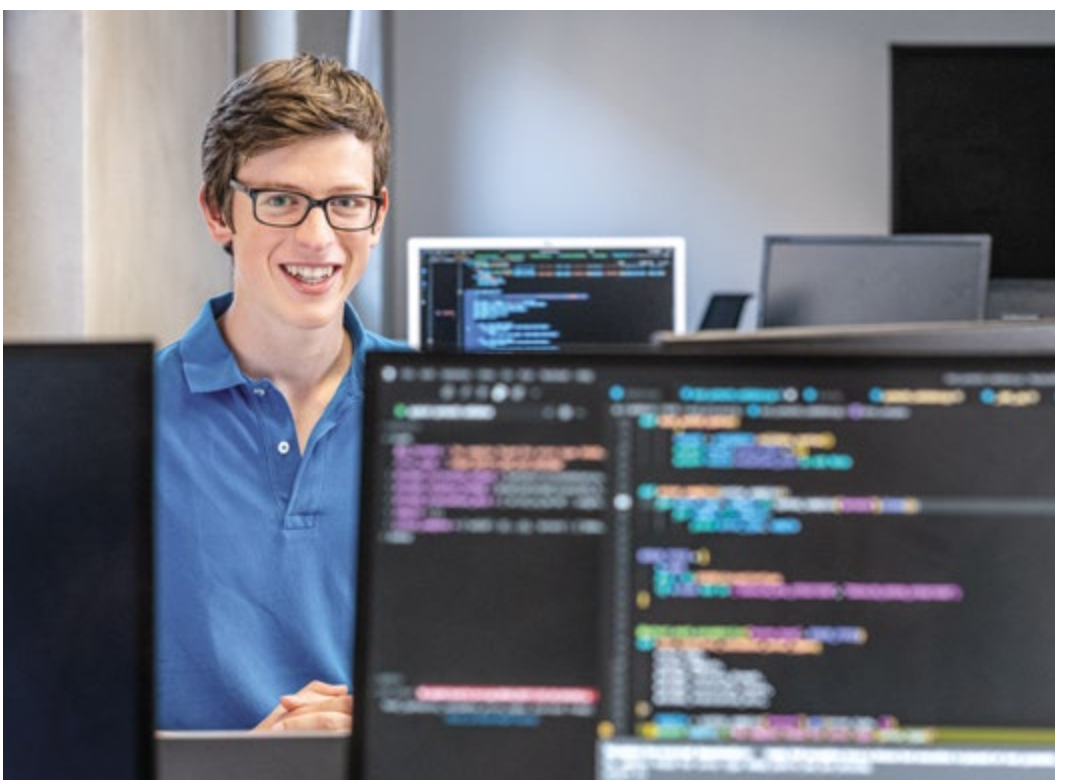
Trees have the potential to become living building blocks of architecture. Prof. Ferdinand Ludwig and his team at the Professorship of Green Technologies in Landscape Architecture are researching this pioneering concept. Their goal is to integrate plants into architectural concepts as supporting structures, not just use them as design elements. One outstanding example is the “Arbor Kitchen” from 2022—a growing structure that uniquely combines functionality and plant growth.

The TUM Architecture Museum in the Pinakothek der Moderne is hosting the exhibition “Trees, Time, Architecture,” showcasing this and other projects by the research group until October 14, 2025.

The day before his high school diploma math exam, Florian Scherl was not studying at home. Instead, he was in a notary's office, founding his own company aged just 18. Now, three years later, the Informatics student is recruiting his first employees.

Starting a company while still in school

TEXT—— *Undine Ziller*
PHOTO—— *Andreas Heddergott*



The founding team of FAST AI Movies, led by Florian Scherl, was able to use the rooms and infrastructure of the TUM Incubator. The company is now based at the start-up incubator, gate Garching.

Florian Scherl, now 21, developed an early interest in IT and Artificial Intelligence. Aged just 12, he taught himself programming after school from online courses, attended programming camps, and entered IT competitions with AI models he had trained himself. But the boy from Traunstein, Upper Bavaria, soon outpaced those beginnings.

"I always got pretty far, but then I didn't take the projects any further, and that used to bother me a bit," says Florian Scherl. Instead of working on a program in purely theoretical terms, his aim was to transform it into entrepreneurial reality. That opportunity came along in Year 11 at his school, the Chiemgau-Gymnasium. As part of a project seminar, Florian Scherl and two of his fellow students drew up a business plan involving the use of Artificial Intelligence to produce short movies. The team's idea scooped second place in JUGEND GRÜNDET, a competition for budding entrepreneurs.

Learning from the Silicon Valley

From those beginnings, Scherl and his teammates took giant leaps towards founding their company. As their prize for achieving second place, they were invited to visit Silicon Valley in the U.S.A., the cradle of so many high-tech companies. Florian Scherl also received a donation of a high-performance AI-computer from a company and was invited to take up an internship at an AI start-up in Pforzheim. "These experiences clinched it for me," he recalls. "I decided to found a start-up of my own." And so it came that on the day before his math exam in May 2022, 18-year-old Scherl was sitting in a notary's office in Traunstein waiting for official notarization of his company's shareholders' agreement.

However, he felt the lack of someone to talk to about his progress and share the responsibility. TUM, which he joined as an Informatics student in 2022, provided exactly what he needed. An entrepreneurship scheme by the student initiative TUM.ai brought him into contact with Philipp Gabriel, a master's student of Information Systems who had already amassed practical experience in a variety of companies. "We make a great team," says Scherl.

Taking up the opportunities in coaching and networking offered by TUM Start-up Consulting and TUM Venture Lab Software/AI, the duo honed their company idea: FAST AI Movies. Their focus is now an AI model that automatically creates explanatory videos based on companies' existing online brochures or Intranet texts. The program recognizes semantic relationships between concepts, such as similarities, hierarchies, and causalities, and transforms them into a graphic structure augmented by easy-to-understand pictograms. The animations are accompanied by quiz questions, likewise generated automatically. Finally, the videos can be edited manually. "Our software is designed to smooth the transfer of knowledge between employees and departments and make the content more memorable," says Florian Scherl.

Promoting accessible knowledge

As the primary market for their product, the company's founders have identified industries that require compliance with complicated regulations or that sell intangible products, such as the IT, financial, and insurance sectors. Their AI software is already used by savings and cooperative banks and by the public health insurance company AOK Baden-Württemberg. In addition, the company gained its first investor at the end of 2024. Scherl is now fully occupied with the task of relocating from the TUM Incubator to his own premises and recruiting his first full-time employees, and has put his studies on hold for the moment.

What's the most exciting aspect of working at a start-up? "Our AI enables us to provide easier and fairer access to work-related knowledge," affirms Florian Scherl. "A start-up may only be a small first step, but it enables us to maximize our limited resources in creating something that will have a great impact."

TUM Venture Labs

The twelve TUM Venture Labs each specialize in one important field of technology. They offer the start-up teams a direct link to cutting-edge research, specific technical infrastructure, tailored training programs, expertise for the respective market and global networking with the industry and investors.

Start-up Fusix Biotech is exploring new paths in immunotherapy. Founded by researchers from TUM, the company is developing virus-based cancer therapies that mobilize the body's own immune defenses in the fight against the disease.

A virus against cancer

TEXT—— *Paul Hellmich*
PHOTOS—— *Juli Eberle*

At TUM University Hospital, Dr. Jennifer Altomonte studies oncolytic viruses—pathogens that target tumor cells. In her start-up Fusix Biotech, she is working to turn them into new cancer therapies.

Even tumor cells can be infected by pathogens. In fact, they are especially vulnerable—a side-effect of their ability to hide from the immune system. Dr. Jennifer Altomonte and her team at Fusix Biotech are making use of exactly that.

The Fusix virus wreaks havoc in tumor cells, with the goal of fighting cancer and saving lives. It does so by causing an infected tumor cell to produce large amounts of a protein that anchors itself to the cell's surface. This sends a signal to neighboring cells to fuse with the infected one. They obey immediately, first one, then the next, and so on, until the entire structure literally bursts and releases the cell contents, which trigger the immune system. Alerted immune cells clear the debris, attack intact cancer cells that had previously evaded immune detection, and help limit the further spread of the virus. This approach could one day help treat tumors that do not respond to conventional therapies.

At the Clinic and Polyclinic for Internal Medicine II at the TUM University Hospital, Altomonte is developing virus-mediated immunotherapies. She laid the scientific foundation for Fusix Biotech back in 2016. At the time, she was exploring ways to employ viruses to fight cancer.

Combination of two pathogens

"Cancer isn't a natural host for viruses, so finding the perfect therapeutic virus in nature was unlikely. That's why we built one," says Altomonte. Her starting material was two pathogens that infect animals: The first replicates rapidly in specific tissue types, while the second triggers the characteristic fusion mechanism. Altomonte and her team combined the beneficial properties of both viruses while addressing safety risks for patients.

In cell and animal studies, the researchers demonstrated that the therapeutic virus replicates exclusively in tumor cells. Even at relatively low doses, the cancer cells were destroyed with remarkable efficiency. Altomonte had the process patented.

"At that point, I had to decide whether to license the technology to an existing company or start my own," she says. The decision came easily after she exchanged ideas with other founders in her network and took part in several entrepreneurship programs, including TUM Start-up Consulting and offerings from UnternehmerTUM, the center for innovation and business creation at TUM. "In the end, I was excited to expand my role as a scientist and learn something completely new."

An established scientist, Jennifer Altomonte (r.) has already been awarded an ERC Starting Grant and an ERC Proof of Concept by the European Research Council (ERC).

Initial funding came from an EXIST research transfer grant and the M[4] Award for biomedical projects from the Bavarian Ministry of Economic Affairs. Through TUM, she continued to have access to state-of-the-art research infrastructure. A crucial step was to bring in the right co-founders: Dr. Teresa Krabbe, who had worked on the topic as a doctoral student; Prof. Markus Gerhard, a microbiologist at TUM with start-up experience; and Dr. Marian Wiegand, who contributed extensive expertise in viral vector production. The team also received support from the TUM Venture Lab Healthcare.

Ready for the clinical phase

Since Fusix Biotech was founded in 2022, Altomonte's team has continued to advance the technology. The project's preclinical phase is now nearly complete. In it, the team uses animal and cell models to verify that the approach works as intended. Once funding is secured, the team plans to produce the drug under GMP conditions—that is, under the strictly regulated pharmaceutical standards required for medications used in humans. They then plan to conduct initial clinical trials in patients with liver cancer.

Research at TUM is the basis for the spin-off Fusix Biotech.

Entrepreneurship News

Launch of the Isar Aerospace rocket at Andøya Spaceport, Norway.

First rocket launch

In March, TUM spin-off Isar Aerospace launched its rocket from Andøya Spaceport in Norway. It completed a short test flight before crashing. However, crashes are quite common during rocket tests designed to gather data and experience. The 28-meter carrier rocket is tailored to small and mid-sized satellites, which are crucial for applications such as communication networks, autonomous driving, and digital agriculture. The start-up was founded by three graduates with intensive support from TUM.

Concentrated energy

UnternehmerTUM, Europe's leading center for innovation and start-ups, has established the Energy Innovation Initiative. The initiative brings together companies from the fields of energy supply, grids, digital services, and mobility as well as start-ups and research institutions, with the aim of supporting and accelerating the development of new business models for a resilient, decarbonized, and affordable energy system. The founding partners are Accenture and SAP.

Jump-start for battery startups

TUM has launched the Battery Start-up Incubator (BaStI) with the goal of strengthening Germany's technological sovereignty in the field of battery technologies. It is funded with 3.3 million euros by the Federal Ministry of Education and Research. As an integral part of the TUM Venture Labs, BaStI will provide support and advice to start-up applicants from all over Germany in the first phase.

At our hackathons, students from all subjects develop product ideas together.

Record for spin-offs

2024 saw the number of newly founded start-ups at TUM exceed 100 for the first time. In that year UnternehmerTUM and the TUM Venture Labs supported more than 1,100 start-up teams, and TUM also led the field for EXIST start-up scholarships. These scholarships are provided by the Federal Ministry of Economic Affairs for spinout companies at supporting universities. More than 30 scholarships were granted to TUM projects in 2024, by far the largest number awarded to any university. With over 250 projects receiving EXIST scholarships since the program began in 2007, TUM is ahead of all other German universities.

Europe's best start-up hub—again

Start-up teams find the best conditions at TUM, for example in the Venture Lab Food / Agro / Biotech.

For the second consecutive year, British business paper *Financial Times* (FT) has named UnternehmerTUM as the leading start-up hub in Europe. A decisive factor behind this success is the powerful network available to tech start-ups. FT's "Europe's Leading Start-Up Hubs" ranking covers start-up centers with at least one physical location in Europe that offer incubator and/or accelerator programs for start-up teams. The rankings covered 150 centers that meet the criteria.

Alexander Braun studied construction engineering at TUM, where he also gained his doctorate in the subject. He has been Executive Vice President Digitalization and IT Systems since 2021.

TUM is Germany's first university to publish a comprehensive strategy for using Artificial Intelligence (AI) in research, teaching, and administration. We talked to our Executive Vice President Digitalization and IT Systems, Dr. Alexander Braun, about the subject.

"We aim to work proactively with AI"

INTERVIEW—— *Andreas Schmidt*
PHOTO——*Astrid Eckert*

Dr. Braun, our university has published a comprehensive AI strategy under your guidance. Why is it so important for an institution to adopt a stance on this subject?

As a major university but also a large employer, our aim was to set out our fundamental position concerning AI, particularly large language models (LLMs). We were fielding a constant stream of questions from lecturers, students, and office employees, but also from politicians. Shortly before we published our strategy, the issue took on a whole new dimension with the EU AI Act.

The law with which the European Union aims to establish a legal framework for the development of AI while supporting innovation in the sector.

Yes. Drawing up regulations for a technology that is still evolving and continuously adding new functions is a complex task. It's hardly encouraging when innovation and development have to start by asking: "So what am I *not* allowed to do?"

At TUM, our aim is to properly evaluate everything we can do with the technology, in order to make well-founded decisions based on the complete scope of ethical, legal, and data privacy considerations. But first and foremost, we want to view the use of AI as an opportunity.

And that applies across the board, from students to administration?

Yes, absolutely. We structured the paper along those lines, starting with the area of study and teaching, followed by research and, naturally, administration. The fourth area then comprises overarching data privacy and ethics. When we look at the individual areas, our basic message is that we aim to work proactively with the new AI technologies across all fields, and we want the ways they are used to deliver the maximum benefit.

A new resource, then? But such a powerful one that it can also cause concern …

That makes it all the more important for everyone involved to be thoroughly familiar with AI and how to work with it. For example, a cornerstone of our strategy is to ensure all of our graduates leave us with AI skills under their belt. In other words, we want students to know how to apply an AI or LLM effectively in their specialist field. But of course, there's also the issue of the downside. What are the ethical requirements? How far can I trust an AI? How does an AI behave in specific borderline cases? What about distortion and similar problems that can always occur in a statistical system of that kind?

Does that mean that AI expertise will be incorporated into all curricula across all disciplines?

No, not quite. In some subjects or their logical extensions, yes, certainly. However, our goal is more widely drawn than that. Because AI impacts on so many areas, AI skills must be integrated into existing modules in every subject. Alongside this subject-based integration, we will continue to expand our range of social sciences courses that address ethical questions in more concrete terms.

You mentioned data privacy earlier. What position will TUM take on that in the future?

When it comes to data privacy, the same principles that have always applied to IT systems still apply: If I want to process personal data in some way, irrespective of whether that involves an AI system, an LLM, or a simple database, I have to ensure that I comply with the principles of data minimization, that personal data are anonymized, that they cannot be used for any other purposes, and that all individuals concerned consent to the processing of their data. Those are the principles. As AI systems naturally in-

»All of our students need to leave us with AI skills under their belt.«

——*Alexander Braun*

volve working with far greater volumes of data, that data anonymization takes on even greater significance. Raising awareness is an ongoing necessity to ensure that sensitivity and minimization drive the treatment of these data volumes.

As far as data administration and control are concerned, we already have good infrastructure in place in the form of the Leibniz Supercomputing Centre (LRZ) and various TUM institutions. What new aspects of data governance will be added?

We set up the TUM Research Data Hub as a new institution that will focus closely on data preservation, data processing, and data handling in general. It is a partnership between the university library and our Munich Data Science Institute, which will deal with the subjects of data storage and processing in strategic, technical, and conceptual terms. It will also be a center for developing new tools for data storage and for the semantic enrichment of data with metadata. Sensitivity to the requirements involved in handling different types of data and data volumes is paramount.

We already provide researchers with Data Science Storage, a facility in partnership with the LRZ. Depending on the type of data for storage, requirements differ widely—from a connection to our high-powered computers to the classic requirement to share data with research partners. Our Research Data Hub addresses all these needs, and is working with the LRZ and other partners to develop appropriate strategies and solutions that can provide solid answers to our researchers and students.

Returning to the application, is it possible to make generalized statements that cover research, teaching, studies, and administration?

Yes, to a certain extent. Use of AI must always be transparent and take data privacy and ethical principles into consideration. This applies to administration just as much as to study and research. As a basic scientific principle, all tools and resources are described and the tools and resources used for theses, dissertations, or publications are specified. It therefore follows that I have to do exactly the same with AI. But there is a special aspect here: Lecturers in some fields are still able to draw up their own rules.

What does that mean?

It means, for example, that the use of tools or resources can be prohibited altogether. But that is precisely why we drew up this strategy and why we have played an active role in teaching for some time, with schemes such as AI tutors. Our clear message is that this technology is here to stay. We want it to be used, so we want everyone to know that the goal is not to find the best way of checking students' work for the use of AI, but to design examinations in such a way that they continue to be an appropriate gage of examination performance.

More information:
https:/go.tum.de/aistrategy

Before studying at TUM, Dr. María José Barragán-Paladines worked in research projects for the conservation of endangered marine life. Today she is the Scientific Director of the Charles Darwin Foundation on the Galápagos Islands, one of the world's most precious nature reserves.

Research in a natural paradise

TEXT—*Sabrina Eisele*
PHOTO—*Magdalena Jooss*

Even as a child, María José Barragán-Paladines had ambitions of becoming a scientist. After studying biology in her home country of Ecuador, she initially spent almost ten years working on research projects for NGOs dedicated to preserving endangered marine species.

During that time, she often found that biological expertise alone was not enough to solve the complex issues involved in marine biodiversity protection. To gain a clearer understanding of current marine conservation problems, she sought an integrated perspective that considered both sustainability and, later, ocean politics. She found it in the master's program in Sustainable Resource Management at TUM. "It's an internationally recognized program at one of Europe's most prestigious universities," she says. "I was so lucky to be accepted."

Barragán-Paladines took up her studies in Munich in 2006. The passionate researcher's time at TUM would prove to have a decisive impact on her life and career: "My studies taught me that nature conservation and sustainability only seem to be separate topics at first glance. In fact, they are closely interlinked," she says. "When—and only when—I had understood this, I was able to see the big picture and realized how incomplete and one-sided my previous research had been."

She found the international nature of the program as enriching as the teaching, and recalls: "A single course could have up to twenty different nationalities. TUM provided a truly rich and absorbing learning environment where cultures, languages, and interests converged and were shared."

TUM alumna María José Barragán-Paladines has been Scientific Director of the Charles Darwin Foundation on the Galápagos Islands since 2018.

Giant tortoises are a focus of the active species protection measures on the Galápagos Islands.

Engagement for the TUM Network

Our alumna Dr. María José Barragán-Paladines has been a dedicated volunteer with the TUM Network for many years, taking roles including speaker for Women of TUM and mentor for students and alumnae. She recently met with her mentee and TUM alumna Annika Aurbach (Master's in Environmental Planning and Ecological Engineering, 2015) on the Galápagos Islands and gave her a tour of the Charles Darwin Research Station.

If you are an alumna or alumnus with an interest in getting involved with the TUM Network, visit www.community.tum.de/alumni

Barragán-Paladines has continued to prioritize interdisciplinary and multicultural teams in her position at the Charles Darwin Foundation. "You could say that this journey of mine, which began at TUM, has become a trend," she says. The institution's Scientific Director since 2018, she is the first woman and the first Ecuadorian to hold the position.

Unique wealth of flora and fauna

The Galápagos archipelago is a chain of remote Pacific islands with a unique wealth of flora and fauna. Virtually all the islands are designated as a national park under special conservation management. It was the first region to be declared a UNESCO World Natural Heritage Site.

Barragán-Paladines addresses numerous topics in her current position, including treatment of invasive species, preservation and restoration of ecosystems alongside the impacts on human well-being, sustainable development of a continuously expanding human system, and the need to bridge the gulf between science and politics in connection with both the Galápagos Islands and the tropical East Pacific.

"Last year we revised our institution's mission statement and set out the strategic research agenda for the next five years. I am working on the planning, management, implementation, and funding for this scientific portfolio and ensuring that it will be as interdisciplinary as possible over the next decade," says the TUM alumna. "My goal is to motivate researchers to leave the comfort zone of their own specialism."

She also has words of advice for young scientists, encouraging them to broaden their horizons and be open to findings that extend beyond their own field. But most of all, the researcher wants to pass her own life philosophy on to young people: "Determination is vital. It reinforces important values such as discipline and commitment, which are essential for achieving personal and professional goals." It is this recipe for success that has helped María José Barragán-Paladines to achieve her life's dream.

Master's student Anna Lena Salfer is part of TUM's Agnes Mackensen funding grant program. She is currently in Singapore, immersed in top-flight research in an international context.

Promoting first-generation students

TEXT—*Andreas Schmidt*
PHOTO—*Astrid Eckert*

Anna Lena Salfer (l.) at an Agnes-Mackensen-Program mentoring event.

For more information about the program and details of how to get involved as a mentor, visit: https://go.tum.de/amp

In a laboratory at Nanyang Technological University (NTU) in Singapore, flickering monitors show a succession of satellite images, soil data, and chemical analyses from the university's nearby experimental field. Anna Lena Salfer is part of a research team investigating the potential of enhanced rock weathering as a method of binding carbon in land used for agricultural purposes. Alongside geoscientific modeling, the team's analyses primarily draw on data from international emissions trading registries, which help to improve their understanding of the criteria used in standardizing and certifying carbon reduction technologies. Their research assists in supporting credible emissions trading schemes in south-east Asia, representing a key step towards establishing sustainable climate protection strategies in the region.

Salfer is a student on TUM's elite master's program Responsibility in Science, Engineering and Technology, or RESET. One of seventeen Global Connect Fellows from NTU, she is currently in Singapore and immersed in top-level research in a global context. For the master's student, the post is a further milestone along her academic career. She is the first in her family to gain a university degree and has pursued her ambition to enter the world of science with determination. Last year she joined the Agnes-Mackensen-Program, a funding program by TUM's Diversity & Inclusion staff unit to support women and FINTA* (the German abbreviation for women and intersex, non-binary, trans, and agender individuals) from non-academic backgrounds. The program is designed to strengthen those students' self-esteem and encourage their leadership skills and personal development.

Breaking down social bias

"While I was studying for my bachelor's degree, I often felt I was alone with my doubts and difficulties, particularly because university-related knowledge is not a given for me," says Salfer. "The Agnes-Mackensen-Program helped me to recognize that my experiences as a student from a non-academic background are valuable and are seen."

In Germany, only 27 percent of young people from non-academic homes attend university, compared to nearly three times as many from academic backgrounds. Named after the first woman to graduate from TUM, the Agnes-Mackensen-Program is designed to break down this social bias in the educational system.

Prof. Claudia Peus, Senior Vice-President for Talent Management and Diversity at TUM and the program's patron, stresses the importance of initiatives of this kind: "We must not allow so many talents to fall short of developing their full individual potential. Unfortunately, social divisions are rife in the German educational system. They have an adverse impact not only on the students concerned, but also on society as a whole. With this in mind, at TUM we are working on improving the situation in very concrete ways."

The program offers mentoring schemes, networking opportunities, and workshops for developing individual, entrepreneurial, and academic skills. Its mentors support the participants in building self-confidence and making future-facing decisions. The discussions and dialogues provide the mentees with practical knowledge while also inspiring and encouraging them to achieve their goals.

In addition, the program partners with the company Avanade to select ten students per cohort as recipients of exclusive MINT grants—and Salfer is one of them. She gains a host of benefits from the grant scheme: "We recently took part in a hackathon organized by Avanade. My team and I even reached the final! It was incredibly inspiring to be involved in actively shaping innovation in this international context," she says. "The mentoring is also based on a very personal and individual approach, ranging from Python programming workshops to personal career planning."

From her laboratory in Singapore to international hackathons, exposure to a variety of perspectives has shaped Anna Lena Salfer's professional and personal development and is honing her self-perception as an up-and-coming researcher. The Agnes-Mackensen-Program supports students on their chosen path by removing obstacles and creating opportunities to make science more inclusive.

Funded as part of the Excellence Strategy by the federal and state governments

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TUM in figures

www.tum.de/facts

>180

degree programs

available at TUM

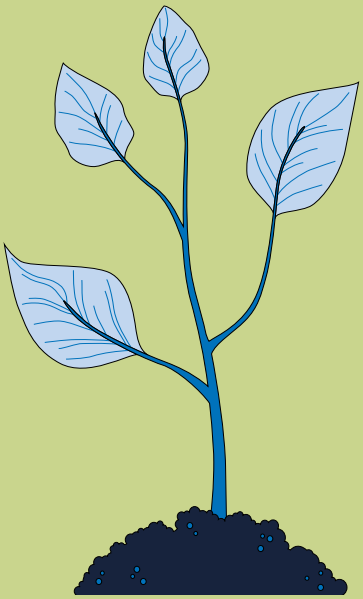
80

patents

on first-time inventions by researchers are submitted on average per year

>100

start-ups founded in 2024 – a new record



1,168

doctorates were awarded by TUM in the academic year 2023/24

544

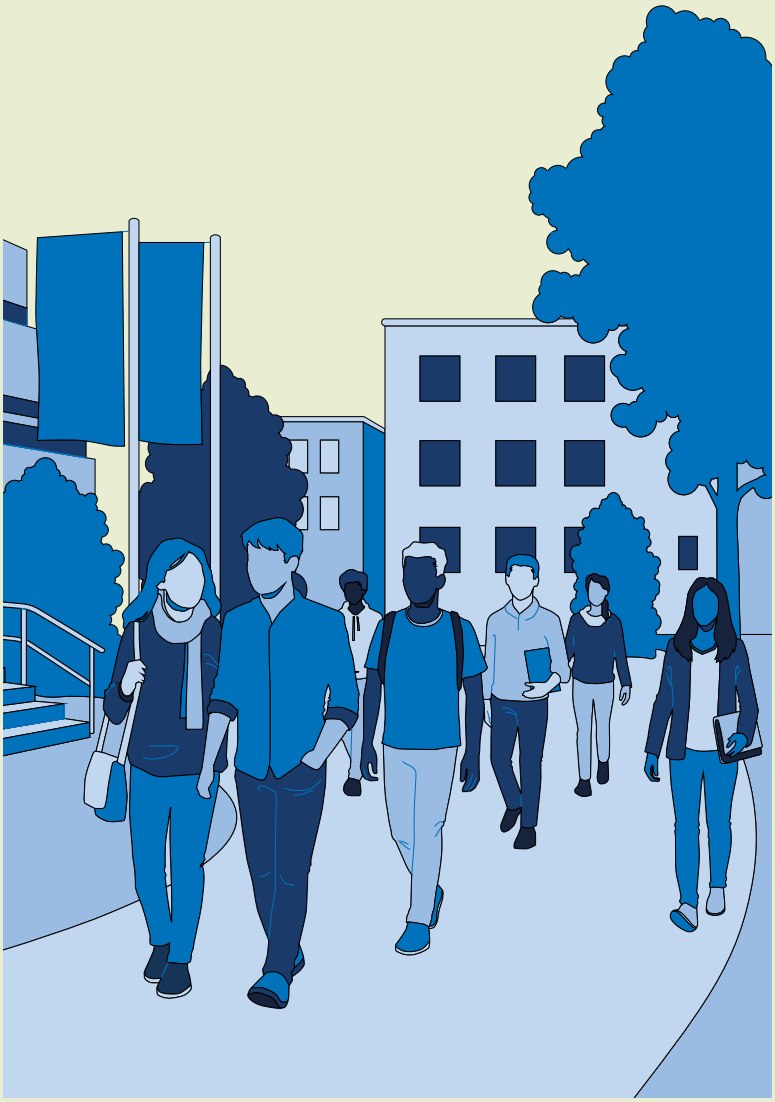
million euros

in third-party funding were raised for research and teaching in 2024

Promoting talents

Since 2011, young people throughout Germany have received support through Deutschlandstipendium scholarships. The program offers more than just financial support: It is a sign of recognition for outstanding achievements and an incentive for future success. Get involved and support students at TUM with a Deutschlandstipendium.

www.tum.de/en/deutschlandstipendium



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The federal government doubles your donation

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scholarships have been awarded at TUM since the start of the program

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are currently committed to the Deutschland-stipendium at TUM

Studies in Barcelona, a doctorate from the École Polytechnique near Paris, postdoc at CalTech and Habilitation at the TUM Walter Schottky Institute: Anna Fontcuberta i Morral has seen the world in the course of her career. The physicist has been president of the École Polytechnique Fédérale de Lausanne (EPFL) since January 2025.

The woman at the helm of EPFL

TEXT—— *Jeanne Rubner*
PHOTO—— *Nicolas Righetti*

"I have very happy memories of Munich," says Anna Fontcuberta i Morral. Aged just 30, she took up a position there as team leader at the Walter Schottky Institute, and completed her doctorate at TUM in 2008. She expresses her gratitude for the opportunity to establish her own autonomous working group there and that she was trusted to prove herself in a research field that was new to her without yet having publications to her name. "An unprecedented level of support for a young academic." At that time, Fontcuberta i Morral was conducting research into filamentary crystals, ultra-fine crystalline "whiskers" with interesting electronic properties. She then joined EPFL as tenure track professor and was appointed associate professor in 2014 and full professor five years later.

And now, she is president of the university. Her packed schedule means this interview takes place on Zoom. Fontcuberta i Morral is sitting in her office, against a virtual background depicting the campus with breathtaking views over Lake Geneva and the mountains, modern buildings, and plenty of green. "That's where students like to get some sun at lunchtime," she says, leaning forward to give a better view of the futuristic building with its undulating concrete roof. "This is the Rolex Learning Center, where our library is also located."

European partners

EPFL and TUM are both "technical universities," which evolved from nineteenth-century engineering institutes. In 1969 the École Polytechnique de l'Université de Lausanne, attached to Canton de Vaud, became Switzerland's second federal institute of technology. "Both TUM and EPFL are located in regions with a strong track record of research and innovation," says Fontcuberta i Morral, adding that both are notable for their high-caliber students. But

TUM alumna Anna Fontcuberta i Morral has been president of EPFL since 2025.

what about the differences? “We’re a comparatively small institution, more like a start-up. Very agile.” While EPFL has around 14,000 students, TUM has nearly four times as many. Both institutions are linked as members of the EuroTech Universities Alliance and the European EuroTeQ Campus; they operate exchange programs for students and hold joint courses in mechanical engineering and applied mathematics.

Speaking with focus and lucidity, the president outlines her clear-cut vision of what she aims to achieve during her term of office. First and foremost, she needs to make savings because the government in Bern has reduced the university’s budget in line with the debt constraints set out in the constitution. “We have to do more with less, so we are aiming to streamline our efficiency.” EPFL still has reserves in hand for this and next year. Fontcuberta i Morral and her management team plan to make the most of this time to select which tasks to prioritize and which to shelve. To achieve this, she is relying on the community spirit that reigns at EPFL: “That’s our strength as a relatively small university.” Other plans for closing the budget deficit involve boosting private donations and founding partnerships with companies.

The president is passionate about fostering interdisciplinary collaboration. Two years ago, while still representing EPFL’s research centers, she launched an interdisciplinary seed fund. “We aim to build stronger collaborations in vital cross-sectional areas such as AI, medical technology, sustainability, and energy transition,” she explains, adding that EPFL is seeking to enhance its impact on society by leveraging innovations and driving knowledge and technology transfer. A new position of Vice President Innovation and Impact has been created for that purpose.

View over the EPFL campus with Lake Geneva in the background.

In Fontcuberta i Morral's view, solidarity with society is vital. "We have to prevent polarization in public opinion," warns the physicist. "Populist movements are making their presence felt in Europe, too, often accompanied by skepticism over science. Perhaps we have neglected to listen to people closely enough in the past and forgotten that narratives are needed." She believes that science must now become more approachable and must constantly explain that scientists are working on a greater mission: to improve people's lives.

With this in mind, the EPFL governing board is ensuring that its professors show engagement. "Any colleagues we promote need to be excellent in at least two out of the three areas of research, teaching, and transfer or impact." Candidates are interviewed and assessed based on their performance in all three areas. Fontcuberta i Morral gives an example: "We have just sent out an offer to a young researcher whose research is naturally outstanding, but who ultimately won us over with his public engagement."

Fontcuberta i Morral did not set out to be a physicist. At school, she was equally at home in all subjects. But one day, she recalls, she realized there was one great advantage to mathematics: There is no need to learn anything by rote. All it takes is an understanding of the interrelations. From then on, she embraced mathematics, and later developed a love of physics as well. "I wanted to understand how the world works." She certainly proved successful, winning numerous awards including a Marie Curie Excellence Grant and an ERC Starting Grant from the European Research Council (ERC). In 2013 she was appointed to TUM's newly introduced honorary role of TUM Ambassador, a title now awarded annually to internationally outstanding scientists.

The office of president likewise initially formed no part of her plans for the future. However, alongside pursuing her research, she had always been

actively involved in EPFL. “After expressing criticism of an organizational issue, I was asked whether I wanted to take over EPFL’s research centers.” Aware that accepting responsibility is a key part of making change, Fontcuberta i Morral later began to consider applying for the office of President.

However, she had no intention of stepping away from research entirely: “My two predecessors ran small research groups, so I decided that could work for me, too,” she says. “Working with postgrad students is so fulfilling, so I set aside two half-days a week for them.”

Promoting diverse talents

In keeping with Fontcuberta i Morral’s firm conviction that an excellent university needs a wide variety of talents, EPFL is actively involved in school activities, such as coding courses for girls. The institution is also on the lookout for outstanding women for new professorships. The approach is now paying off: “Based on the number of ERC Grants, our researchers here are more successful than elsewhere in Switzerland.” When Fontcuberta i Morral joined EPFL in 2008, the number of women professors only just reached double figures; now, 91 out of a total of 370 are women. The culture has changed, she points out: “Diversity works in an organization if it has the support of the leadership. Women leaders go where they are genuinely welcome.”

When asked how she balances her career with family life, the president responds with a slightly impatient retort: Why is that question only ever directed at women? She then answers that she has always worked hard and her family is used to it. Her husband is also a professor and is likewise constantly busy. “But when I spend time with the family, I’m one hundred percent there for them. We do activities together; we make sure we have great experiences together.” She runs regularly and practices yoga: “It’s important for my mind as well as my body.”

Fontcuberta i Morral’s career is certainly an inspiration for many young researchers. She thinks back fondly to her own mentor—her supervisor at the California Institute of Technology (CalTech), where she did postdoc work. “He changed my life, particularly in my approach to research and to managing my teams.” She describes him as one of the best researchers she knows, who nevertheless always remains accessible: “He showed me how to be an excellent researcher without ever losing the human touch.”

But when Fontcuberta i Morral now thinks of CalTech and other top US universities, she is concerned: “Science is ultra-international. We make progress because we discuss ideas and findings across borders.” She points out that as early as the era of Newton and Leibniz, scientists were corresponding and visiting each other in search of inspiration, and worries that the radical cuts imposed on research funding in the USA are damaging to science, not only in that country: “The whole world will suffer.” Her expectation is that the EPFL will take on more specialists from the USA in the future: “It’s good for us, but bad for research as a whole.”

At the end of our interview, we turn to the subject of Artificial Intelligence. “The AI revolution we are currently experiencing will slow its pace. When that happens, changes, including to our own research work, will become more clearly visible.” For example, she points out that ten years ago nobody would have imagined that an AI could predict the properties of new materials, as is customary today. “One day, AI will be viewed as a normal tool, just like a computer. The difference is that everything is happening so quickly. Because of that, we have to train our scientists and engineers differently in terms of methodology and ethics. Our aim is to send responsible leaders out into the world.”

EuroTeQ

EuroTeQ Engineering University is an alliance of EPFL, TUM, and further European universities to provide joint training for engineers. It evolved from the EuroTech Universities Alliance.

More information: www.euroteq.eu

The exhibition "Light and Matter" at the Deutsches Museum is part of the Cluster of Excellence MCQST.

Particles that simultaneously change their state despite vast distances between them? Electrons with the properties of both waves and particles? Quantum phenomena are often dramatically different from anything we can experience and imagine. Despite this, the exhibition “Light and Matter” by the Cluster of Excellence MCQST aims to make them understandable for young people.

Between waves and particles

TEXT—*Andreas Schmidt*
PHOTOS—*Andreas Heddergott*

The entrance hall of the Deutsches Museum is a hive of activity this morning, packed with school classes waiting to be admitted. Among them is a group of students about to visit the “Light and Matter” exhibition as part of a Science Communication training course.

“In my view, outreach work is a key element of research,” says one. She is Paula Garcia-Mochales, studying at TUM for a Master’s in Quantum Science and Technology. “And where complex quantum phenomena are concerned, it’s particularly important to make these topics accessible to the public.”

Hands-on excellence research

The special exhibition “Light and Matter” was designed in cooperation with the Munich Center for Quantum Science and Technology (MCQST), a Cluster of Excellence comprising Ludwig-Maximilians-Universität München, TUM, and further research institutions as well as the Deutsches Museum. The exhibition presents the history and fundamental principles of quantum physics in the twentieth century, enhanced with various stories of the personalities involved—such as Dr. Alice Golsen. She was the first

Paula García-Mochales (r.) and students from the Science Communication training course explore the exhibition.

person to succeed in precisely measuring the radiation pressure of light as a physical quantity in 1923. Despite her achievements, she was denied due recognition for her research during her lifetime. During the National Socialist regime in Germany, Golsen was forced to flee Germany and eventually took her own life in exile. A scenorama of appealingly crafted set-pieces tells this moving story, including an interactive push-button element that shows the setup of her groundbreaking experiment.

Alongside these scenic exhibits, the interactive stations are the most popular with visitors. Here, children and adults alike can explore phenomena such as how the "Paul trap" works, using a simple ping-pong ball that stays in place on a rotating bed. This ion trap enables highly precise analyses of the properties of charged particles to be performed, and

Quantum Year 2025

UNESCO has designated 2025 as the "International Year of Quantum Science and Technology." Germany is marking the year with a nationwide program of events, talks, and interactive projects, all aimed at making the complex topic more accessible. As part of this, teaching materials are being supplied to schools, online platforms offer interactive quantum worlds, and universities and institutes are holding laboratory open days.

is crucial in spectroscopy and the development of quantum computers. Its inventor, Wolfgang Paul, received the 1989 Nobel Prize in Physics.

The researchers at the cluster and the team at the Deutsches Museum spent almost five years creating the exhibits. "We can only create the individual objects and devise the overall concept for an exhibition of this kind because we have our workshops right here on site. As a result, we can assess very quickly whether a particular idea will repay further work, or whether it is impossible to present in a way that fits the exhibition," says Katharina Stuhrberg, today's guide for the group of training course students. She is currently demonstrating an experiment on display called "Atomic Harmonies," in which the line spectrum of the hydrogen atom is converted into sound. "The line or radiation spectrum of an atom can be explained using quantum physics, and can even be calculated for a hydrogen atom," she says. "The frequencies of the light waves are in an integer ratio, creating harmonious sounds here in our experiment."

Quantum technologies — part of our daily lives

In Paula Garcia-Mochales' view, the exhibition definitely achieves its aim of bringing quantum physics closer to real life: "So many people think that quantum physics is only a matter for scientific researchers," she says. "The exhibition demonstrates how it has already become part of our everyday lives, used in applications from laser technology to GPS navigation."

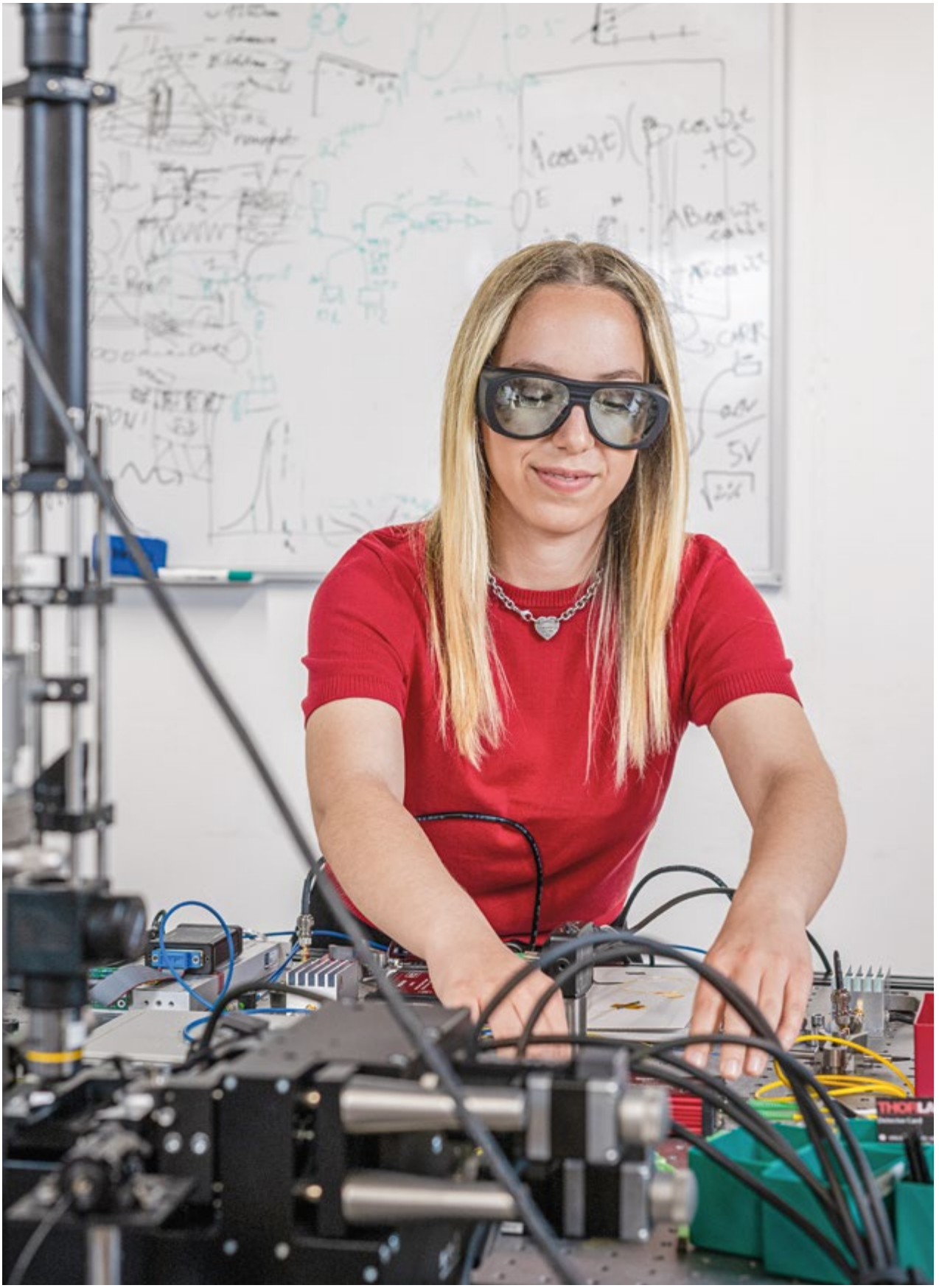
Outside the museum, Paula continues to engage in communicating the topic and is an active member of the student club PushQuantum (see following page). The club enables students in a variety of specialisms to gain practical insights into quantum technologies, and provides opportunities for debate and dialog with experts from industry and research. "It's a great way to bring science to life and make it accessible," affirms Paula Garcia-Mochales. After the tour, she and the others in the group discuss the exhibition and come up with suggestions for improvement.

Their feedback is welcomed by museum staff member Katharina Stuhrberg: "This special exhibition will become part of our permanent physics exhibition in 2028," she points out. "In fact, our exhibition is constantly changing and developing as we take feedback on board from experts and, of course, from visitors, and we are in constant contact with the researchers at the MCQST Cluster."

The final part of the exhibition showcases this dialog particularly clearly, providing an outlook of future avenues in quantum research, and thus of sub-projects of MCQST—from cryptography to quantum sensors. Three researchers from the Cluster of Excellence give interactive insights into their work and their laboratories on a life-size touchscreen. And visitors can design postcards where they write their questions for the researchers in the Cluster of Excellence, who post the answers on the cluster's website. By now at the latest, it's clear that the world of quantum science is teeming with answers—but also with questions that lead straight to the heart of all our lives.

Cluster of Excellence MCQST

The Cluster of Excellence Munich Center for Quantum Science and Technology (MCQST) comprises seven research units in fields including physics, computer science, and material science, covering all aspects of quantum science and technologies. Its primary aim is to establish a world-leading center for quantum science and technologies, with a multidisciplinary profile that will address important scientific and technological issues.



Ginevra Fulco is working on her Master's at the Professorship of Quantum Networks.

It may be hard to explain, but for the students at PushQuantum, it's very easy to be fascinated by the world of quantum mechanics. Their mission is to make quantum technology understandable and accessible for all.

Quantum technology for all

TEXT—— *Undine Ziller*
PHOTOS—— *Andreas Heddergott*

It all started with an article on quantum physics. "As a schoolgirl, I came across a report on quantum computing," recalls Ginevra Fulco. "Quantum mechanics was all so new to me, a tiny universe crammed with possibilities. It was love at first sight, and inspired me to study physics at university." She is now studying for a Master's in Applied and Engineering Physics at TUM and is an active member of the student initiative PushQuantum.

This student club has the aim of connecting like-minded students and supporting them in their career planning, as well as bringing knowledge of quantum technologies to a wider public. At first sight, many phenomena in quantum physics seem to be impenetrably complex: For example, a pair of quantum-entangled particles can change their state simultaneously even when separated by vast distances.

A quantum object can adopt states that are mutually exclusive under the laws of standard physics, such as an electron that spins clockwise and counterclockwise simultaneously.

As bizarre as these properties may seem, they form the physical bedrock of many modern technologies. While earlier inventions such as lasers, transistors, and solar cells are based on fundamental quantum effects, newer applications make targeted use of them, for example, in quantum computers or for the development of a tap-proof quantum internet. Ginevra Fulco is convinced that these new technologies will have an ever-increasing influence on our daily lives. For her Master's degree at the Professorship of Quantum Networks, she is developing a system that isolates sensitive quantum particles from external influences such as vibrations. This could allow many quantum experiments to run more stably in the future. "It's so important for all of us to understand the basic principles," she says.

Toward a societal discussion

Alexander Orlov, President of PushQuantum, agrees. With a Bachelor's degree in Physics and Political Science already under his belt, he is now studying for a Master's in Quantum Science and Technology: "We need to discuss as a society ways of dealing with these technologies responsibly—before they come into use. For that to happen, readily understandable information is essential, and that is exactly what we aim to provide." As part of their endeavors, the team organizes regular "Quantum Tuesday" talks at the Deutsches Museum. In addition, the students work on the research project "Quanten-(t)räume" (Quantum Spaces, Quantum Dreams), developing outreach formats that address the possible applications of quantum technologies, including an interactive exhibition at the Deutsches Museum (see page 58).

An online "Wiqi" page in German and English on the basics of quantum technology is also on the students' to-do list. "We aim to engage the readers through the use of different knowledge levels, regardless of their prior knowledge in the field of physics," says Leart Zuka. Currently studying for a Master's in Condensed Matter Physics at TUM, he is PushQuantum's IT officer. "So even my grandma can finally understand why I spend so much time in the lab," he adds with a grin.

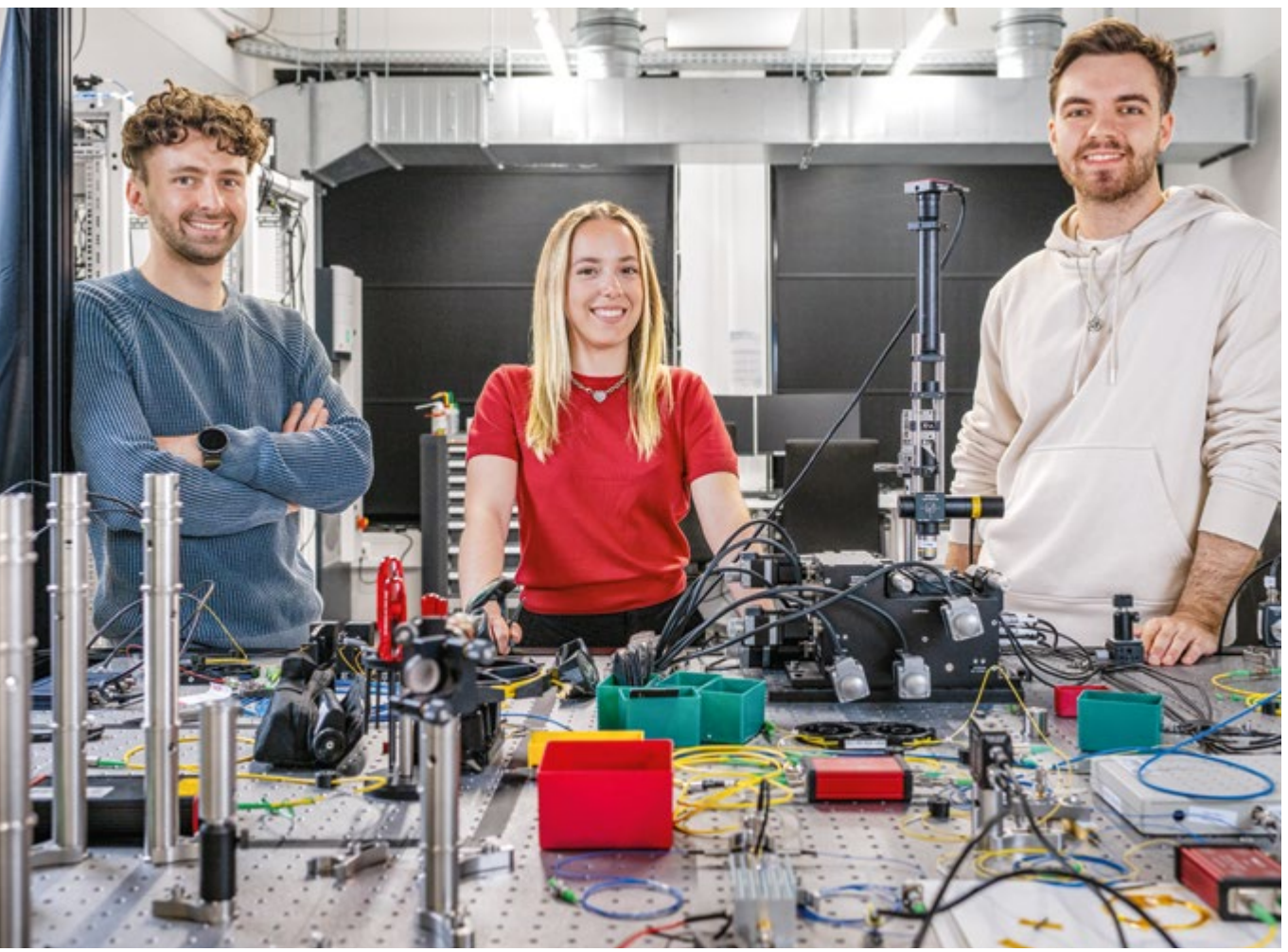
PushQuantum currently has around 100 members, comprising both students and alumni. To enable them to gain professional benefits from their involvement, the club holds regular panel discussions and visits to research groups and companies. "We see our role as a bridge between science and society, but also as a stepping-stone for the upcoming generation of quantum talents," says Alexander Orlov.

As one example, the students are partnering with TUM Venture Lab Quantum / Semicon to run the Quantum Entrepreneurship Laboratory. In this course, students with technical and economics backgrounds form teams to tackle problems related to quantum research. Together, the participants can experience the phases of a simulated start-up—from the research idea to the business plan. In addition, PushQuantum is repeating its three-day hackathon in the fall, with visits to research groups, panel discussions, and quantum technology-based challenges to solve. Preparations are already in full swing.

"There's a great atmosphere of camaraderie at our meetings and events," says Ginevra Fulco, who is responsible for marketing and social media at the student club. "We're all crazy about quantum technologies, and can talk about them for hours!" She hopes to see more women students taking part in the next hackathon. "Some people are still baffled by the fact that I'm a woman studying physics." Convinced that more women are urgently needed in the field of natural sciences, she hopes her involvement will help convince girls and women to be inspired by quantum engineering. "It's important to me to pass on something of my personal passion."

»We need to discuss as a society ways of dealing with these technologies responsibly—before they come into use.«

——*Alexander Orlov*



Alexander Orlov, Ginevra Fulco and Leart Zuka (from left) of PushQuantum can talk for hours about quantum physics.

A first-class address: TUM Convergence Center at Munich Airport

The new TUM Convergence Center brings together students, talented scientists, start-up teams, companies, and citizens to collaborate on pioneering projects. The research focus includes aviation, mobility, robotics, and security. The TUM Sustainable and Future Aviation Center is being established in partnership with the Lufthansa Group and Munich Airport. The location also offers space for courses and student clubs. The Robotics Institute Germany, the TUM Institute for LifeLong Learning, and the TUM THINK TANK will also be represented.

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