SUMMER 2026 21

Dimensions

THE MAGAZINE FOR EDUCATION, RESEARCH AND INNOVATION OF EPFL

Water all around

AI. What your voice gives away. **Climate.** When trees can no longer cool themselves. **Interview.** Samuel Schär, CEO of the Bühler Group. **Extreme environments.** At the heart of scientific expeditions.

EPFL

Water, is taught by thirst.

Emily Dickinson

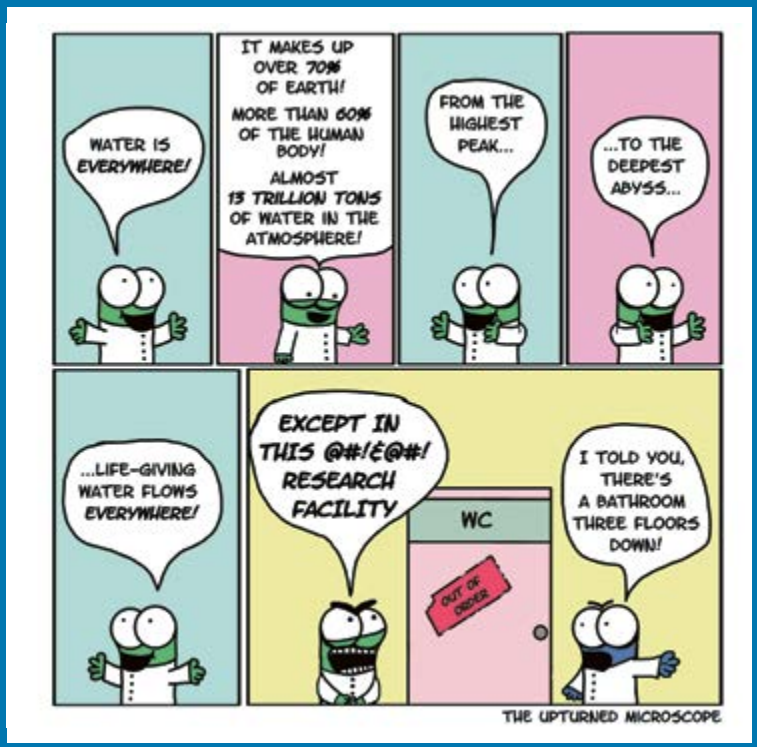
A recluse from Amherst (1830–1886), Emily Dickinson led a spectacularly invisible life in her family home. In secret, she built a monumental body of work comprising nearly 1,800 poems, only about a dozen of which were published during her lifetime. Her writing, of rare intensity, explores the mysteries of nature, death and eternity with absolute freedom.

Dimensions 21

SUMMER 2026

FOCUS

Cartoon | Nik Papageorgiou



NEWS

NETWORK

CAMPUS

Let the (next) adventure begin

The *Dimensions* editorial team

It's with a combination of pride and gratitude, some sadness and a lot of ambition that we, the members of the *Dimensions* editorial team, close out the 21st and final issue of this printed magazine. For a little over five years, we've looked forward to the smell of fresh ink when the magazines were delivered to our office, to seeing people crowd around the distribution boxes on campus, and to having to refill the boxes in the walkway under the metro tracks several times a day.

Yet while the printed version will cease to exist – a victim of the cost-cutting measures that EPFL is forced to implement – the editorial concept is getting a new lease on life. We'll continue to publish special reports on topics of interest to the EPFL community in an interactive format designed to give you an enlightening and enjoyable reading experience on all our digital platforms. You'll find these special reports on the EPFL home page starting this fall. We'll keep pouring our energy, curiosity and journalistic experience into them. And we'll seek out the leading experts and most talented researchers – at EPFL or elsewhere – to gain insight into societal issues through the prism of the latest scientific discoveries.

So the format will change, but not our approach. That's because we know – as reflected in our 21st special report once again – that our region is brimming with exceptional individuals as well as cutting-edge knowledge, in an array of fields that we want to bring to our readers' attention. We encourage you to dive into our special report on water – you'll learn things you never suspected about the substance you thought you knew so well, yet that still has a number of secrets to reveal.

We're already looking forward to sharing our special reports with you, in different ways. Until then, we wish you a great summer. ■

MASTHEAD

Publisher
EPFL Mediacom
Gael Hürlimann

ISSN *Dimensions*
ISSN 3042-965X (print)
ISSN 3042-9668 (online)

Editorial contact
EPFL Dimensions
P-Mediacom
CM 2 360
Station 10
CH-1015 Lausanne
dimensions@epfl.ch
dimensions.epfl.ch
021 693 21 09
Suzanne Setz,
layout, editorial and production secretariat
Emmanuel Barraud,
editorial manager
Anne-Muriel Brouet,
head of editing

Proofreading
Marco Di Biase
Bill Gilonis

Translation
Scala Wells Sàrl
Apostroph Group

Illustrations
Denis Kormann
(focus and cover)

Comics
Nik Papageorgiou
Kevin Crelerot
Vivienne Baillie Gerritsen

Graphic design
EPFL Mediacom
communication visuelle
Marc Borboën
Ivan Savicev
Suzanne Setz

Printer
PCL Print Conseil
Logistique SA, Renens
Printed on certified
Rebello ange bleu -
100% recycled paper, matt

Circulation
29,200 (Fr)
13,400 (En)

Advertising
EPFL Alumni
Rolex Learning Center
Station 20
CH-1015 Lausanne
career.alumni@epfl.ch

IMPRIM'VERT®
RECYCLED Paper FSC® C081883
MADE SWISS

The crowd

Over 50 years ago, Edith Piaf sang about a chance encounter in a crowd – a romantic moment that ends abruptly when the crowd subsequently forces the two people apart. At EPFL's events, our focus is more prosaic: we have to deal with the very real logistical problem of managing 15,000 festival-goers without letting things get out of hand.

Meticulous planning goes into the Balélec Festival, which has been held annually on EPFL's Lausanne campus for the past 44 years. The organizing committee has around 50 members, but nearly 500 people are brought into play during the week before the event to build stages, handle logistics and implement security measures – nothing is left to chance. During the event, visitors' movements are analyzed as they enter, leave and walk around in order to keep a lid on attendee numbers. Security agents, entrance checks, crowd management. Emergency exits are kept clear, signs are equipped with their own power supply in case of an outage, and first-aid stations and secured areas are set up.

All this because a fun atmosphere can turn volatile as the evening wears on. We've seen it happen in sports: tensions can rise quickly in large groups of people. And a stirred-up crowd can become unpredictable or even dangerous unless well-designed controls are in place. A number of EPFL research groups are working on systems related to crowd management, such as by modeling how people interact with vehicles or predicting their movements. ■

SANDY EVANGELISTA

On the EPFL campus during the Balélec Festival on 1 May 2026.

A matter of social dynamics

While many researchers analyze crowds using physics and mathematical models, Vincent Kaufmann and his team at EPFL's Laboratory of Urban Sociology are studying them from the perspective of social dynamics and the use of public spaces. They're running a project called Social Life of Campus Public Spaces, which entails using tracking technology to measure the intensity of social interactions and examine how fixtures such as urban furniture can affect these interactions. The team is also studying congested trains in Switzerland to gain insight into how the crowded conditions influence people's behavior and transport choices. ■

Managing the flow of people

Alexandre Alahi, head of EPFL's Visual Intelligence for Transportation Laboratory, is conducting research at the crossroads of computer vision, artificial intelligence and robotics, with a particular focus on mobility in urban environments. He's developing algorithms that can predict the movements of pedestrians and vehicles in congested areas and using computer vision to analyze the flow of people in train stations, airports and large events. ■

Festivalgoers' safety and experience

Technis, spun off from EPFL in 2015, produces smart, connected flooring that can measure footfall in a given area to improve security and quantify the success of an event. The company has also developed AI programs created specifically for understanding crowd dynamics. Technis's technology was used at the Paléo festival for the first time in 2025, helping the event run more smoothly and ensuring the 50,000 daily visitors could enjoy the experience. ■

Robots designed for crowds

The researchers at EPFL's Learning Algorithms and Systems Laboratory, headed by Aude Billard, are taking part in Crowdbot, an EU Horizon project to develop robots that can move around in a crowd. The team has built a machine that's part robot, part wheelchair, and tested it at the farmers' market in Lausanne. The project team is also examining issues related to safety and the acceptance of robots that come into close contact with individuals. ■

TICINO TRANSLATES WITH APERTUS

Multiple languages, sensitive documents and strict privacy rules: for the employees of the canton of Ticino, automated translation is not trivial. The administration is now introducing an in-house translation system based on Switzerland's Apertus large language model — keeping both sensitive data and the underlying technology under its own control.

As one of only two Swiss cantons with Italian as an official language, Ticino handles a large volume of documents that require translation. Often, the information in these documents is sensitive and must remain confidential. For this reason, the cantonal administration is in the process of introducing a closed, secure in-house solution.

Apertus, launched in September 2025, is Switzerland's transparent, fully open-source large language model. It was developed within the Swiss AI Initiative by ETH Zurich, EPFL, and the Swiss National Supercomputing Centre CSCS. ■ SR

EPFL researchers successfully mimic dyslexia in an AI brain

For the first time, researchers have used an advanced AI model that understands both images and language, allowing them to model dyslexia.

Dyslexia, the world's most common learning disorder that impacts reading, spelling and writing, is estimated to affect up to 20% of the global population. Until now, traditional approaches to studying dyslexia, such as behavioral and neuroimaging methods, have provided valuable insights but remain limited in their ability to test the underlying mechanisms of reading impairments.

Now, researchers from EPFL's NeuroAI Lab have modeled dyslexia using next-generation Vision Language Models that can fully model the whole pipeline from seeing words to processing and understanding the context.

In a paper presented at one of the fastest-growing artificial intelligence conferences in the world, the 2026 International Conference on Learning Representations, the researchers outlined how, using stimuli from cognitive neuroscience, they found that parts of the AI digital-twin brain act in the same way a human brain processes written words. They then changed how those parts worked.

Similarities in behavior

"When we had identified the visual word form areas of the AI brain, areas that respond strongly to written words, we "turned these parts off" to see if the model had neurons that form a whole network and that would do the same thing as a human brain. We found that the AI had trouble reading, but it could still understand images and language in general … just as with people affected by dyslexia," explained Melika Honarmand, a doctoral assistant in the NeuroAI Lab and lead author of the paper. "It did work and showed us similarities in behavior."

This research comes on the back of almost a decade of work using vision and language models independently and has only been possible with the very latest generation of combined Vision Language Models.

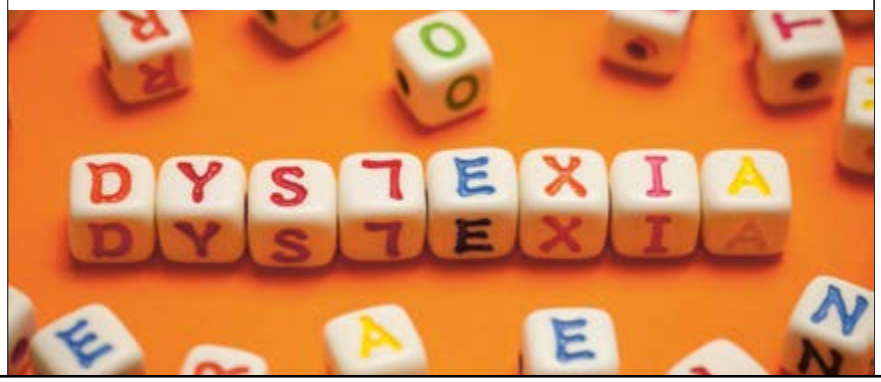
After completing this part of the study, the researchers turned to assessing different fonts, some commonly used and others developed specifically for those impacted by dyslexia.

A general framework

"We checked how accurately the model could read texts using different fonts without anything else changing and we found that it did significantly better with the fonts specifically made for dyslexic people and worse on those known to be problematic for them. We are now using the model to create the best font possible for the model itself and, by extension, for people with dyslexia," said Honarmand.

"Although they are not made with exactly the same architecture, these models do try to replicate the brain, so of course we expect to see some similarities. But it was surprising that a hypothesis about how a specific human brain region affects behavior when impaired turned out to apply to the model in exactly the same way," she continued.

Beyond the study results, perhaps one of the most exciting outcomes of the research is the establishment of a computational framework for investigating brain disorders. ■ TANYA PETERSEN



PHOTOS: CSCS | ISTOCK

When oxygen determines if a limb can regrow

Researchers at EPFL have discovered how oxygen-sensing explains why amphibians regenerate limbs and mammals do not.

Some animals can regrow lost body parts. Salamanders and frog tadpoles can rebuild entire limbs after amputation. Mammals cannot. For decades, biologists have tried to understand why.

One key difference lies in the environment. Amphibian larvae develop in water, where oxygen levels are lower than in air. Moreover, many regeneration-competent species live in aquatic environments. Meanwhile, mammalian tissues are typically exposed to higher oxygen levels after injury.

What was unclear was whether this difference played a direct role in regeneration or was merely a consequence of lifestyle. A team led by Can Aztekin at EPFL (now at the Friedrich Miescher Laboratory of the Max Planck Society) discovered that oxygen plays a crucial role in limb regeneration. By comparing amputated limbs from frog tadpoles and embryonic mice, the researchers found that the way cells sense oxygen determines if regeneration can even begin.

A latent regenerative capacity

"For a long time, regeneration research focused on amphibians, while mammalian regeneration was rarely examined experimentally side by side in a comparable manner," says Aztekin. "Although many studies showed that regenerative creatures, such as amphibians, and non-regenerative classes of animals, such as mammals, share similar genes, suggesting that mammals may retain a latent regenerative capacity, it remained unclear whether mammalian tissues can indeed activate limb regenerative programs, and what prevents them from doing so."

Regeneration-competent amphibians show reduced oxygen-sensing capacity, allowing regenerative programs to be initiated and sustained. Mammals show the opposite pattern. Their cells respond strongly to oxygen and switch regenerative programs off soon after injury.

A centuries-old question

The results suggest that mammalian limbs retain latent regenerative potential at early stages, depending on how cells respond to environmental signals such as oxygen. This means that adjusting oxygen-sensing pathways might one day improve wound healing or regenerative responses in humans.

Importantly, the findings demonstrate the activation of regenerative mechanisms in mammals, not the complete regrowth of a fully formed limb. But although the study does not claim that human limb regrowth is imminent, it does show that differences once thought to be fixed between species may instead hinge on how cells respond to their environment.

"We are very excited about our findings," says Aztekin. "By directly comparing classes of creatures that can and cannot regenerate, we bring a fresh perspective to a centuries-old question. Our results show that regenerative programs can be triggered in mammalian tissues, thereby outlining a clear, testable path toward promoting limb regeneration in adult mammals." ■

MEDIACOM

This experiment, conducted at EPFL under conditions governed by Swiss animal welfare legislation, was approved by the relevant veterinary authorities.

«I help develop the food of tomorrow and ensure product safety.»

Fabiano
Research Associate, Market Access

Work where you can put your scientific knowledge into practice.
Apply now.
vacancies.admin.ch

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Swiss Federal Administration
Helping to shape Switzerland

Trees can no longer cool themselves when they lack water

Trees can tolerate heat as long as sufficient water is available. However, under water stress, they lose their ability to cool themselves.

A team of biologists from EPFL and the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf subjected young European beech and downy oak trees to hot, dry conditions. "The downy oak grows mainly in Mediterranean areas but is also found in Switzerland. We wanted to compare its water-use strategy with that of the beech, a tree more sensitive to droughts, especially in the sapling stage," says Alyssa Therese Kullberg, a scientist at EPFL's Plant Ecology Research Laboratory who has long studied this process.

The study aimed to examine how trees adapt to dry weather and extreme heat, and what factors are at play when tree leaves become dehydrated, lose their ability to cool off or even become scorched. "We looked specifically at the trees' thermoregulatory response," says Kullberg. "Leaves in the canopy are directly exposed to sunlight and can become up to 10°C hotter than the ambient air, reaching temperatures of 40°–45°C, which is higher than what we typically observe in Central Europe. Despite this level of heat, the thermoregulatory response usually works normally. We might sometimes see a little leaf scorch with minor damage to the photosynthesis system, but that damage is usually temporary."

Heatstroke and scorching

The real difference appeared in the longer-term effects on the leaves. "We didn't see much scorching on oak leaves, even though their thermal safety margins were exceeded roughly as often as those of beech," says Alyssa Therese Kullberg. "In other words, both species reached critical temperatures with similar frequency, but the oak seemed better able to tolerate those conditions. This unexpected difference isn't fully explained by the mechanisms we measured in our study."

The researcher found certain trade-offs taking place within trees. When subjected to high temperatures alone, the trees get close to the hydraulic safety margin – beyond which there's no longer enough water present to prevent wilting. Individual trees allow just enough water to evaporate to keep their leaves cool while staying inside the safety margin. But when subjected to high temperatures combined with dry soil, the amount of water required for the cooling mechanism to work is far higher. The leaves become both dehydrated and too hot.

"Our experiments proved that if leaves go beyond the thermal safety margin – meaning they go into a thermal danger zone – and are subject to drought conditions at the same time, the leaves begin to experience permanent damage in the form of scorching," says Kullberg. "This is an important finding because that link had never been so clearly established with experimental data." ■

SANDY EVANGELISTA

PHOTO: ALYSSA THERESE KULLBERG / EPFL / WSL

CONSTRUCTION TECH COULD REDUCE EMISSIONS

Production of construction materials contributes up to 17% of human-made carbon dioxide emissions each year, and most materials used in construction today are cement-based. It is often assumed that generating housing and infrastructure to support fast-growing populations – especially in low- and middle-income countries – will drive carbon emissions upward.

An international team of researchers, including from EPFL, has conducted a study that reframes this concern by examining alternative development pathways. The EPFL team combined historical global growth and construction trends with detailed forecasts of housing and infrastructure needs, particularly in low- and middle-income countries. They found that cement and steel use typically rises as countries develop, and then levels off as infrastructure becomes established.

Widespread adoption of existing sustainable construction technologies could reduce carbon emissions from cement-based materials and steel by about 73% compared to business-as-usual scenario. These technologies include more efficient structural design and concrete production practices that reduce waste, as well as greater reliance on steel and concrete recycling powered by renewable electricity. Another priority is replacing clinker, the high-emission component of cement, with low-carbon cementitious materials. ■ CL

SME software propels an EPFL spin-off to a European group

Aubep — now called bangr. — is a Swiss enterprise software developer that has grown over the past 20 years thanks in part to its close ties with the EPFL ecosystem. That relationship continues to pay off as the company moves forward. By Raphaël Pomey

In April, Aubep changed its name to bangr. – a stylized version of a word that's popular among young people. The move marks a break with the firm's intentionally low-key, engineering-oriented culture. Based at the Y-PARC technology park in Yverdon-les-Bains, bangr. develops enterprise resource planning (ERP) software. With its new identity, the firm intends to build on its reputation for excellence and position itself as the provider of "an ERP system that truly understands our customers' business processes and is at the forefront of innovation."

Since spinning off from an EPFL lab, bangr. has gradually gained market share in Switzerland thanks in part to features tailored to small businesses. Its strong bonds with customers also play a role: the firm provides close support in the areas of accounting, HR management, project management and production. All of bangr.'s employees are based in Switzerland.

Despite its new look and feel, bangr.'s roots run deep. The company has been working closely with the EPFL ecosystem for two decades, establishing a genuine win-win relationship. "When we were first creating our business, we participated in local startup support programs such as Venturelab and Venture Kick," says Jean Bourgeois, the chairman and founder of bangr. "Of course, we didn't win all the competitions, but being in that environment taught us a lot about starting a company: how to write a business plan, speak with banks and manage our affairs in general. We also learned what the common pitfalls for founders are and how to avoid them."

Helpful support for startups

The firm is grateful for these kinds of programs, as well as the additional support it's received from EPFL throughout its journey. Bourgeois notes that EPFL has consistently been very accommodating, such as in allowing bangr. to market technology initially developed under the guidance of EPFL Professor Emeritus Claude Petitpierre, an expert in programming languages. Did he see this entrepreneurship potential in bangr.'s founders when they were his students? "Actually, they were the ones who saw the potential in what our research group was doing," says Petitpierre. "I was happy to see someone take our technology to market. I've often had big ideas, but they aren't always easy to turn into a business case."

bangr. has maintained close ties with EPFL in a number of ways. For instance, it has taken part in initiatives associated with the EPFL ecosystem, such as Trust Valley. Through these initiatives, bangr. has been able to shore up its digital capabilities, especially in the area of cybersecurity. Bourgeois also enjoys serving as a mentor to students developing their own projects. "We're always flattered when they ask for our help, and it gives us an opportunity to pay it forward," he says. "Some of the good advice we received when we were starting out is still very relevant to students today, even though the technology itself has evolved very quickly."

HR a prime example

And then there are the many benefits to bangr. in terms of its workforce. The firm was founded by three EPFL alumni and continues to work with EPFL students on their degree projects. "Every year we work on projects in conjunction with student interns coached by EPFL professors," says Jonathan Payot, the technical director at bangr. "EPFL has a great in-company internship program that deserves to get more attention. We've seen that we can go really far with these students. That's why we've been hiring interns and supporting students' projects continuously for the past 20 years."

Today, bangr. has a CEO from a completely different background, Mirela Filipovic, who will help Bourgeois with the firm's European expansion. In addition to its bold makeover, bangr. recently formed a partnership with In Extenso, a key provider of accounting services for microenterprises and SMEs in Europe. Based in Lyon, In Extenso has over 7,300 employees and more than 280 offices in France, Switzerland, Belgium and Luxembourg. "Even though I come from a different industry, I can say without a doubt that none of this would have been possible if bangr. hadn't maintained its relationship with EPFL from the beginning," says Filipovic.

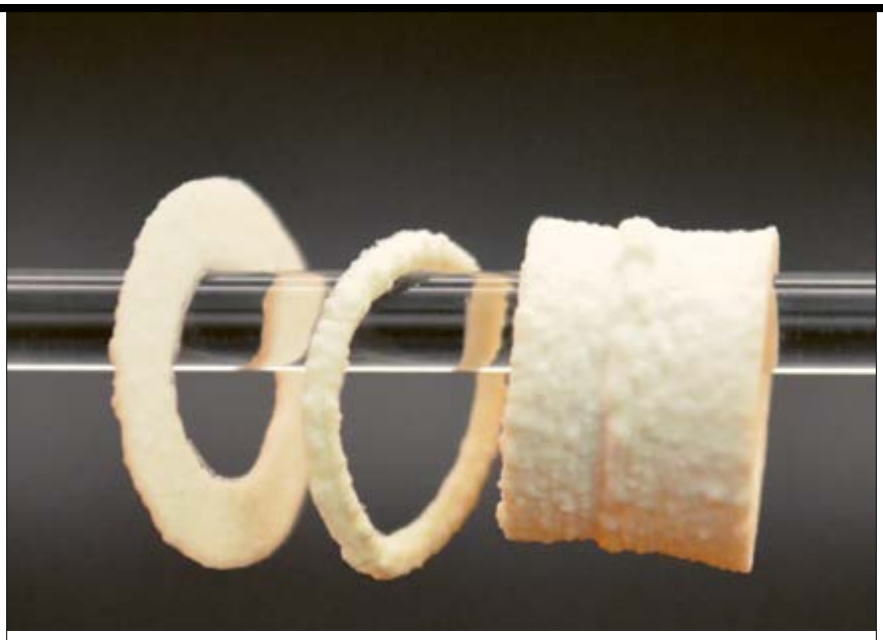


PHOTO: EPFL/SMAL

A 3D printable scaffold to support fast bone growth

A bone-like composite uses naturally occurring enzymes to accelerate mineralization through an energy-efficient, room-temperature process.

Inspired by the resilient and self-repairing mechanical properties of bone, scientists have been developing synthetic materials using one of bone's main components: a mineral called hydroxyapatite (HA). However, the high-temperature processes typically required to produce HA-based materials use significant energy and restrict the use of biologically active components, like enzymes, to promote bone growth.

Researchers in the Soft Materials Laboratory (SMaL) at EPFL, in collaboration with ETH Zurich, Empa and the University of Fribourg, have now developed a way to 3D-print HA-based scaffolds using a room-temperature process that harnesses enzymes for fast mineralization. The resulting bone-like porous scaffolds can become load-bearing within just seven days. The research has been published in *Advanced Functional Materials*.

"Our idea was to generate a 3D printable and injectable 'ink' that can be mineralized into scaffolds with mechanical properties similar to those of highly porous trabecular bone, which is found in human vertebrae and the ends of long bones such as the femur," says laboratory head Esther Amstad. "We hope that our technology's combination of mechanical performance, bioactivity and energy-efficient processing will open new avenues for bone tissue engineering."

Stronger scaffolds

In one experiment, 14 days after seeding scaffolds with human stem cells and placing them in a bone growth-supporting medium, the researchers detected the presence of collagen and the bone matrix protein osteocalcin – both indicators of cell growth. These results support the approach's potential for tissue engineering.

Amstad adds that the SMaL team's enzyme-aided approach yields HA scaffolds that are stronger than those produced via high-temperature methods, demonstrating compressive strength comparable to that of human trabecular bone. Their technique can be used to print highly complex scaffolds and can also be used with commercially available bioprinters.

"Looking ahead, our work might lay the foundation for injectable scaffolds that aid bone regeneration and potentially enable patients to load their broken bones much earlier than can be achieved with currently available technologies," she says. ■ CELIA LUTERBACHER

Awards

Engineering

Anastasia Ailamaki, head of the Data-Intensive Applications and Systems Laboratory, and **Giovanni De Micheli,** scientific director of EPFL's Ecocloud Center, have been named a member and an international member, respectively, of the American National Academy of Engineering Class of 2026. ■

Electrical engineering

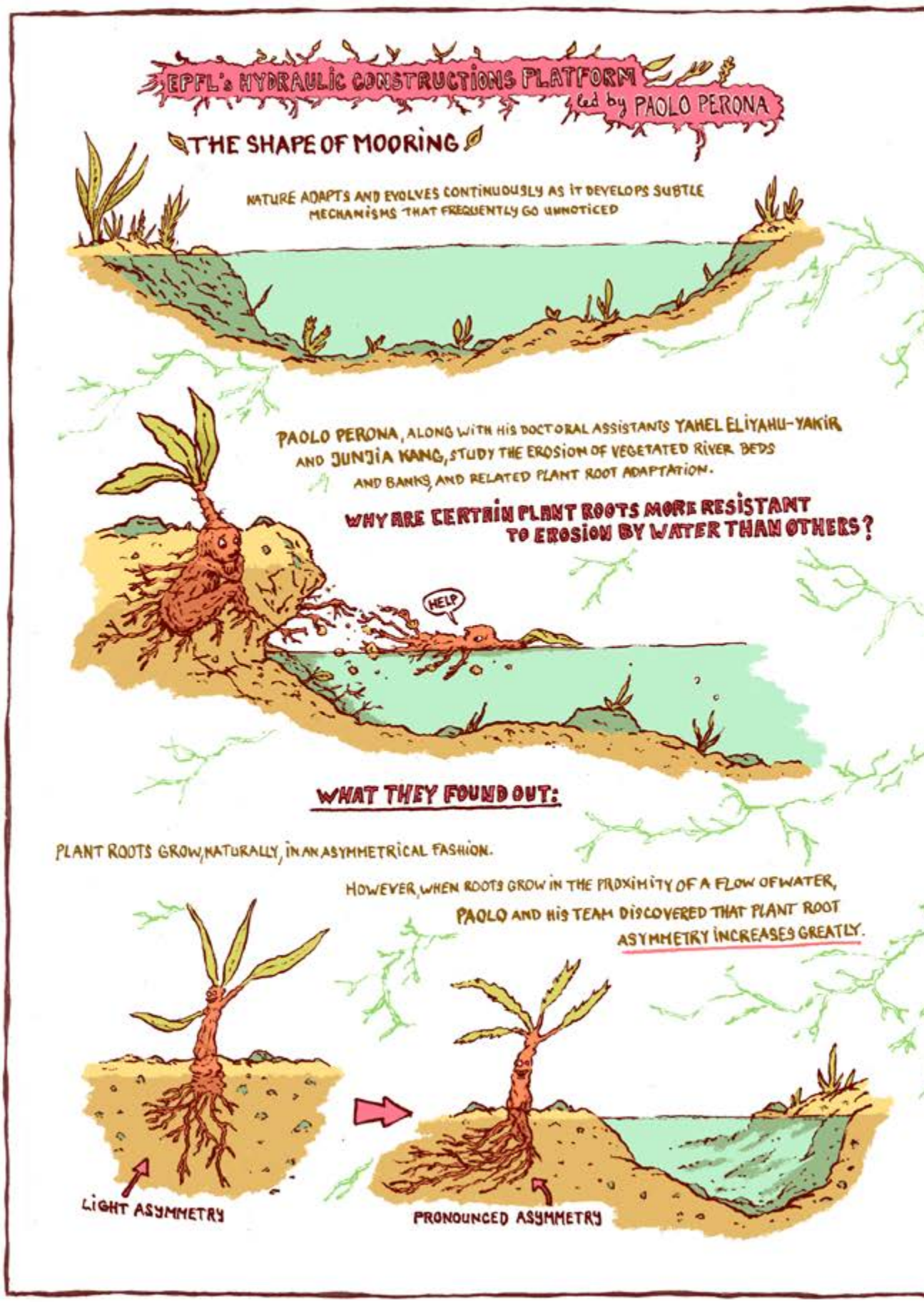
David Atienza, professor at the Embedded Systems Laboratory, has been elected to the Pan-European Academy of Humanities, Letters and Sciences. ■

Mathematics and biology

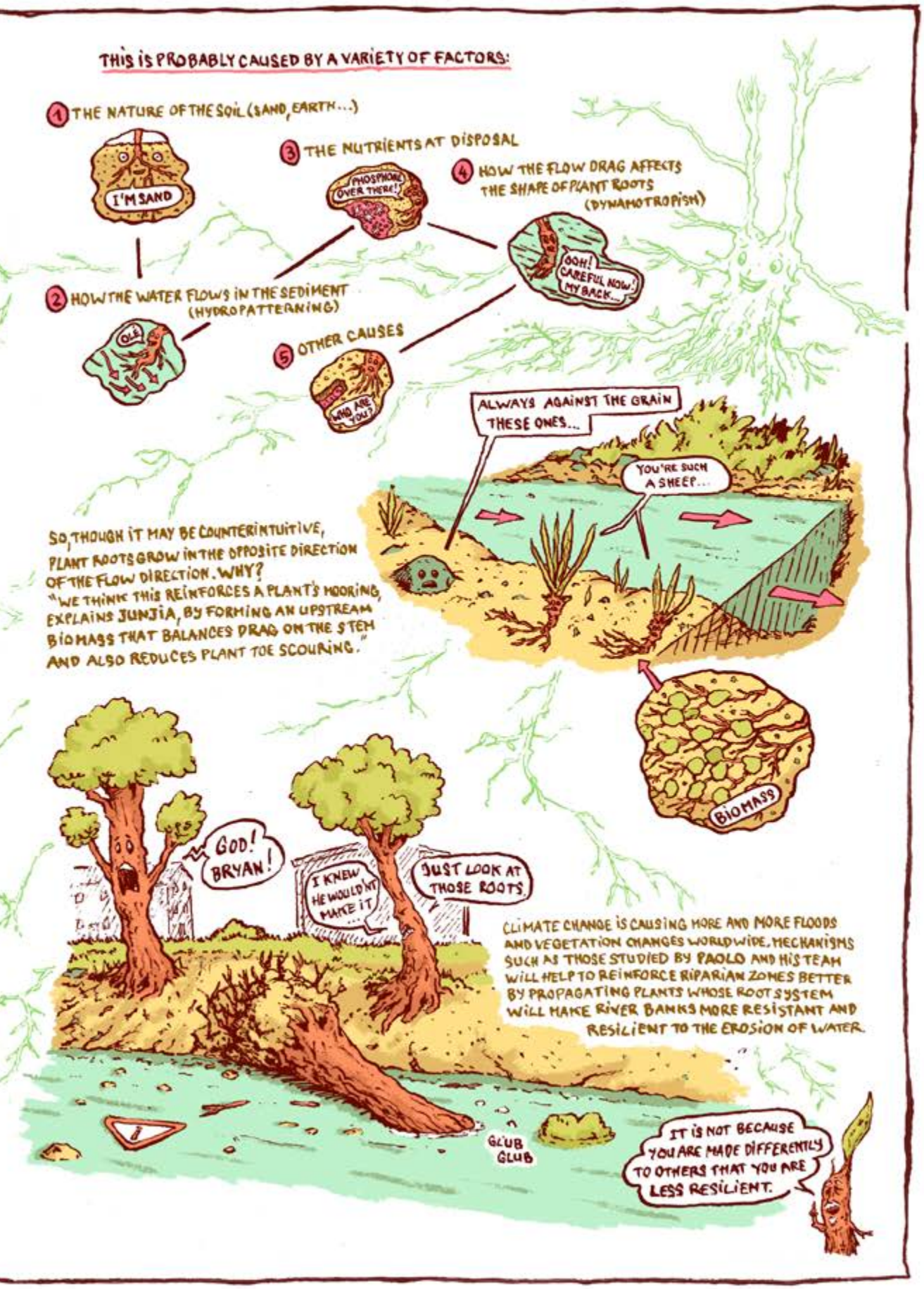
Gisou van der Goot, professor at the Laboratory of Cell and Membrane Biology, and **Martin Hairer,** head of the Chair of Probability and Partial Differential Equations, have been elected to the American Academy of Arts and Sciences. ■

Economics

Honorary Professor **Dominique Foray** has been awarded the 2026 Grand Prix Turgot, which honors the best book on economics of the year, for his book *Innovations: une économie pour les temps à venir*. ■



KEVIN CRELEROT, VIVIENNE BAILLIE GERRITSEN


THIS IS PROBABLY CAUSED BY A VARIETY OF FACTORS:
1 THE NATURE OF THE SOIL (SAND, EARTH...)
I'M SAND
2 HOW THE WATER FLOWS IN THE SEDIMENT (HYDROPATTERNING)
3 THE NUTRIENTS AT DISPOSAL
PHOSPHORE OVER THERE!
4 HOW THE FLOW DRAG AFFECTS THE SHAPE OF PLANT ROOTS (DYNAMOTROPISM)
OOH! CAREFUL NOW! MY BACK...
5 OTHER CAUSES
WHO ARE YOU?
ALWAYS AGAINST THE GRAIN THESE ONES...
YOU'RE SUCH A SHEEP...
SO, THOUGH IT MAY BE COUNTERINTUITIVE, PLANT ROOTS GROW IN THE OPPOSITE DIRECTION OF THE FLOW DIRECTION. WHY? "WE THINK THIS REINFORCES A PLANT'S MOORING, EXPLAINS JUNJIA, BY FORMING AN UPSTREAM BIOMASS THAT BALANCES DRAG ON THE STEM AND ALSO REDUCES PLANT TOE SCOURING."
BIOMASS
GOD! BRYAN!
I KNEW HE WOULDN'T MAKE IT
JUST LOOK AT THOSE ROOTS
CLIMATE CHANGE IS CAUSING MORE AND MORE FLOODS AND VEGETATION CHANGES WORLDWIDE. MECHANISMS SUCH AS THOSE STUDIED BY PAOLO AND HIS TEAM WILL HELP TO REINFORCE RIPARIAN ZONES BETTER BY PROPAGATING PLANTS WHOSE ROOT SYSTEM WILL MAKE RIVER BANKS MORE RESISTANT AND RESILIENT TO THE EROSION OF WATER.
GLUB GLUB
IT IS NOT BECAUSE YOU ARE MADE DIFFERENTLY TO OTHERS THAT YOU ARE LESS RESILIENT.

In the media

Le Temps, 5.5.2026

“No, I don’t think I’ll put ‘Dr Odermatt’ on my mailbox ...”

Marco Odermatt, honorary doctorate from EPFL

RTS, 14.4.2026

“You can’t want a carbon-free society without batteries.”

Christophe Ballif, Laboratory of Photovoltaic Electronics and Thin Films

Le quotidien jurassien, 13.4.2026

“Artemis 2 already signals the next step: setting foot once again on this famous moon.”

Emmanuelle David, director of the EPFL Space Center

What your voice gives away

With AI, the voice has acquired a new significance. Behind the words lies data that can be used both to diagnose a health problem and to steal someone's identity.

Speaking to machines is no longer the stuff of science fiction. Alexa (Amazon) has been present in our homes for over a decade, and an increasing number of users now favor voice interactions with chatbots. Whether dictating a message or asking for directions, this shift is not only technical – although AI systems are becoming ever more powerful – but also societal, reflecting how humans engage with machines. Behind the words, however, lies data.

Unlike a password, a voice cannot easily be changed. It is shaped by physiological, linguistic and personal characteristics. This “voiceprint” can identify an individual and reveal sensitive information such as origin or gender. Voice is, therefore, an especially rich form of biometric data.

“When a user interacts with a voice-based system, they not only convey content but also implicit information: emotions, physical traits or behavioral patterns,” explains Andrea Cavallaro, professor and head of the Laboratory of Multimodal Intelligent Systems at EPFL. The voice indeed contains numerous, sometimes subtle, features like rhythm, accent, tone, speed, intonation, volume and vocabulary that can all reveal something about its owner.

A resource for health care

Cavallaro’s research shows that such information can be exploited by analytical systems, raising significant privacy concerns. The potential uses of voice data are numerous, particularly in health care. Subtle variations in speech may reveal neurological disorders, respiratory diseases or emotional states. This is the premise behind Virtuosis AI, a startup led by EPFL alumna Lara Gervaise, which explores the use of voice as a diagnostic tool. Voice analysis could offer a noninvasive approach to medical monitoring.

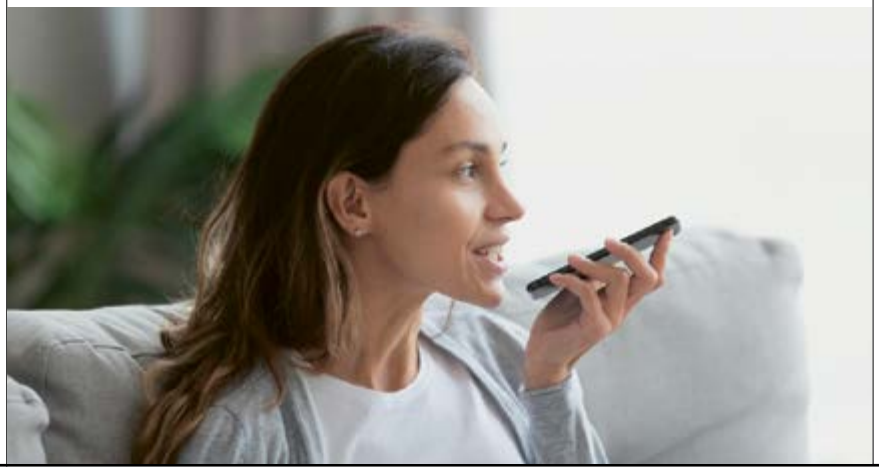
In another context, actors and dubbing professionals have taken legal action against companies accused of using their voices to train AI models without consent. The argument is straightforward: a voice is part of a person’s identity and is therefore protected under personality or image rights.

At the same time, voice cloning tools are now widely accessible, sometimes even free of charge. It is no longer only the voices of professional actors that can be replicated, but potentially anyone’s. “With AI, voice becomes a vector for identity theft at scale,” warns Cavallaro.

Protecting privacy

How, then, can voice data be protected? One promising avenue is voice anonymization. Cavallaro’s work explores ways of transforming speech to preserve intelligibility while masking the speaker’s identity or gender. The approach involves generating “ambiguous” voices, reducing the ability of systems to detect sensitive attributes. ■

MÉLISSA ANCHISI



ANNE-MARIE **KERMARREC**

Head of EPFL's Scalable Computing Systems Laboratory and Associate Vice President for Doctoral and Lifelong Education

"The only way to truly fail is not to try."

I often use this quote to encourage students to aim for the best scientific journals, take on new challenges, train for a marathon, and so on.

IN MY LIFE

1996
I defended my thesis.

1999
My son Malo was born. Today he's a PhD student at EPFL.

2002
My daughter Anaëlle was born. On the day I found out I was pregnant, I presented a demo to Bill Gates.

2015
I founded the startup Mediego.

2019
My book *Numérique, compter avec les femmes* was published by Odile Jacob.

2024
I was elected to the French Academy of Sciences.

IN MY LAB

On my first day at EPFL in January 2020, I dropped my badge down the elevator shaft. So my first interaction with staff at the VPO was about getting it back. That's a great way to meet people!

My research group goes on science retreats to Brittany. For one week, we work on distributed AI systems and go surfing in the afternoon. Learning to stand on a surfboard is an integral part of my PhD students' education.

Research is all about starting over. We came up with the idea of fragmenting a model in a distributed machine learning system as a way of keeping data confidential. This turned out to be a powerful approach. And what's striking is that it stems from work I did 25 years ago on distributed hash tables.

"Simple is beautiful."

This is a common expression in the tech sector and it's particularly well-suited to my field of research: distributed systems.

IN MY AGENDA

My short-term goal is to introduce an excellence program at EPFL to spot high-potential female students early on (at the bachelor's level), so that we can support them and actively encourage them to pursue a career in research.

Looking further out, I'd like to write another book, but not necessarily a scientific one.

PHOTOS: ISTOCK | DR/ANNE-MARIE KERMARREC

Water all around

ILLUSTRATIONS: DENIS KORMANN

Small molecule, huge stakes

It's why Earth is called the Blue Planet. Water is everywhere – it enables life, yet it also triggers conflicts. It's been flowing, dripping and evaporating in a cycle that spans millennia. This edition of *Dimensions* explores some key issues related to water, from the nanoscopic scale to the cosmic scale. **BY EMMANUEL BARRAUD**

Without water, there would be no life. This tiny molecule – H_2O, just three atoms – is essential for all living organisms on Earth and probably elsewhere, too. And even though this substance makes up two-thirds of the human body and is essential for producing all the food we consume, we generally have a poor understanding of it. Experts in a wide range of fields are studying every aspect of water, from its atomic behavior to its natural forms, and from its potential as an energy source to its status as a medium of exchange – not to mention its likely existence in other parts of the universe. Water is a treasure trove of information (some recent discoveries are discussed in this special report) yet still holds numerous secrets.

Water may be everywhere, but it's nevertheless a precious resource – and that's just one of its many paradoxes. And while 98.5% of the water on the planet is out of sight, the part we can see is under considerable stress owing to human activity. Just look at the many types of pollution that it absorbs, carries and then buries underground.

Water is also a reflection of both the visible and future effects of climate change. Melting glaciers are exposing ecosystems that had long been protected, while disappearing polar ice caps threaten to alter major ocean currents. According to the latest climate models, this could shift the distribution of water on our planet, with severe flooding and devastating droughts becoming more common.

We often nag children about not wasting water, but perhaps that's not as important – at least in our part of the world – as telling them to do all they can to respect our planet and preserve the climate as a whole. This could help prevent our most valuable ally from also becoming our worst enemy. ■

“Today, climate change is a convenient truth”

Mark Zeitoun is the director of the Geneva Water Hub, whose mission is to bring peace through water. He discusses the major geopolitical challenges involved.

BY ANNE-MURIEL BROUET AND EMMANUEL BARRAUD

After working as an engineer for the ICRC, Mark Zeitoun chose to prevent war rather than try to repair its damage. He is now the director of the Geneva Water Hub, whose mission is to bring peace through water, whether by improving social cohesion or by using diplomacy and politics to ease tensions related to water. Funded at more than 60% by the Swiss Agency for Development and Cooperation, the Geneva Water Hub is hosted by the University of Geneva and the Graduate Institute and brings together about fifteen people.

We can easily understand water as a source of conflict, but less so as a tool for peace. Does that actually work?

Indeed, it always depends on which side you look at. If we look at West Africa, we see that states cooperate extensively, in a spirit of multilateralism that is no longer very fashionable today. For example, since decolonization, the countries bordering the Senegal River have shared its waters through the Organisation de Mise en Valeur du Fleuve Sénégal (OMVS). The OMVS has weathered conflicts between parties, such as the one between Mauritania and Senegal. Leaders continue to collaborate because the river binds them together, and they know that cutting off or destroying the water supply for another country would be devastating.

In contrast, along the Tigris and Euphrates, we are seeing a proliferation of dams built without coordination, which is causing terrible droughts in southern Iraq, where farmers no longer have enough water for agriculture because of the dams upstream.

Why does it work in one case and not the other?

Everyone is trying to answer this question. There are a variety of factors at play, but politics explains a great deal. In both examples, the rivers have similar topographies, crossing desert regions. In the 1950s, in West Africa, political leaders shared a common vision to work together for the benefit of all citizens living in the basin. This is clearly not the case for the Tigris and Euphrates today. Turkey has water needs for its population, but also for its intensive export-oriented agriculture. Political economy dictates this appropriation of the resource. Efforts are being made to improve the situation, but, for now, the Iraqi population is suffering greatly.

“WE PROMOTE INTERNATIONAL FRESHWATER LAW AND THE UNITED NATIONS CONVENTION ON WATER AND ADVOCATE WITHIN POLITICAL CIRCLES AND INTERNATIONAL LEGAL COMMISSIONS FOR COUNTRIES TO RESPECT THEM.”

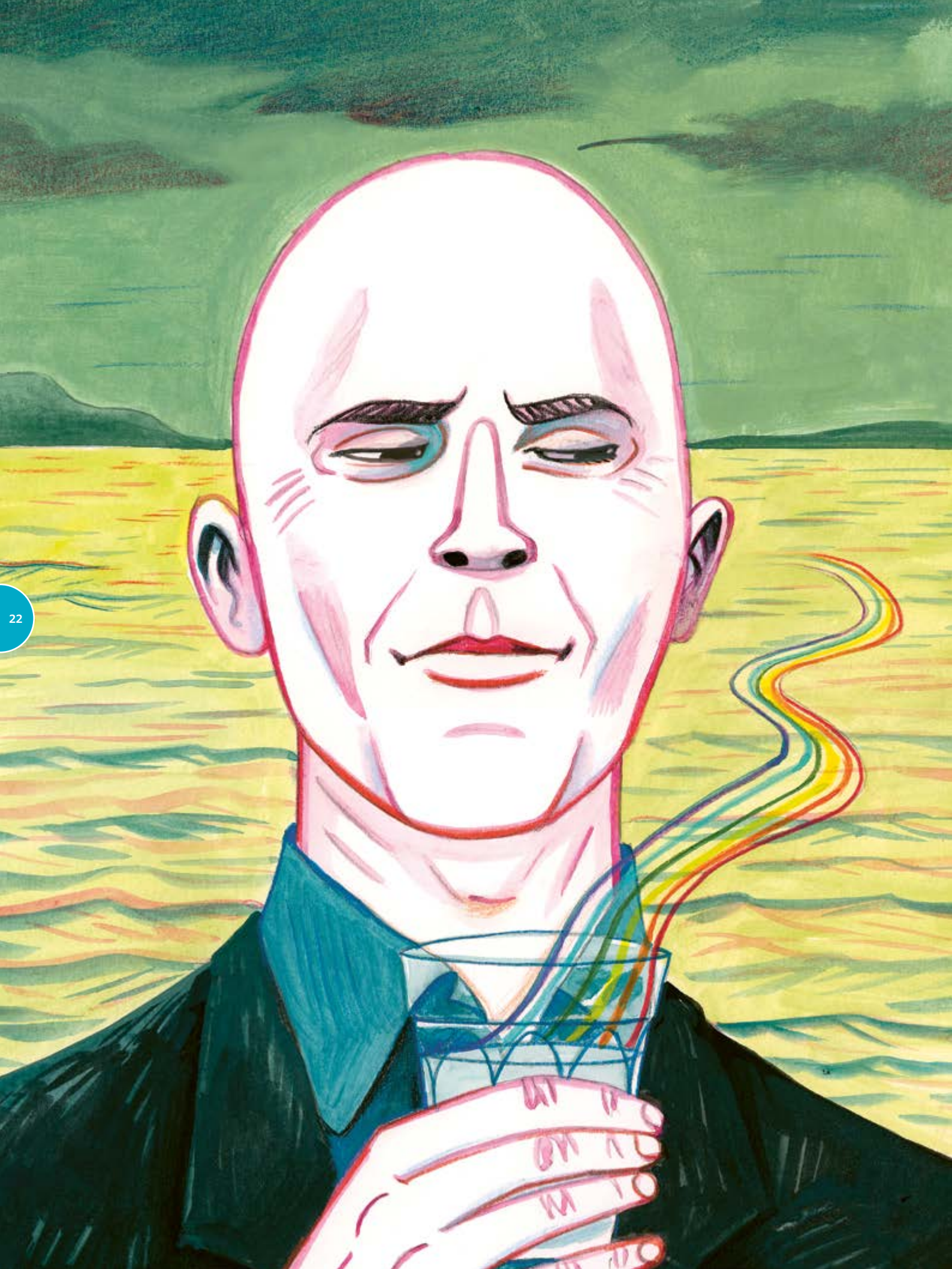
What is the role of the Geneva Water Hub?

We promote international freshwater law and the United Nations Convention on Water (UNECE Water Convention) and advocate within political circles and international legal commissions for countries to respect them. We also engage in hydrodiplomacy to strengthen established peace and help distribute water more equitably between and within countries.

How do you feel about the growing demographic and political pressures on water ressources?

First, we must never forget where things are working, because that is where we can learn lessons. Ever more countries are signing or ratifying the UNECE Convention, particularly but not only in Africa, and this is a very positive sign. At the same time, we are very concerned about the trend toward nationalism in water use, whether along the Tigris, the Jordan, the Ganges or the Colorado rivers – where we see more hoarding than sharing.

An even more worrying trend is the use of water as a weapon of war. International humanitarian law protects water during hostilities by prohibiting it from being targeted, as well as the infrastructure and the people who manage it. But beyond



being a casualty of war, water has become an instrument of war. The destruction of the Kakhovka Dam in Ukraine is a striking example. Or in Gaza: the Israeli blockade of fuel needed to run the pumps or the lack of aid to repair damaged infrastructure is a denial of the right to water. Even if the fighting stops, people continue to suffer. The lack of international condemnation normalizes this situation, which must not be allowed to continue.

In Iran, too, water is a crucial issue.

Indeed, following US and Israeli attacks on water facilities, Iran retaliated by targeting desalination plants in Gulf countries. The violence has ceased for now, but water has become an acceptable weapon of war. We see this in southern Lebanon as well, where water infrastructure is being targeted. Our work is to raise awareness about this situation and document its impact on populations. At the military level, we work with the ICRC, particularly with their legal experts, to engage with military officials so they can be aware of the consequences of targeting water and recognize that it constitutes a violation of international humanitarian law. On the political front, we are also part of the Global Alliance to Spare Water from Armed Conflict, which includes Switzerland, Slovenia, Indonesia, Panama, Costa Rica, Jordan and Kuwait, as well as organizations such as UNICEF and the IUCN. We are trying to raise public awareness and are holding informal discussions with the UN Security Council.

To what extent can innovation play a role in safeguarding this resource?

Technology can certainly help where countries cooperate, such as in Europe or Africa. But it also depends on the technologies. Reusing and recycling domestic or industrial wastewater for irrigation, for example, is an excellent way to use water. Desalination, on the other hand, isn't always a good thing. When you have no choice and plenty of money, it's undoubtedly an option for making drinking water. But for irrigation, it's far too expensive and energy-intensive. Furthermore, desalination causes massive pollution. By removing salt from 20% of the water, you increase the salinity of the remaining 80%, and the salt pollutes the aquatic environment. Finally, it creates huge dependency and vulnerability, as we can see in the Gulf countries. Therefore, it is better to use existing water sustainably rather than rely on desalination. If we get carried away by technology, we lose our common sense and miss out on sustainable solutions that use less water or use it more intelligently.

"INTERNATIONAL HUMANITARIAN LAW PROTECTS WATER DURING HOSTILITIES BY PROHIBITING IT FROM BEING TARGETED, AS WELL AS THE INFRASTRUCTURE AND THE PEOPLE WHO MANAGE IT. BUT BEYOND BEING A CASUALTY OF WAR, WATER HAS BECOME AN INSTRUMENT OF WAR."

As Europe's "water tower," is Switzerland immune to water concerns?

We are indeed very fortunate to live in Switzerland, and since we are upstream from everyone else, we are less vulnerable to water shortages. Nevertheless, we Swiss should not be complacent. We know the glaciers are melting, and we know the climate in Switzerland is warming. Our water security will go on evolving, and we must continue to rise to the challenges it brings. Another issue is water quality: there is always a risk of contamination. We must never lose sight of the fact that this is a fragile balance and that new chemicals, such as PFAS, certain medications and microplastics, could contaminate the water. And how are we going to address the problem of quagga mussels colonizing our lakes?

Will all the water on the planet soon be polluted, threatening our survival?

It's a major challenge. But it's not necessarily a lost cause. If we take a historical perspective, water was much more polluted in the 1950s than it is today. Factories and farms were polluting, and water wasn't treated. Then we learned to detect and treat pollutants. With PFAS and micropollutants, we're back to where we were in the 1950s: we do not test, we do not treat. This is where universities and scientists have a role to play. They can document a problem; the public then pressures the government to act, which implements regulations, and ultimately, with enough funding, the problem is addressed. It's not hopeless, especially in Switzerland. In wealthy countries, we have no excuse for not following science and regulations. We should think of our children.

Does climate change also particularly affect water resources?

Of course, but the effects are highly local. On the one hand, we see more water with floods, as in Spain or Pakistan, and on the other, droughts. The effects of climate change are often reduced to these extreme phenomena, but in reality, as the examples show, it's more a problem of dams and how we use water. There's a tendency to blame everything on climate change. Twenty years ago, US Vice President Al Gore spoke of an "inconvenient truth." Today, we could say it's a "convenient truth." Climate change certainly complicates matters, but most of our problems come from our own decisions. And that is actually good news, because if we were able to create a problem, we can also fix it. ■

Quantum and molecular plumbing

How liquids, and water in particular, behave at scales of a few nanometers is one of the big gaps in modern physics. BY HECTOR GARCIA MORALES

Our body contains an intricate system of tiny vessels through which blood, water and other molecules flow. When the size of the pipes shrinks to the nanoscale, where only a few molecules can fit side-by-side, the classical laws of physics governing the behavior of water are influenced by the atomic structure of the walls. "It's not that classical hydrodynamics breaks down, but rather that it gets mixed with the condensed matter physics of the solid walls," says Nikita Kavokine, tenure-track assistant professor and leader of the EPFL Quantum Plumbing Lab.

How liquids, and water in particular, behave at scales of a few nanometers is one of the big gaps in modern physics. For example, in some experiments it has been observed that water flows through carbon nanotubes orders of magnitude faster than expected. Scientists are trying to understand phenomena that biology has mastered after millions of years of evolution. "At the nanometer scale, our body leverages specific properties of water to filter molecules with high energy efficiency," explains Kavokine. Aquaporins, for example, are protein channels embedded in cell membranes that use these molecular-scale interactions to let water pass while blocking ions and other molecules.

An unknown mechanism

At the nanoscale, water molecules interact with the electrons in the channel wall through electromagnetic coupling. "It is here where things get quantum. And that's why we talk about quantum plumbing," explains Kavokine. Researchers have found that these interactions between water and the channel boundaries create a new friction mechanism. In this mechanism, water molecules and electrons in the channel wall push each other, creating a source of energy dissipation. However, the details of this mechanism are still being investigated. "It is paradoxical that we understand so much about how electrons behave at small scales, but so little about liquids," notes Kavokine.

Since friction is a force, there exists a net transfer of momentum to the electrons in the wall, leading to a sort of hydro-electronic drag, where the flow of water pulls electrons along the surface. This additional momentum generates an electric current flowing through the solid. This current could provide a new way of converting hydraulic energy at the nanoscale. In the future, this small-scale hydroelectric energy conversion could be used for energy recovery in all sorts of filtration processes without relying on any dissolved ions. This mechanism could also help in water treatment and energy harvesting from salinity gradients where seawater meets freshwater.

From single nanochannels to artificial organs

The experimental and technical implementation of a single nanochannel, essential to perform the studies, is challenging. "There are several groups working on this problem around the world, but we still have too few experiments to draw firm conclusions," says Kavokine. Fabricating a single nanochannel that functions like a biological ion channel is already a complex task. But interesting applications will require building large networks that integrate thousands, maybe millions, of these channels on a chip and within a controlled architecture. "In the next few years, we will begin to face this engineering challenge of scaling fundamental nanofluidics to something useful," explains Kavokine.

But the field is still young: nanofluidics emerged only about 20 years ago. Researchers are just figuring out the building blocks of how liquids flow through nanochannels, both theoretically and experimentally. "The equations we have now are not the right language to describe what we observe in our experiments," admits Kavokine. That is why part of the work carried out at the Quantum Plumbing Lab focuses on figuring out new theoretical frameworks that help understand the observations.

Building nanotubes is just one of many projects Kavokine's Quantum Plumbing Lab is working on. Other projects seek to explore the inner structure of carbon nanotubes using quantum sensing. This would allow researchers to understand why water flows with almost no friction through them.

In the long term, the scale-up of single-channel devices can lead to the fabrication of artificial nanofluidic networks that mimic natural ones. This would be the first step towards the creation of new high-efficiency computing architectures based on water and salt. However, there is still a long way to go before researchers can implement these networks. "We are just figuring out how it all works. My dream is to build something like an artificial brain or a kidney that rival their biological analogues in terms of energy efficiency," explains Kavokine.

A recipe to mix water and oil

But not all of water's unusual properties occur only at the nanoscale. Some phenomena that remain unexplained can be observed in everyday life. For instance, it is well known that, under normal conditions, water and oil do not mix. They can, however, form emulsions. The mechanism underlying the stability of oil nanodrops in water was uncovered by Sylvie Roke, professor and director of the EPFL Laboratory for Fundamental BioPhotonics, and her team. Using optical techniques, the researchers created micro-

scopic oil droplets capable of mixing with water. Their findings showed that the explanation for this observation lies in the transfer of small amounts of electric charge from water to oil across the interface between the two liquids via weak hydrogen bonding interactions.

Yet the interface between water and oil can reveal many other processes. Roke's team, for example, also explained how basicity influences the movement of oil droplets in water. The mechanism is linked to the pH-dependent conductivity of bulk water. This general mechanism helps explain a wide range of pH dependent processes in biology, chemistry and nanotechnology.

Understanding water at the molecular level, however, requires scientists to observe how hydrogen bonds form and organize into networks. A new method developed by Roke and her collaborators allows researchers to directly measure interacting hydrogen bonds in bulk water. "We can now measure charge transfer, nuclear quantum effects and other elusive phenomena directly at the atomistic scale where it occurs. It is almost like measuring the unmeasurable," says Roke. The technique provides direct access into molecular couplings and can help elucidate many other molecular properties of water, and other liquids. ■

From the faucet to the sewer, and vice versa

Water purification and recycling – the process of running sewage water through a treatment plant – is essential for public hygiene and for conserving this natural resource.

BY ANNE-MURIEL BROUET

The water we drink today was previously consumed by other people as well as by plants and animals – think ferns, dinosaurs, Cleopatra and other organisms closer to us in time and space. That's owing to the very nature of water molecules and the water cycle. This compound continuously transitions between the gas, liquid and solid states, and – depending on wind, temperature and altitude – can be found in rain clouds, rivers, the water table, oceans, glaciers and more. But the molecules themselves, while extremely numerous, are the same ones that have existed since the dawn of time, whether we use them for drinking, cleaning, bathing or evacuating our waste.

In Switzerland, water was officially recognized as a foodstuff in 1990, meaning it's subject to the same specifications as other products we consume. Our country is fortunate to have a high-quality supply of water that needs very little treatment to become potable. "Most of our water comes from the water table, so it's already been filtered over weeks or months – and that water is plentiful," says Tamar Kohn, the head of EPFL's Laboratory of Environmental Virology. "So we can simply drink it as is. But lake water requires a little more treatment to make sure it's free of pathogens." This water purification process is carried out mainly using chlorine, ozone or UV radiation.

"IT'S IMPORTANT TO ALWAYS KEEP WASTE AND WASTEWATER SEPARATE FROM DRINKING WATER TO ENSURE GOOD HYGIENE."

Tamar Kohn, head of EPFL's Laboratory of Environmental Virology

Testing only for bacteria, not viruses

Switzerland's drinking water does get contaminated from time to time, but that often goes unnoticed. "Testing is only carried out for bacteria, not viruses," says Kohn. "Viruses are smaller and replicate more slowly, so they're harder to track. But some viruses are common and can affect newborns and patients with weakened immune systems. That's why we recommend boiling water for these people."

"The trick is to find the right balance between eliminating pathogens and maintaining the water's high level of purity," says Kohn. That's because water purification processes based on chlorine and ozone, for example, involve adding chemicals to our drinking water. Kohn's research group is studying adenoviruses, which are pathogens that affect the respiratory tract. "These viruses' DNA is very similar to ours," says Kohn. "Even if we kill them, they can replicate using our cells' own DNA repair mechanisms. What's more, adenoviruses have an array of variants that can be randomly more or less resistant. We need to find a way to get rid of such viruses without having to pour chemical disinfectants into aquatic environments."

In the days before purification systems

"It's important to always keep waste and wastewater separate from drinking water to ensure good hygiene," says Kohn. Things weren't always done that way. In the middle of the 19th century, European homes had cesspits rather than indoor plumbing, and sewers were initially used to drain rainwater. Advances in water provision led to more efficient drainage systems, but it took a few cholera epidemics before large cities started to manage wastewater and dispose of it separately. London was a pioneer in the mid-1800s; Zurich followed suit after a cholera epidemic in 1867.

The problem was that the wastewater was being discharged directly into rivers and lakes without prior treatment, leading to large-scale contamination, wiping out certain organisms and promoting the growth of algae. It wasn't until after the turn of the century, in 1917, that Switzerland's first mechanical-biological water treatment plant was built, in St. Gallen. In the late 1950s, less than 10% of Swiss households were hooked up to a publicly run water treatment plant. Water protection was written into the Swiss constitution three years later, and the implementing act went into effect one year after that. In the 1960s, many lakes still had high levels of phosphate fertilizer, and swimming bans were common. Yet things gradually improved. The number of mechanical-biological water treatment plants rose from 67 in 1964 to 901 in 1983, and the percentage of households connected to one grew from 30% in 1970 to 90% in 1990*.

Turning wastewater back into potable water

Today, people are taking a fresh look at possible uses for wastewater, in response to environmental concerns and the mounting pressure on ecosystems. A growing number of cities and countries are using treated wastewater for irrigation, watering and cleaning, rather than discharging it directly into the environment. The US, South Africa, Australia and southern European countries have been using

this approach for a while. Switzerland hasn't yet passed a law to this effect, but Yverdon-les-Bains is leading the way by testing new technology developed in Europe for using treated wastewater to clean its streets and water its parks.

Some countries are planning to go even further by recycling treated wastewater into potable water. "That's a huge challenge because there are many pathogens, and they're the biggest threat," says Kohn. The processes are complicated and vary from one country to the next, as they're subject to different national regulations. These processes are designed to remove not only microbes but also hazardous and toxic chemicals, not to mention nanoplastics – although that's getting harder and harder to do.

Panning for molecular gold

Wastewater is also a social indicator, and it doesn't lie. Scientists can use it to trace the use of addictive substances or, as they did during the pandemic, detect the presence of coronavirus levels. A team of EPFL researchers led by Kohn worked with Eawag in 2020 to track the spread and development of SARS-CoV-2 by measuring coronavirus levels.

In Sion, Wendy Queen, who heads EPFL's Laboratory for Functional Inorganic Materials, is looking not for viruses or narcotics, but rather the gold and heavy metals that result from the excessive use of electronics. She's using molecular sponges with a structure similar to gunpowder that can absorb and separate tiny molecules. The sponges' crystalline structure can be adjusted to target different chemicals including gold, mercury, lead and hexavalent chromium – a toxic compound that's occasionally found in wastewater. Her process can both purify water and support the recycling of electronic equipment. While it has shown encouraging results in the lab, the next challenge will be to roll it out at scale. ■

* Source: *Dictionnaire historique de la Suisse.*

TURNING CITIES INTO SPONGES

A century of concrete-intensive urban development has left a lasting mark. Vast areas are now covered with pavement, preventing the soil from serving one of its primary hydrological functions – absorbing precipitation. Experts describe this process with colors: "blue" water, or rain, becomes "green" when it flows into bodies of water or the water table. But if it runs down buildings and over city squares and roads, it becomes "gray." Most of this gray water ends up discharged into rivers.

Scientists became aware of the problems that this causes only a few decades ago. And the problems have become even more salient with climate change, as, for example, uncontrolled surges in lakes and rivers flood entire cities. "Back in the day, it was perfectly normal to collect a little rainwater for your plants," says Paolo Perona, the academic director of EPFL's Hydraulic Constructions Platform. "But people stopped doing that with the installation of watering systems. Today, urban sprawl has made huge swathes of the ground impervious. As a result, heavy rainfall turns directly from blue to gray and overflows the spillways located upstream of cities, leading to flooding."

Researchers in many fields are working to find solutions. Urban planners are designing cities with more unpaved surface area – parks, squares and the space between tram rails, for example. Architects are incorporating rainwater recovery systems into the roofs of buildings; when installed on new structures, these systems can use collected rainwater for toilet flushing or irrigation and stem the overflow of gray water. Civil engineers and materials scientists are developing porous road surfaces. And computer scientists are programming models to quantify the improvements that can be made over a given surface area.

An open-air laboratory

When it comes to testing these solutions, EPFL is serving as an open-air laboratory. For instance, the Lausanne campus has been taking part in a sponge-city project for several years. "Initially, only 20% of rainwater was recovered on the campus; the remaining 80% turned into gray water and flowed into the Sorge," says Perona. That was due to the large areas that had been paved over more than 50 years ago. "But our models show that it's possible to achieve a 60% to 65% recovery rate, meaning just 35% to 40% would become gray water," says Perona. Potential steps in this direction include changing the pavement on roads and squares, planting more trees, creating wet biotopes and collecting rainwater on rooftops.

Some of these measures are already being taken under EPFL's Campus Piéton initiative. In addition, a sponge-city prototype was set up in Lausanne's Jardin de la Circulation. This pilot project shows how rainwater runoff can be mitigated and illustrates sustainable water handling methods for urban spaces using permeable soil and vegetated ditches. "We hope to work with the Union of Swiss Cities to implement sponge cities widely," says Paola Viganò, a member of the project team and the head of EPFL's Laboratory of Urbanism.

While the concept is still being rolled out in Europe, it has already been adopted in many cities in China. EPFL researchers have also modeled several cities in Mauritania and Kenya, and they're working on a project with the City of Paris to replicate what was done in Lausanne and limit the risk of flooding in the French capital, which is particularly vulnerable owing to its topography and subway system. "We're able to map the extent of flooding that would occur in each Paris neighborhood after a given weather event in the city's catchment area," says Perona. Such modeling can help city officials plan – and most importantly, act – at a time when extreme events will only become more common. ■ **EBA**

How rivers shape cities and societies

Cities and communities have often develped around waterways. Today, they play a vital role in adapting to climate change and strengthening social bonds. BY HECTOR GARCIA MORALES

Rivers are a key resource for food, directly through fishing or indirectly for irrigating crops. In the 19th century, when industrialization began, they became essential to run factories and revolutionize the economy, thus shaping the urban landscape. For that reason, humans have always established their settlements near rivers and have diverted their natural course to adapt to their needs.

However, as cities keep growing, rivers reclaim the space that they occupied. "Rivers are very complex ecosystems that raise a lot of questions in many areas: ecological, political and social," explains Paola Viganò, professor at the Laboratory of Urbanism, who for years has studied the integration of natural and urban environments. "River management requires not only technical solutions but also political agreement and alliances between different stakeholders."

The Rhône, from Valais to the Mediterranean Sea, for instance, is one of the rivers that has been transformed over the decades and has lost a significant fraction of its rich biodiversity. For that reason, several plans to restore part of the original river space have been under discussion for decades. Among other projects, the third correction of the Rhône in Switzerland combines flood protection along its course through the canton of Valais with elements to make the river more natural while improving safety and ecological functions. It involves widening parts of the riverbed and redesigning floodplains. According to Viganò, the way rivers have been domesticated has established a hierarchy between the big city and more marginal territories with a higher risk of floods: "The proximity to water sources is traditional, but the type of relationship and the risk are contemporary."

In the fight against climate change, every drop counts

Preserving not only the quantity but also the quality of water in rivers is essential to respond to climate change. "Many cities in Europe are exposed to heat stress. So each drop counts," says Viganò. According to the urbanism expert, designing future cities and neighborhoods does not involve only preparing them for the next flood. City councils need to find strategies to address the problems related to climate change rather than finding solutions for its consequences. "Climate change will create more extreme conditions. We need to understand that the risks are growing," says Viganò.

Sometimes, the risks that accumulate in the downstream areas of rivers originate way upstream. Viganò is particularly concerned about the population living in these areas. "Often, in the lower parts of the river you can find the most fragile population. This becomes a political problem of environmental justice," says the expert in urbanism. For her, territorial solidarity between upstream and downstream zones is key to understanding how the different parts of the valley can contribute to reducing flood risk. "In this regard, agriculture is fundamental but needs to be rethought in the modern context," says Viganò.

"MANY CITIES IN EUROPE ARE EXPOSED TO HEAT STRESS. SO EACH DROP COUNTS."

Paola Viganò, professor at the Laboratory of Urbanism

Adapting to climate change

The territory with all its different functions and characters needs to be resilient and contribute to reducing the risks. "To face these challenges, you need to bring together a lot of different types of people, from those that are working on transport to those that are working on biodiversity or on sports activities. Putting together all these actors is challenging. We need to prepare for that," says Viganò.

A closer relationship between nature and cities can help adapt to climate change in many ways. If cities contain more trees, there will be more shade, and they will help refresh urban spaces. At the same time, cities can help retain large quantities of water thanks to soil filtration or groundwater recharge. That is why cities can act as big water collectors. Based on this idea, the concept of sponge cities was born (see "Turning cities into sponges" on p.28). By using natural resources such as green spaces (green roofs, rain

gardens) and permeable pavements to absorb excess rainwater, sponge cities can not only help mitigate flooding but also enhance the relationship between urban and natural environments.

The privilege of swimming in Swiss rivers

Some cities are finding strategies to guarantee healthy rivers. For instance, the Seine in Paris was partially reconditioned for the 2024 Olympic Games as part of efforts to reduce sewage overflow, microplastics and bacteria. On the other hand, thanks to legislation established forty years ago, Switzerland is one of the rare places where people can swim in urban rivers. As summers become warmer, more and more people use rivers to refresh on hot days or even to commute, as happens in the cities of Bern or Basel. "It is a spectacle when you pass by some Swiss rivers and lakes and see so many people enjoying themselves. We have to realize this is not possible in many places in Europe," says Viganò.

Social dimensions

Today, rivers are very important spaces, crucial for inhabiting cities responsibly and supporting climate adaptation. To restore our relationship with water, both visually and practically, citizens need to remain socially connected to water. Viganò calls for "a new way of reframing the concept of cities," where water can be a driver for more egalitarian cities. Viganò warns that interpreting water as a kind of resource one can claim will lead to significant conflicts in the future: "We need to listen to water. If we accept how water behaves and its interdependencies, it can certainly help build more democratic societies." ■

RESEARCH AND SUSTAINABLE ENERGY MEET AT CHAMBERONNE

Just a few steps from the EPFL campus lies one of the best examples of how a river can be integrated into an urban environment. Running through both the UNIL and EPFL campuses, the Chamberonne river is formed by two parent rivers, the Sorge and the Mèbre, which cross the western side of Lausanne before converging and continuing their journey toward Lake Geneva.

Flowing through forests, agricultural land and urban landscapes, this watercourse tells a story of environmental change, water innovation. This proximity to the city also comes with challenges. Urban growth has gradually influenced the river's water quality, with aging hydraulic infrastructures and increasing sources of pollution that affect the river's ecosystem.

But all these factors make of the Chamberonne a living laboratory for research, education and environmental monitoring. Thanks to its accessibility to the EPFL campus, the Chamberonne offers unique opportunities to study the influence of human activities on aquatic systems. For instance, in the framework of the UrbanTwins project, the research group led by EPFL professor Rizlan Bernier-Latmani, from the Environmental Microbiology Laboratory, installed sensors along the Sorge to monitor the river and assess the impact of the campus environment on water quality.

The proximity to these sources of water also provides a place to build sustainable infrastructures that heat and cool the campus. Since 1978, Lake Geneva has been the main source of cooling for the Lausanne campus, with water pumped from the lake and distributed through an underground network. In 1986, the installation of heat pumps also enabled the recovery of thermal energy from the lake for use in heating buildings.

Over the years, the infrastructure has evolved significantly, and renovation work enabled EPFL to become entirely oil-free by 2022, reducing its carbon emissions by around 1,400 tons of CO_2 per year. Today, more than 85% of the energy used for heating and cooling the buildings on the campus comes from renewable sources, including the campus' 2 MW data center, which is cooled with water from the lake, while the heat produced by its servers is recovered and reused to heat the university buildings.

The EPFL's heating and cooling plant, with its distinctive red blocks covered in solar panels, has become a landmark of the area and a symbol of innovation and sustainability. ■ **HGM**

A floating multidisciplinary lab on Lake Geneva

As the most advanced experimental station ever installed on a lake, LéXPLORE is equipped with state-of-the-art instruments for collecting high-resolution data across a wide range of fields.

BY HECTOR GARCIA MORALES

It only takes four minutes by boat to reach it from Pully's Nautic Club. Five hundred and seventy meters from the shoreline, delimited by a set of yellow buoys, small but magnificent, the LéXPLORE platform floats on Lake Geneva, the largest natural water reservoir in Western Europe. A hundred square meters packed with cutting-edge scientific research equipment anchored at the bottom of the lake, which at that point already reaches a depth of 110 meters. Four heavy concrete blocks stabilize the platform that, even with the presence of more than ten people, barely moves.

LéXPLORE became operational in 2019, thanks to a partnership established between five research institutions: EPFL, Eawag (the Swiss Federal Institute of Aquatic Science and Technology), UNIL, the University of Geneva, and CARRTEL (Alpine Center for Research on Trophic Networks and Limnic Ecosystems). Since then, the platform has become a unique place where biologists, chemists, physicists and engineers can conduct their research, test new technologies, and take measurements of the water conditions with high precision at any moment.

Open Research 24/7

Lakes are a source of life and a precise indicator of the health of the ecosystems around them. Beyond being an important resource for drinking water, fisheries and recreation, Lake Geneva is also extremely sensitive to changes in land use and climate, as well as to different sources of contamination. The lake provides early warning signals for global changes and the state of ecosystems.

The LéXPLORE team, operational 24 hours a day, seven days a week, constantly checks the vital signs of the lake. Every two hours, a probe dives down to the bottom of the lake and takes measurements of different water parameters such as temperature, pH, oxygen, or conductivity. While usually researchers can only take data in dedicated campaigns, LéXPLORE allows continuous data collection. This distinctive characteristic makes the platform unique worldwide. "The goal of this platform is to provide high-quality and high-frequency data for researchers," explains Jérémy Keller, technical manager.

A weather station on the roof of the platform keeps track of the air temperature, humidity, and wind speed and direction. But the platform and its surroundings house many and diverse items of scientific equipment: from thermometers to devices that measure wave dynamics and particle detectors that measure cosmic rays. All this equipment was meticulously installed and calibrated by Keller and his team.

Jérémy Keller is, in fact, the man who does almost everything to keep the platform up and running in the best conditions and helps scientists install their instrumentation. Keller collaborates with scientists and discusses the best way to put their ideas into practice. "We have 30 projects ongoing. Coordinating all of them at the same time is often challenging," confesses Keller.

But not all work has the aura of science. The maintenance requires performing all sorts of activities, from repairing and calibrating scientific instrumentation to building furniture, driving a submarine drone and removing seagull excrement. But if there is one single aspect that operators struggle with, it is the invasion of quagga mussels. This mussel not only affects the LéXPLORE platform and its equipment, but also all the lake's natural and urban ecosystems. "These mussels attach to everything, including the scientific instruments. We need to clean them," explains Keller.

A special focus on climate change

One of the main purposes of the platform is carrying out climate change studies. Lake Geneva accurately reflects the challenges and the impact global warming has across ecosystems. In particular, researchers have observed that global warming affects the turnover of the lake. Seasonal changes in water temperature allows the vertical migration of water layers. This mix of water layers helps preserve the ecosystems of the lake. For the turnover to occur, water temperatures have to be below four degrees Celsius, the point where water density reaches its maximum. However, the mild winters of the last thirteen years did not allow surface water to reach the critical temperature. As a result, the upper and deeper layers of the lake do not mix, thereby critically reducing its biodiversity.

A platform for citizen science

Another of the objectives of LéXPLORE is to be a space open to visitors but also open in terms of data. Anyone interested in visiting the platform can book a guided tour during specific periods throughout the year. The strange

object floating near the coastline attracts the attention of visitors coming from the local area. “I thought that only a small group of EPFL researchers used the platform. But now I see that there are many researchers from different domains who come to carry out their studies,” comments a neighbor from Pully taking part in a visit to the platform.

All the data collected by the platform is available online. Datalakes is a digital platform that facilitates the visualization and dissemination of data coming from Swiss lakes. As part of an open science approach, Datalakes offers an interactive map viewer and a comprehensive data portal that serve researchers, public authorities and citizens alike, helping them to make decisions that impact ecosystems and society.

One of the most successful stories of collaborative science linked to the lake has been the project Lémanscope. For about two years, hundreds of citizens carried out more than 3,500 measurements of the color and transparency of the lake at different locations. The data acquired has been used to map the entire surface of the lake, allowing a detailed understanding of its seasonal changes. But the platform is not reserved for professional researchers; it is also open to research proposals from high school students, who can carry out their projects or test their technologies.

The platform and all the projects taking place on it will continue collecting information that has already proved essential in many areas for understanding the ecosystems linked to the lake and finding strategies to mitigate and revert climate change. ■

“LAKE GENEVA IS A CORNERSTONE OF THE REGIONAL WATER CYCLE”

Natacha Pasche, the operational director of EPFL’s Limnology Center, explains the important functions lakes serve in regulating the climate, serving as freshwater reservoirs and moderating water flow and flooding. **BY SARAH PERRIN**

What's the role of Lake Geneva – Europe's biggest lake – in the local and continental water cycle and in global climate mechanisms? For answers, we turned to Natacha Pasche, who, in addition to her position at the Limnology Center, oversees operations, development and research coordination for the LéXPLORE platform.

How does Lake Geneva fit into the regional water cycle?

Lake Geneva acts as an engine of hydrological processes, serving as a reservoir, regulator and stabilizer. Water from the Rhône and other rivers collects in the lake, which helps to naturally reduce flooding. During droughts, this water gradually returns to the rivers, providing a steady flow and securing the supply of drinking water for nearly one million people. Lake Geneva also influences the atmosphere: its large surface area promotes evaporation and the local formation of clouds, while its thermal mass tempers the climate along the lakeshore. In short, Lake Geneva isn't just another lake – it's a cornerstone of the regional water cycle.

How do lakes affect the global water cycle?

Lakes contain almost all the surface freshwater on the planet. They're huge reservoirs that are essential for regulating hydrological processes – they reduce the severity of floods, feed into rivers during droughts and stabilize ecosystems. They also influence the local climate. For instance, they either heat or cool the air depending on the season, which can produce breezes, and they affect humidity levels and can even trigger specific weather events, such as the intense snowfall that occurs around the Great Lakes in North America. They also play a direct role in the global water cycle, returning a substantial amount of water back into the atmosphere through surface evaporation.

How will glacier melt impact Lake Geneva, and what are the risks to the water cycle?

Glacier melt will considerably alter the Rhône's dynamics. We expect the river to run higher in the winter and much lower in the summer, when glacier runoff will become increasingly rare. Hydrological forecasts for Switzerland clearly corroborate this trend, with estimates of 30% more water in the winter and 40% less in the summer by the end of the century, if no climate action is taken. The river's annual volume won't change much, falling by around 10%, but the seasonal fluctuations will increase dramatically. That means significantly less cold water will flow into Lake Geneva in the summer, further warming the lake's surface. Unless Swiss policymakers take bold climate measures, the temperature of the country's lakes is forecast to rise by 3°C to 4°C by 2100. Warmer water will considerably alter lakes' internal processes: summer stratification will last longer and winter mixing will be reduced – meaning less oxygen will be carried deep underwater. These are critical processes, and changes in them could have a major impact on lake ecosystems, water quality and the amount of oxygen available deep below the surface.

We can also expect to see more extreme weather events. Intense precipitation will become more common in Switzerland, causing rivers to overflow – as we saw in the summer of 2024 when several regions experienced major flooding. Of the various factors at play, I would highlight the decrease in cold water streams in the summer, as this will contribute significantly to warmer temperatures in Lake Geneva and give rise to a number of environmental changes. ■

Retreating glaciers are taking entire worlds with them

Some 40% of Switzerland's glacial reserves have disappeared in the past 25 years. That means the country is losing not just a water and energy resource but also living ecosystems that we're only now discovering. Two EPFL researchers describe the scope of the issue. **BY GREGORY WICKY**

These days, when you talk about glaciers, the conversation invariably turns to glacier melt. According to Glacier Monitoring in Switzerland (GLAMOS), over 1,100 of the country's small glaciers have vanished since the early 1970s, and those that remain are melting at a rapid pace. They've lost 40% of their volume since 2000, shrinking from 75 km^3 to 45 km^3 by the end of 2025. Switzerland could be nearly glacier-free by 2050–2070, with only a few giants, such as the Aletsch and Rhône glaciers, surviving to the end of the century.

These figures raise a number of environmental, economic and landscape-related questions, but perhaps the most tangible problem has to do with Switzerland's energy supply. What does glacier melt mean for a country that gets nearly 60% of its energy from hydropower? Giovanni De Cesare, a civil engineer and head of operations at EPFL's Hydraulic Constructions Platform, has been studying hydropower dams for over 30 years. "The problem isn't just that there will be less water," he says. "Today, glaciers melt all summer long, providing a steady stream of runoff. When they're gone, we'll have to rely directly on precipitation – rain and snowfall – which is much less predictable."

The Grande Dixence, world's tallest gravity dam, is a case in point. Some 540 million m^3 of water flows into its catchment area per year, mostly from glacier-fed streams, and fills the dam's 400 million m^3 reservoir. Scientists estimate that this inflow could shrink by 30% by the end of the century. If the glacier that regulates the flow of water disappears, the reservoir – sized for the original glacier runoff – won't be able to compensate for the difference between the wet and dry seasons.

Making dams higher

One option for mitigating the impact on the energy supply is to build more dams. Construction began on the Trift dam in the Bernese Oberland, for example, around 12 years ago. But this is a slow and often controversial process. Instead, De Cesare suggests another approach: raising the height of existing dams. This has already been done successfully at Mauvoisin (raised by 13 meters), Vieux-Émosson (21.5 meters) and Luzzone (17 meters). Those are relatively small additions considering that the dams are around 200 meters high, but they've been effective at expanding the reservoirs' capacity due to the V-shape of the dam walls. The capacity of the Luzzone dam, for instance, grew from 87 million m^3 to 107 million m^3. Thirteen such dam-raising projects are currently under consideration in Switzerland.

Dams also face another, more insidious enemy: sedimentation. "Rock flour" tends to deposit at the bottom of dam reservoirs, but, recently, the morainic deposits have been getting larger, forming deltas and steadily reducing the reservoirs' capacity. In a study carried out on the Gries dam in the canton of Valais, De Cesare found that this problem is getting worse as glaciers retreat. "Solutions do exist, such as sediment bypass systems, or tunnels that direct sediment-laden floodwater around a dam reservoir," he says. "But building them is expensive and they have to be incorporated into a dam's initial design, which is rarely done."

De Cesare believes that, in the future, dams will need to serve a variety of functions. Reservoir water is currently used mainly for power generation, but it could also be employed for irrigation, producing artificial snow, flood protection and more. "The process of generating hydropower doesn't actually consume water – it just harnesses the fluid's energy as it flows and falls," he says. "Only a few dams in Switzerland are designed so that the water can be used for other purposes, but that should change."

When greening is not a good sign

In addition to providing valuable stores of water, glaciers are also full of life. Tom Battin, a professor of environmental science and head of EPFL's River Ecosystems Laboratory, studies the microorganisms contained in glaciers. "When I tell glaciologists that millions of living cells lie beneath their feet when they walk on ice, they're often stunned," he says. "Glaciology is still thought of largely in terms of physics. Cryosphere biology is the next frontier!"

Battin spent five years traveling the globe as part of the Vanishing Glaciers Project funded by the NOMIS Foundation. He and his team took samples from 170 glacier-fed streams on every continent and found a much more diverse microbiome than expected. Their research was published in *Nature and Nature Microbiology* in early 2025.

Microorganisms in glacier-fed streams live in biofilms, which are matrices of a gelatinous material clinging onto rocks. Battin describes them as "sticky megalopolises." These communities include microbes that are experts in survival: they've evolved over thousands of years to withstand near-freezing water, intense UV radiation and an environment with almost no nutrients. "We call them 'rock-eaters' because they feed on minerals, iron, sulfur and gases in the air," says Battin. "But from an energy perspective, it's much more viable to feed on organic carbon – these microbes are extremely vulnerable to changing conditions."

And, as we know, conditions are changing. Mountain streams are becoming clearer, calmer and warmer as glaciers disappear. In some cases, algae are proliferating

and the ecosystems are turning from gray to green. Battin studied this "green transition" in research published in *Nature Geoscience* in 2024, analyzing samples from 154 glacier-fed streams worldwide. For instance, he found that streams fed by the Rwenzori glacier in Uganda, one of Africa's last remaining glaciers – and one that's at a much more advanced stage of retreat than Alpine glaciers – are already mostly green. This gives scientists a glimpse of what's likely to occur in Switzerland in a few decades.

"By the end of this century, the land freed up by disappearing glaciers will be home to streams that, if put together, will be 40 to 60 times longer than the Nile – the world's longest river," says Battin. That will be a visible consequence of a permanent loss: the microbes that have adapted to extreme conditions will steadily be replaced by more general ones moving upstream. "We stand to lose all that biodiversity – and with it, a genetic treasure trove," says Battin.

Biological assets worth conserving

If it's too late to save the glaciers, can we at least preserve their biological heritage? "It's our moral duty!" says Battin. That's why he introduced the Microbial Initiative for the Cryosphere, an international initiative led by EPFL together with Institut Pasteur and the European Molecular Biology Laboratory. The goal is to protect and study the diverse microbiome contained in glaciers before it disappears. Battin's idea is simple yet ambitious: he intends to build up a biobank – a kind of Noah's Ark for microbes – containing bacteria, viruses, fungi and algae collected from glaciers around the world. This will allow scientists to examine how these organisms have evolved and leverage their biotechnological potential. "That would enable the development of low-temperature enzymes, new forms of antibiotics and biomaterials," says Battin. "These streams harbor a wealth of genetic possibility, and it's slipping away before we've even had a chance to document it." Battin hopes to set up the biobank at EPFL's ALPOLE center in the canton of Valais, giving scientists who don't have a glacier nearby the opportunity to conduct research in this area.

Battin's research group isn't the only one at EPFL working to preserve glaciers' natural assets. Jérôme Chappellaz, a professor of environmental science at EPFL Valais Wallis, introduced the international Ice Memory initiative in 2015. This initiative, backed by UNESCO, is being conducted jointly by seven top-tier research centers, including CNRS and the Paul Scherrer Institute. Scientists are collecting ice core samples from glaciers under threat – from the Alps to the Andes, and from the Caucasus to Svalbard – and keeping them in natural storage at –50°C at Concordia Station, a French-Italian research facility in the Antarctic.

Time to act

Ice Memory is based on the idea that glaciers can be read like history books – the air bubbles they contain can be hundreds of thousands of years old and, by analyzing them, scientists can learn about changes in the climate and the composition of the atmosphere over vast time periods. Chappellaz is certain that, one day, technology will be developed that's capable of extracting information from glacier samples we currently can't interpret. But this assumes the samples will still exist when such technology is ready.

Considering the impending changes to our water supply, De Cesare likes to remind people of a little-known fact: 98% of the liquid freshwater on Earth is contained right under our feet, in the water table. "That's our strategic reserve – and it's what we're in the process of contaminating," he says. "River water can renew itself naturally in just a few hours, depending on how fast the river flows. A body of water like Lake Geneva takes around a dozen years to renew. But for the water table, we're talking about 100 to 10,000 years. So the water we contaminate today will be with us for centuries. We'll become aware of the value of this water only when it starts to become scarce."

Battin adds: "We need to act now, not 20 or 30 years from now. We have the knowledge and technology. Unfortunately, we're our own worst enemy." ■

EPFL+ECAL LAB REACHES NEW HEIGHTS

How can mountain regions best respond to the challenges of climate change? This is the ambitious question that the Mount-Resilience project, funded by the EU's Horizon Europe program, aims to answer. The project brings together 47 partner organizations in nine countries, from Lapland in Finland to the Italian Alps. The Swiss team is based in Val de Bagnes in the canton of Valais and led by the EPFL+ECAL Lab. There, scientists – including those at the RIVER lab headed by Tom Battin – and engineers are working with interaction designers, policymakers and water-system users (such as farmers, tourism companies and residents) to study this natural resource.

"We're increasingly knowledgeable about the environment, but, as a society, we're taking that knowledge less and less into account in our decisions," says Nicolas Henchoz, head of the EPFL+ECAL Lab. "With MountResilience, we want to connect people on the ground – not just experts – with environmental science and data." To that end, the project team is developing a web application that will display real-time measurements of the quality and quantity of catchment water, in the form of readily understandable indicators. "The app will also let users share information and receive alerts about these data," says Henchoz. "And it will include a list of solutions that users can take as inspiration."

Two research papers – one on methods for getting local stakeholders involved, and the other on a prototype of the web application – will be presented at the Regional Mountain Conference this summer in Obergurgl, Austria. The functioning prototype itself will be unveiled at the BlueArk Conference in Châble, Switzerland, in November of this year. ■

How can we harness the vast energy potential of sea water?

Seas and oceans are brimming with untapped potential for producing energy. Two EPFL research groups are developing nanoscale devices for converting saltwater into electricity. BY GREGORY WICKY

Rising tides and rolling waves release massive amounts of energy from the seas and oceans every day. Attempts to harness this energy are nothing new: for decades, engineers have been building tidal power plants, marine turbines and wave energy systems in order to use the mechanics of water to produce electricity. But take-up of such technology has been marginal. According to the International Renewable Energy Agency, the installed capacity of marine energy production worldwide is around 500 megawatts. For comparison, the equivalent figure for wind power is 1,100 gigawatts – or 2,200 times higher.

There are also other, less evident ways to produce energy from water: one is the salinity difference between saltwater and freshwater, and another is the evaporation that occurs at the surface of seas and lakes. Such natural phenomena are continuous and can be found everywhere. Researchers have long known how to describe them using physics – but concrete applications are thin on the ground. At EPFL, two research groups, each with its own approach, have taken major steps forward in developing systems for generating renewable marine energy at a nanometric scale.

Sliding ions

Osmotic power, also known as blue energy, is one of the promising options being explored. It can be produced anywhere freshwater comes into contact with saltwater, such as where a river pours into an ocean. In theory, osmotic power has huge potential – over 15,000 TWh per year, or 75% of total global energy use. But in practice, formidable technical constraints mean that only around 600–2,000 TWh per year of power can be harnessed, or between France's annual electricity demand and that of India. The method for producing osmotic power has been around for decades. It entails separating freshwater and saltwater by a selective membrane and then, as ions naturally pass from the solution with a high salt concentration to that with a lower one, taking advantage of the voltage difference. The problem is that, with existing membranes, engineers must choose between speed and precision: either the ions pass rapidly but in a haphazard way, or they pass slowly but with good selectivity.

> **"THESE SYSTEMS ALREADY USE EVAPORATION TO TURN SALTWATER INTO FRESHWATER. SO WE CAN ENVISAGE CREATING A SYSTEM THAT GENERATES BOTH DRINKING WATER AND ELECTRICAL POWER."**
>
> Tarique Anwar, doctoral assistant at LNET

The research group led by Aleksandra Radenovic at EPFL's Laboratory of Nanoscale Biology (LBEN) has found an elegant way to square this circle. In a study appearing in *Nature Energy* in February 2026, the scientists developed a device made of hafnium oxide nanopores that have been coated with a lipid biofilm – the same lipid molecules as those in our cell membranes. Water molecules are attracted to this biofilm and form a layer only a few molecules thick. This layer serves as a lubricant, enabling ions to slide through the pores quickly while maintaining a high degree of selectivity. As a result, the device containing 1,000 nanopores has a power density of around 15 watts/m^2, which is two to three times higher than that achieved by existing polymer systems.

The next challenge will be to scale up the technology. "We need to move from chips in a lab to large membranes with a high pore density, precise pore-size controls and a reliable coating – all at a reasonable cost," says Yunfei Teng, a doctoral assistant at LBEN. The team must also demonstrate the device's long-term stability and resistance to biofouling. However, the underlying concept can be applied universally. Such water-based lubrication could also improve the performance of membranes used for desalination and medical devices.

Evaporation as a continuous energy source

The research group led by Giulia Tagliabue at EPFL's Laboratory of Nanoscience for Energy Technologies (LNET) is exploring an even more surprising energy source: evaporation. Their method uses the hydrovoltaic effect, which is based on a simple mechanism: when liquid evaporates at the surface of a nanodevice, that creates a continuous flow of liquid in the nanochannels – similar to the transpiration that causes sap to rise in a tree. If an electric charge is applied to the nanochannel walls, the ions start to move and generate an electric current. In an article published in *Device* in 2024, the LNET team reported an unexpected discovery: contrary to what scientists had previously thought, this process works with saltwater and not just purified water. That paves the way to concrete applications using evaporation at the ocean surface.

The team made another breakthrough in 2026, in a study published in *Nature Communications*. They developed a silicon nanodevice composed of three layers: one for evaporation, one for ion transport and one for collecting the electrical charge. The device uses sunlight and heat to not just speed evaporation, but also directly control the movement of ions and electrons. "This natural process has always occurred, but we're the first to harness it," says Tagliabue. Thanks to the device's dual approach, it can generate five times more energy than systems employing evaporation alone.

One big advantage of LNET's technology is that it can run continuously. Unlike the solar radiation needed for solar power, evaporation occurs day and night over a broad range of temperatures. The nanodevice can therefore be employed wherever there's water, heat and light. For example, it can be used to run self-powered environmental sensors. Tarique Anwar, a doctoral assistant at LNET, also points to potential synergies with desalination systems. "These systems already use evaporation to turn saltwater into freshwater. So we can envisage creating a system that generates both drinking water and electrical power."

Being able to produce both of these would bring massive benefits to coastal areas with little access to freshwater and electricity. For now, nanofluidic devices can't compete with major power generators, but their ability to take advantage of continuous, ubiquitous phenomena at a small scale opens up exciting prospects. ■

Water is one condition for planetary habitability

While water is essential for living organisms to thrive, it's only one of several conditions. To support life, planets need the right combination of factors.

BY SARAH PERRIN

The first question scientists ask when they want to know if there could be life on a planet is whether the planet has liquid water. That's a decisive question given the fundamental role that the H_2O molecule plays in the biochemical reactions that sustain life. Not only must all known living organisms consume water to survive, but water serves a number of other critical functions that enable life to exist on a planet.

On Earth, water carries nutrients, eliminates waste and enables organisms to regulate their body temperatures. In addition, water's ability to absorb and release heat helps stabilize environments by preventing abrupt temperature swings.

What's more, water plays a key role in climate mechanisms. Its natural cycle, consisting of evaporation, condensation and precipitation, redistributes this resource all over the planet. Oceans serve as reservoirs and temperature regulators, while clouds contribute to the greenhouse effect as well as to albedo, which refers to the reflection of sunlight by a light-colored surface (as opposed to a black surface that absorbs radiation). Planets without water can be highly unstable – take Mars, which is cold and dry, and Venus, which has an extreme greenhouse effect that caused all liquid water to disappear.

For water to serve all the functions necessary for life, it must be in liquid form. That means a planet's environment must not be too cold – otherwise it would contain only ice – or too hot, as all the water would evaporate. Researchers refer to this as the "habitable zone," or the distance from a star where a planet's temperature enables water to exist in all three states. The Earth sits precisely in this zone relative to the Sun, which is a key reason why life developed here.

An important balance

That said, merely having water doesn't guarantee that life will be found on a planet. Other conditions come into play, and Earth meets them all. These include a stable energy source, the right chemical elements, a magnetic field that deflects dangerous cosmic rays, an ozone layer that filters much of the UV radiation, a protective atmosphere – held in place by the appropriate gravitational pull – that creates a moderate greenhouse effect, and an axial tilt that results in regular seasons and is kept stable by the Moon.

So although water is vital for making Earth habitable, it's just one piece of a complex puzzle with pieces from physics, chemistry and astronomy. When properly combined, they make life possible. ■

From source to watt: water

From alpine turbines to untapped oceans: portrait of an age-old energy facing the climate challenge

Hydrogen production through water electrolysis is not included in these charts.

Water use per person

Liters/person/day – direct and indirect use

Sources: FOEN · SDC/WWF · EEA 2023 · FAO AQUASTAT

Evolution of hydropower production by technology

TWh/yr – Switzerland – Europe – World – 2024 data – 2050 projections

Sources: IEA · SFOE · Ember · IHA · Eurostat · NZE / SE2050 / REPowerEU projections

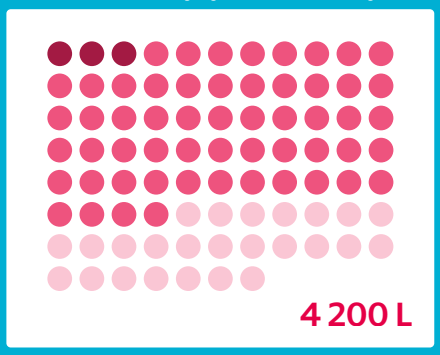
● Domestic ● Food* ● Industry ●= 50 L

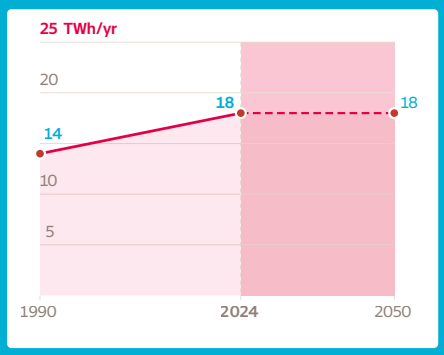
RUN-OF-RIVER

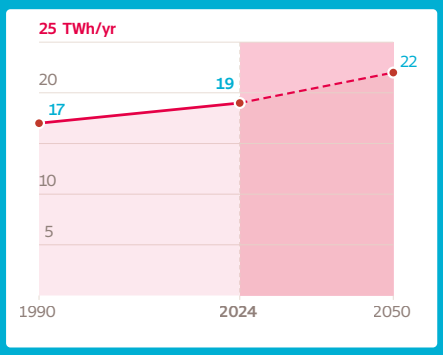
RESERVOIRS/STORAGE DAMS

SWITZERLAND

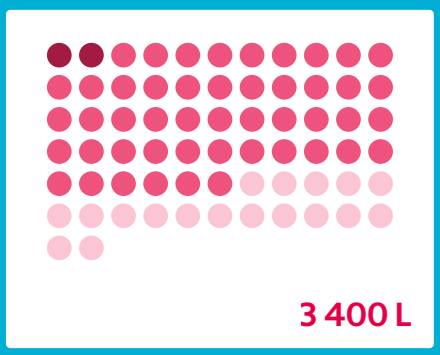
* Including irrigation and livestock farming

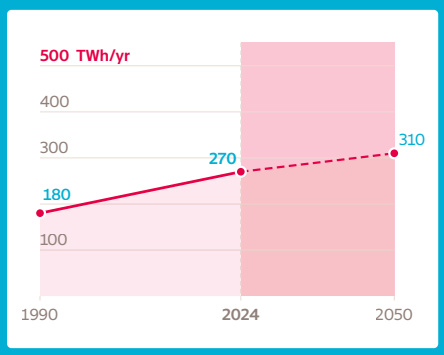


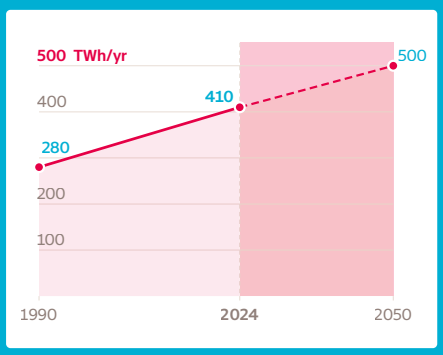




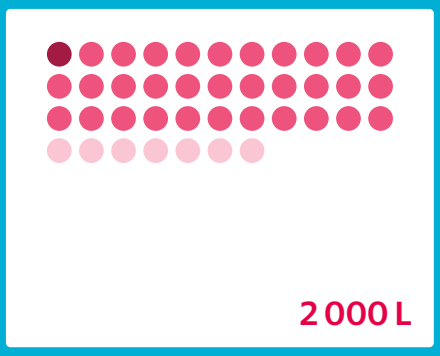
EUROPE

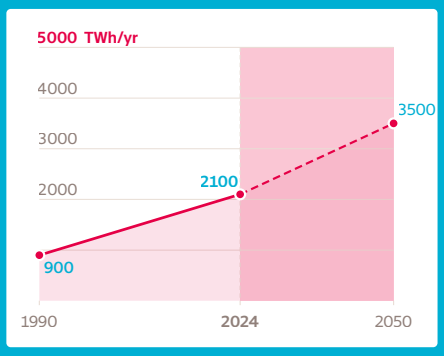


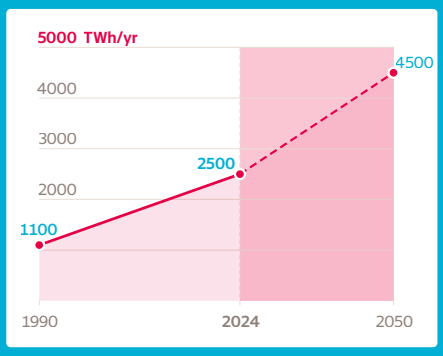




WORLD

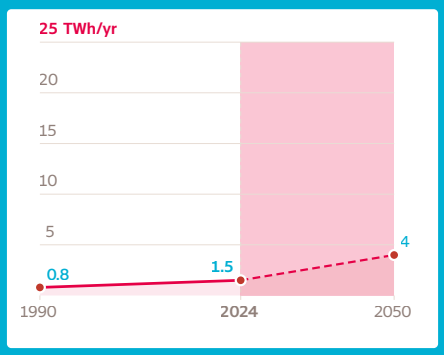




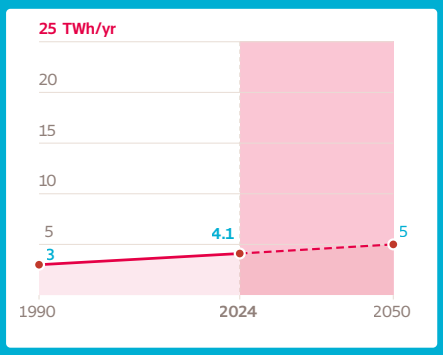


powering the world

PUMPED-STORAGE HYDROPOWER (PSH)



SMALL HYDROPOWER

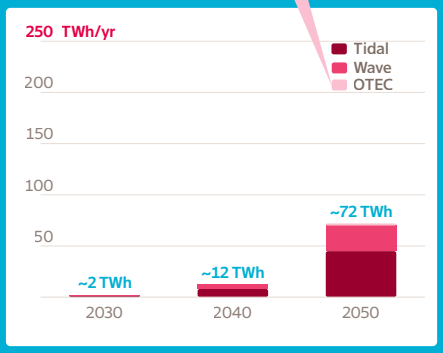


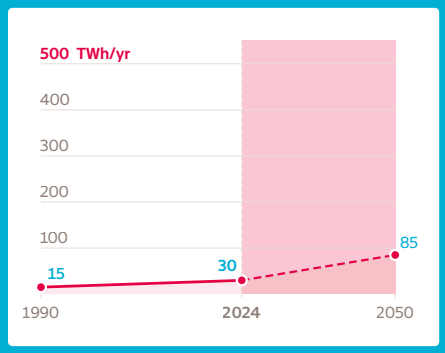
OTEC
Ocean Thermal Energy Conversion

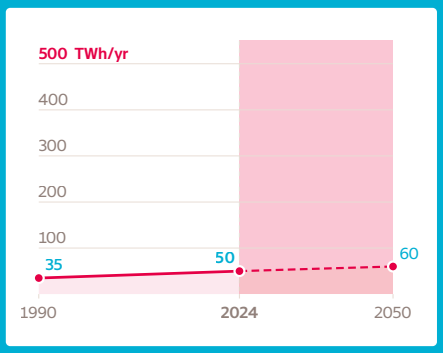
OTEC harnesses the temperature difference between warm surface waters (~25°C in tropical regions) and cold deep waters (~4–5°C at 800–1,000m depth).

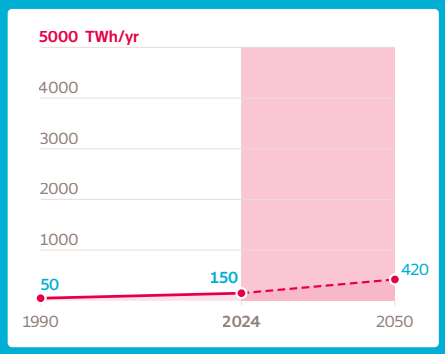
This difference of at least 20°C drives a thermodynamic cycle that powers a turbine to generate electricity.

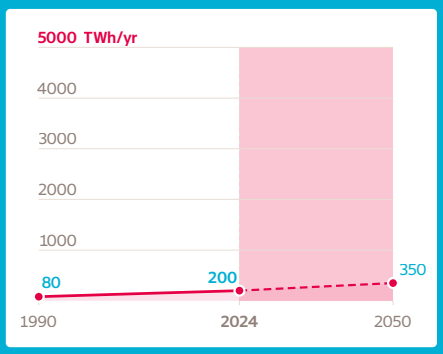
OCEAN ENERGY

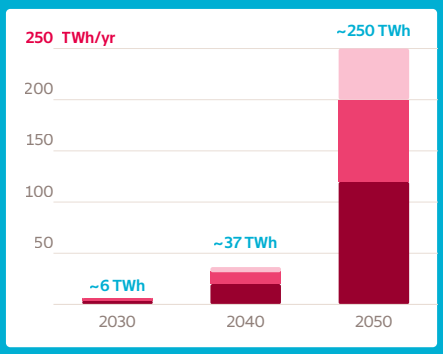












Sources: Ocean Energy Europe · JRC 2024 · IEA NZE · REN21

SAMUEL SCHÄR

“Nothing replaces your alma mater”

Since January 2026, Samuel Schär has been the CEO of Bühler Group, a leading Swiss industrial group in food processing and advanced materials processing technologies. For *Dimensions*, he explains the company’s impact on the products we consume every day and reflects on his personal journey, built on two pillars: his passion for science and his strong connection to EPFL, where he earned his degree in physics in 1999. **BY ARNAUD AUBELLE**

PHOTO: DR BÜHLER

When we first reached out to you for this interview, you shared a video of yourself in your lab at the Swiss Plasma Center, when you were only 16 years old. Could you give us some more context? How did your passion for science begin?
Science was an inherent passion for me. It was driven by curiosity, and I was lucky to have a very scientific family environment. Everything was there for me: my grandfather got me into electrical experiments, and I inherited a chemistry lab from my uncles.

At the core of that passion was always physics, and in 1992, when I was 16 years old and still in Gymnasium (high school), I was looking for some equipment to build a plasma accelerator. I got in touch with the Centre de Recherche en Physique des Plasmas (CRPP) in Lausanne and asked them for a high-voltage generator, an oscilloscope and other equipment.

They invited me to Lausanne. When they welcomed me at the train station, they were surprised: they were probably expecting an older scientist, and there was this little boy. They offered me the opportunity to work at the institute, and I arranged my schedule with my school to come to Lausanne every Wednesday and Friday and during all the school vacations. They also introduced me to Robert Keller, a former researcher at the institute, who became my mentor. It was all too good to be true!

In 1993, I spent some time in the US taking senior-level classes in electrical engineering, which helped a lot. Then I came back to Switzerland and finished my project at CRPP. It won several awards, including first prize at the 6th European Union Contest for Young Scientists in 1994, and I got invited to the Stockholm International Youth Science Seminar and to the Nobel Prize festivities.

How did all these early achievements lead you to join EPFL?
It's actually EPFL that invited me to study there. They offered to accelerate my education by allowing me to join without the maturité, and to complete the first and second year in one. That was a bit too fast for me, so I chose to complete my maturité (Swiss high school diploma) during the first year and proceed year by year, so I could still have a social life.

I loved the fact that it was a campus in itself, apart from the city. I also loved the spirit of the people and Lausanne as a city. I became a student assistant in the class of Professor André Châtelain, someone who has been very important to me, among others.

"Building a plant is a long-term commitment: equipment must perform over decades, future investments must be protected, and operators must be trained. Without skilled millers, even the best plant cannot fulfill its purpose. Equipment and service go hand in hand."

I was working very hard but still managed to take part in many activities: I learned how to scuba dive, I joined Fréquence Banane and Artiphys, and we traveled to China with my class. I also participated in the Challenge in 1996. Last winter, I met a student wearing an EPFL jacket and asked him who had won this year. He told me EPFL had won, and I told him we did too in 1996!

Given your strong passion for science, why did you choose to move into consulting and then industry rather than pursuing an academic career?
I really thought I would do a PhD and become a physics professor. At the end of my studies, I developed a passion for quantum electronics and lasers, and joined the lab of Prof. Ursula Keller at ETH Zurich, before coming back to Lausanne for my diploma.

During my thesis, I spent my days in a dark room building an infrared laser. I was wearing night-vision goggles all day long, adjusting mirrors and waiting for the laser to turn on. After two months, something clicked: it could not be my future for the next three or four years. I wanted to have an impact beyond scientific results. In 1999, I was approached by McKinsey. They made me an offer that was a fortune for me at the time, and I accepted it. However, I quickly got drawn into banking rather than technology projects, and my passion for science resurfaced.

I quit McKinsey and went to South America, backpacking for three months. When I came back, a friend from EPFL, who was founding his own company, invited me to join. I invested the pension fund I had accumulated, but the project did not work fast enough. I ran out of belief and money and had to look for a job. That's how I joined Bühler in 2002.

Bühler is not widely known by the general public, yet billions of people consume products processed through its technologies every day. Could you walk us through how its business is structured?
Bühler is a solution provider in the sense of delivering plants, equipment and services for processing industries in food and feed, as well as for a variety of other industries, mainly automotive, optics and inks. We call this business "Advanced materials." Bühler is a B2B company, and its customers use its solutions embedded in their value chains to produce their own products, so that's why end consumers may not know Bühler.

The company employs over 12,000 people, including 2,300 in Switzerland, and its business is very equally distributed around the world in 140 countries. The most revenue, at 30%, is generated by Europe, followed (at 24%) by the Middle East, Africa and India – all fast-growing regions with increasing populations. The rest is equally split between Asia and the Americas.

How do you see the company's impact on value chains and the end consumer?
The impact of our technologies on value chains is significant. If you bite into a piece of bread anywhere in the world, there's a good chance you are, so to speak, biting into Bühler. About 65 percent of the world's flour is produced in mills built by Bühler. For chocolate, it's 60 percent; for malting, it's 70 percent. If you drive an electric car, its cast parts, battery materials, and optical components may have been produced with Bühler solutions.

I'll give you a historical example to show that the spirit of innovation

was present from the beginning. The company started in 1860 as an iron foundry, and Adolf Bühler quickly realized that if you just make parts, there's a lot of competition. So he developed a special centrifugal casting process to create a hard grain structure. This made it possible to produce rolls suited for grinding wheat. Until then, milling relied on grinding stones that pressed down with great force but also wore themselves down, leaving traces of stone in the flour.

With these roller stands, it became possible to industrialize flour milling. Now, modern flour mills typically grind 300 to 1,000 tons per day.

Bühler's scope may seem broad, but there is a clear logic. The same unit operations can be applied across industries, allowing proven technologies to enter new markets. For example, die casting machines were initially developed for internal use, but customers asked for them as well. Similarly, technologies used for breakfast cereals are now applied to plant-based meats and to lithium-ion battery materials.

How do you combine production efficiency with health and safety?

The first element is hygienic design, which ensures there are no contamination points and that machines can be cleaned and maintained very easily. In addition, numerous control loops and monitoring systems are implemented to make sure industrial specifications are consistently met. In the flour industry, for example, the "ash loop" monitors and controls the ash content of the flour. Similar systems exist across many other applications.

You have spent most of your career at Bühler and became CEO in January 2026. What were the key turning points in your journey?

I started at Bühler in a special exploration initiative, testing new business models around an agitator bead mill for the ink business. It exposed me to many industries, and was an incredible training ground, a tech geek's Eldorado combined with solid development experience. That was my first turning point. Next, I became Managing Director of the business unit for this technology, my first larger P&L responsibility, leading a CHF 100 million business for four years. After an acquisition in optical thin film coatings, I joined the division's executive board and helped turn it around.

The third turning point came in 2020, when a close colleague passed away. I then became Chief Services and Sales Officer while still leading Advanced Materials. During the pandemic, it was a complex period. Two years later, I handed over Advanced Materials to focus on international customer-facing organizations, a path that naturally led to the CEO role I hold today.

As the new CEO, what are the main challenges and opportunities you face in this role?

I'm only the seventh CEO in Bühler's 166-year history. It's a family-owned company, and many of its customers are as well, so my role is to ensure continuity with evolution. A key challenge today is resilience, with some regions facing conflicts and disruptions. However, the diversified solutions portfolio across regions and industries keeps us stable through crises, from pandemics to wars. As for opportunities, in addition to Africa, the Middle East and India, we mentioned earlier, China is a focus for innovation.

Service plays a major role and will become even more central. It's not

PHOTO: DR BÜHLER

diversification; it's a natural extension of partnering with customers across the full life cycle. Building a plant is a long-term commitment: equipment must perform over decades, future investments must be protected, and operators must be trained. Without skilled millers, even the best plant cannot fulfill its purpose. Equipment and service go hand in hand.

How and in which areas can industrial companies have a meaningful impact on sustainability?
Energy efficiency is one area where the results are clear. For example, in lithium-ion battery production, switching from batch mixers to continuous extrusion lines reduces energy use by over 80%. In the food industry, flour mills generate side streams during processing. These can be repurposed for animal feed or converted into process heat or electricity, reducing overall CO_2 emissions compared with disposal.

For our own operations, as of December 2025, we had reduced our emissions by around 30% since 2019. But a larger part of our impact comes from the value chains of our customers. In 2019, we set a target that by 2025 our solutions should enable customers to reduce energy use, water consumption and waste by 50% each. Today, out of 15 major value chains, 11 have already achieved at least one of these reductions.

Sustainability is closely linked to operational efficiency: plants that run reliably and use energy effectively reduce costs while also lowering environmental impact. The work is ongoing, and we continue to explore solutions.

What are the roles of the innovation campuses you have at EPFL and in Uzwil?
Bühler's innovation satellite at EPFL focuses on early-stage exploration, partnerships with research labs and startups, and building a bridge between academia and industry. Not every project becomes a large business, but continuous exploration ensures that promising ideas can grow.

Our Cubic Innovation Campus in Uzwil, inaugurated in 2019, is part of a global network of 26 research and training centers. It allows customers to test recipes and processes at pilot scale, which is often not possible on their own equipment. Each site in the network has a specific role. For instance, in Kemptthal, we run The Cultured Hub with Migros and Givaudan. Startups can scale cultured food products from 100 to 1,000 liters in a fully equipped pilot facility, helping them validate concepts before investing in a plant. Overall, innovation and open innovation are clear priorities: around 5% of Bühler's turnover is invested in R&D.

How is AI impacting Bühler's business, and what role does your collaboration with the Swiss Data Science Center at EPFL play?
We take a very practical approach to AI, using it as a tool where it creates value. We were among the first industrial partners of the Swiss Data Science Center, and this partnership has already led to several applications.

One example is the malting process. There, we use AI models to analyze weather conditions and humidity in order to optimize the drying process. It is a critical balance: if you under-dry, there is a risk of spoilage; if you over-dry, you waste energy. AI helps identify the optimal point. We also use AI in grain milling, what we call the "smart mill." Multiple control loops are analyzed, and AI helps detect patterns that have reduced the risk of quality deviations by around 80%.

Is it challenging to recruit engineers?
The war for talent is obviously on. You have certain centers where a lot of talent is naturally attracted, like Lausanne or Zurich, and we are a bit outside of these hubs as well. What helps us is our purpose: to contribute to feeding and moving the world through technology.

As for recruitment, it is often about matching the right skill set. Sometimes we look for a specific skill, but that skill is not available, while other interesting profiles are. But even more important for us is cultural fit.

Are there specific skills that make a real difference for you? What can EPFL learn from that in terms of education?
We look first and foremost for strong fundamentals and this is something EPFL does very well. It provides rigorous training in core disciplines, while encouraging cross-disciplinary thinking and pragmatic problem-solving beyond traditional silos. That combination is exactly what we need: people who are able to take a holistic view of a problem, who understand what they can contribute, but also recognize the limits of their expertise.

They need to be comfortable stepping out and asking for help when necessary. That ability is critical, because complex problems are rarely solved in isolation. We often talk about the difference between a "know-it-all" and a "learn-it-all." For us, it is very clear: we are looking for people who are willing to continuously learn, adapt and collaborate.

You studied at both EPFL and ETH Zurich. Where does your heart lean?
Rationally, I have a strong connection with ETH Zurich: I lectured there and serve on advisory boards. But emotionally, I spent four years of my youth at EPFL, at an age when one's character is truly shaped. That naturally created a strong attachment, and nothing replaces your alma mater. So, my heart leans toward EPFL, and I wear that proudly, but it's all friendly rivalry in the end. The strength really lies in the ETH domain as a whole.

What advice would you give to EPFL students who are about to graduate and are thinking about their future?
Take full advantage of everything EPFL offers. Enjoy your studies but also have a social life: these years are formative, not just academically. And for your future, listen to your heart. Don't chase prestige or monetary rewards; focus on your passion. Where your heart points, the rest will follow naturally. It's simple, but it works: when you pursue what truly excites you, impact and success tend to follow. ■

BIO

1992
Joined the CRPP at just 16 years old

1999
Graduated in physics from EPFL

2002
Joined Bühler Group

2013
Appointed to the Executive Board, Head of Advanced Materials

2020
Named Chief Services & Sales Officer

2026
Named CEO of Bühler Group

Smart sweat patch helps doctors monitor high-risk pregnancies

An EPFL spin-off is developing a patch-like medical device that reads sweat biomarkers.

In Switzerland, nearly half of pregnancies are classified as high-risk. These pregnancies require close monitoring and more frequent check-ups. Yet anxiety and uncertainty remain a daily struggle for parents-to-be. To help attenuate the uncertainty, EPFL spin-off MoleSense is developing a needle-free patch that continuously monitors pregnancies – without disrupting the user's daily activities – by tracking the concentrations of specific compounds in sweat.

MoleSense's device channels the sweat on the wearer's skin through microscopic pathways to DNA-based molecular biosensors, which are capable of precisely recognizing complex compounds such as hormones and inflammatory proteins, even when present in extremely low concentrations. These biological indicators are converted into measurable signals that can be analyzed.

Early patient trials

The data collected by the patches are processed using predictive algorithms, which combine the different signals to produce actionable information. Continuously tracking molecular signals allows doctors to detect important biological changes that conventional spot tests simply miss. As more clinical data are gathered, the system should become more precise and allow for increasingly personalized monitoring.

MoleSense is already working with obstetrics specialists in Lausanne to evaluate how comfortable and practical the device is to use. MoleSense's technology has potential applications beyond pregnancy monitoring. The same approach is also considered in a wide range of other fields where urgency and market needs are clear, including assisted reproductive technologies and reproductive health care. ■ CÉCILIA CARRON

Variable-stiffness endoscopes enable treatment in hard-to-reach areas

EPFL spin-off Dexterous Endoscopes has developed a new generation of endoscopes that can switch from soft to rigid in a fraction of a second, combining reach with precise, stable intervention. These long, thin tubes, equipped with a tiny camera, provide the precision and force needed to dissect tissue and the ability to apply sufficient force on tissue.

PHOTOS: DEXTEROUS ENDOSCOPES | DR

The new approach developed by Dexterous Endoscopes is based on a mechanically segmented architecture. It achieves this high flexibility and rigidity through a series of interconnected segments that move freely during navigation and can be rapidly compressed to lock together, transforming the device into a stable, force-transmitting structure.

The team has already performed preclinical trials with surgeons in conditions closely replicating real surgical procedures at hospitals in Lausanne, Munich and London. And the surgeons' feedback has helped the engineers refine the device to better meet clinical needs.

A number of experts in Switzerland's startup ecosystem have taken an interest in the novel technology. Dexterous Endoscopes now plans to obtain regulatory clearances in the US and Switzerland to bring its device to clinical use in these markets. ■ CÉCILIA CARRON

NEW PODCAST

Drawing is about imagining, trying and starting over. Being an EPFL engineer is a bit like that too: a career is almost never built in a straight line. Launched in March 2026, "Dessine-moi... une ingénieure !", (in French), the podcast from the EPFL Alumni Women's Club (in French), highlights diverse personal journeys through authentic conversations.

Among the first episodes available on epflalumni.ch is Alex Vogler (SC'03), who discusses her international career path guided by curiosity and risk-taking, Laetitia Henriot-Arsever (IN'08), who shares her experience with leadership and taking initiative, as well as Khawla Belqadhi (GM'18), who reflects on the importance of strategic choices, mentoring and adapting to the unexpected. ■ AA

KANDOU AI RAISES $225M

Started in 2011 at EPFL as Kandou Bus, Kandou AI builds high-performance connectivity products for its customers across data center infrastructure, AI and consumer electronics. The company raised $225M (around CHF 180M) during an oversubscribed Series-A funding round. ■ SP

CEREBRAS MAKES NASDAQ DEBUT WITH RECORD-BREAKING AI IPO

In May 2026, Cerebras Systems completed the largest IPO of the year so far, debuting on Nasdaq with a valuation approaching $100 billion. Co-founded by Jean-Philippe Fricker, a graduate of EPFL, the company builds AI supercomputers, wafer-scale chips and cloud infrastructure for large-scale model training and inference. ■ AA

Out on a limb

This is a picture of someone taking a picture, although we can't see the object being photographed. Two colleagues, safely harnessed, seem to be enjoying themselves as they stand on scaffolding over 15 meters off the ground and skillfully manipulate a long extension pole fitted with a camera. They're exploring the inaccessible heights inside the Temple of Kom Ombo – a Greco-Roman sanctuary dedicated to the gods Sobek and Haroeris, located 40 kilometers north of Aswan. Thousands of tourists visit the temple every day, as it's one of the main stops on itineraries along the Nile. It's also the subject of research being carried out by an international, cross-disciplinary team of scientists led by Aurélie Terrier, an architect and archeologist at EPFL's Arts of Sciences Laboratory. She took this picture with her iPad.

Terrier's picture stands out for the juxtaposition between the ultra-modern instruments suspended on the pole and how the photos will ultimately be used, on one hand, and the two-thousand-year-old sculpted reliefs, on the other. It was the deserving winner in the Locations and Instruments category in the Swiss National Science Foundation's 2026 Scientific Image Competition. Commenting on the photograph, the selection panel said: "The strong lines of the image's composition frame the researchers in a somewhat unstable, even dangerous position, in a shot that contrasts modern and traditional tools."

Much of the Temple of Kom Ombo has been destroyed by Nile river erosion, earthquakes, the removal of stones for use in other structures, wear and tear and, more recently, hordes of tourists. It's the only large Greco-Roman temple in Egypt that hadn't been studied by modern architects – until this recent group of researchers took an interest in it.

Terrier has been working on this project since 2019 with the help of Postdoc.Mobility and Ambizione grants from the Swiss National Science Foundation. She and around 20 colleagues are collecting samples and taking pictures of the site in order to perform a complete architectural study. They are looking at the surrounding environment, how the spaces around the temple's religious features were built and developments in the construction methods and techniques used. For their study, Terrier's team is using advanced technology and equipment to unlock the past. "The work shown in this picture may seem improvised, but it will give us precise, high quality images," she says. "It's a good example of the power of the digital humanities – a field at the crossroads of social science and new technology."

Terrier and her colleagues plan to use the findings to develop a 3D computer model of the temple by 2027, providing researchers and the general public with a single tool that draws on all existing information sources. ■

ANNE-MURIEL BROUET

PHOTO : AURÉLIE TERRIER

A NEW CO_2 CALCULATOR

As part of its Climate & Sustainability Strategy, EPFL will launch its new CO_2 Calculator in the fall of 2026, an open-source tool designed to better understand the environmental impact of research activities.

Designed for laboratories, platforms, centers and departments, this tool will enable users to estimate CO_2 emissions per unit, as well as assess the carbon footprint of a project, equipment, or even future professional trips.

The calculator was conceived and developed entirely in-house. It is based on the GHG Protocol, the international standard for greenhouse gas emissions accounting. It specifically takes into account: buildings and energy, scientific equipment, purchases, professional travel, cloud services and AI, research infrastructure, as well as other sources of emissions such as food, commuting, waste, construction and renovations.

Beyond measurement, the goal is clear: to give the EPFL community the tools to better understand its impacts, identify areas for action, and support the transition toward more sustainable research. ■ AT

More info at:
go.epfl.ch/Green_Labs_en

Biosensor can improve the management of Parkinson's

Members of the BioSense EPFL student association are developing a biosensor that can continuously measure levodopa concentrations in people with Parkinson's disease. That's important because doctors often struggle to find the right dosage for a given patient.

"The right dose at the right time." That's the motto driving the team of around a dozen students developing the biosensor, which they plan to enter in this year's SensUs competition – an international event that will be held at the Eindhoven University of Technology from 24 to 28 August. Their innovative device stands to improve the lives of people suffering from Parkinson's, one of the most common neurodegenerative diseases worldwide. The team is part of BioSense EPFL, a student association with approximately 50 members from a variety of disciplines.

The biosensor is designed to continuously measure the concentration of levodopa in patients' interstitial fluid, which is the fluid in the spaces between cells. Levodopa is the drug most often prescribed to manage the symptoms of Parkinson's and has proven to be highly effective, but over time it becomes increasingly difficult to find the right dosage. "If it's too low, the drug is ineffective, but if it's too high, it can lead to dyskinesia, or involuntary muscle movements," says Alixe Kirbihler, a life sciences engineering student and one of the two team leaders, together with Niel Mistry, a robotics student. "Yet there's currently no way to constantly monitor the drug concentration within the body." What's more, the right dosage varies considerably from patient to patient based on many factors, including diet and exercise.

The project team is consulting with doctors and patients as they develop their device, so that it meets as many of their needs as possible. The team is backed by EPFL's MAKE program and a number of the School's research groups, and it's sponsored by two local nonprofit organizations: Défi Parkinson and Parkinson Move. "We're testing the use of aptamers, which are synthetic DNA strands designed to bind to levodopa molecules, causing the strands to change shape and acquire a negative charge that alters the electrode current," says Mistry. The team members point out that it's a novel approach and necessarily "risky." But they're prepared to spend their summer on it.

In any case, students in BioSense EPFL aren't fazed by long hours. The device for the SensUs competition is just one of several projects under way. "We believe it's important to boost the visibility of bioengineering and share discoveries in this area," says Tran Nguyen, a biomedical engineering student and the association's president. Other initiatives include BioSensing Days – a two-day event packed with expert talks and panel discussions on the topic of biosensing – the creation of an R&D group within the association, and the association's participation in Scientastic. The overriding goal is to make a difference where it matters most. "The right dose at the right time." ■ LAURELINE DUVILLARD

Inside science's blind spot: Why the Global South remains erased from view

Swiss science journalist Marion de Vevey explores the inner workings of academia to understand the forces that influence how knowledge is produced.

The scientific method presents itself as objective and universal, the product of shared human endeavor, free from competing truths. But is that really the case? Or are some voices sidelined in the production of scientific knowledge? During a trip to Uganda to study chimpanzees, de Vevey encountered a very different perspective on science – one shaped by the Global South rather than the Western world.

That encounter became the starting point for an investigation into science's blind spot. In her book, de Vevey explores the economic, philosophical, political, methodological, historical and social forces that prevent knowledge produced outside the West from breaking through into the mainstream. As she dissects the factors behind Western dominance – from the media and academic publishing to cultural bias, unequal funding structures and the very mechanisms of knowledge production – she reveals that scientific knowledge is far less universal than it claims to be.

During an investigation that spanned 18 months, de Vevey came face to face with what she describes as "the imbalances between science in the Global North and South," describing how "at every stage in the production of scientific knowledge, an entire part of the picture is erased from view," and noting that "the loss is twofold: human and epistemic."

Over time, what started as a piece of investigative journalism became something deeply personal. Writing in the first person, de Vevey describes how she discovered that scientific knowledge does not begin and end with the Western world – and how this realization forced her to confront "what I had considered untouchable, obvious or even taboo: my own ideologies." She goes on to admit: "As someone from supposedly 'neutral' Switzerland – the 'North of the North' in the world of science – I found myself questioning the very foundations of my worldview: objectivity, universality, determinism and truth."

Rather than simply laying out the problem, de Vevey dedicates an entire chapter to possible ways to address this imbalance. And she ends with a call to action: "Knowledge is everywhere. It's time for us to explore, together, everything that remains to be discovered." ■ ANNE-MURIEL BROUET

Tout ce qu'il reste à découvrir, Marion de Vevey, éditions Quanto, 280 pages, 27 francs (in French only).

Selection of books from La Boutique EPFL – laboutique-livres.epfl.ch

FROM A DROP TO TSUNAMIS

Water.
A fascinating journey through the water cycle, to understand its vital role in our daily lives and on our planet. Rain, drinking water, plants, tsunamis, purification and water conservation: this wonderful book clearly answers the questions of curious young readers and raises their awareness of the importance of preserving this vital resource. For ages 5 and up. ■

The Big Book of Water, by Sarah Garré and Marijke Huysmans, Delachaux et Niestlé, 59 pages, CHF 25.60.

A ROOF FOR THEM

Homeless.
At the crossroads of architecture, urban planning and social sciences, this book explores the place of homeless people in public space. Through analyses, field reports and international projects, it shows how urban design can exclude, but also protect, include and restore dignity. ■

The Roofless Truth – Planning and Architecture for Homelessness, Park Books, 432 pages, CHF 39.

MODERN ENLIGHTENMENT

Epistemology.
In a clear and witty dialogue inspired by Fontenelle, a marquise and a knight explore the major questions of contemporary epistemology: discovery, facts, probability, realism, thought experiments, modern science, biology, mathematics, the values of the scholar, and the relationship between science and religion. ■

Épistémologie pour une Marquise, by Pascal Engel, Eliott Publishing, 182 pages, CHF 25.70 (in French).

THE URGENCY OF LIFE

Infographics.
Understanding to take action. With over 200 concise, clear and precise infographics, this book allows readers to grasp the challenges facing ecosystems at a glance. A wealth of scientific knowledge that offers numerous insights into how to become an active participant in preserving the planet's living fabric. ■

La biodiversité en infographies, by Tatania Giraud, Tana Publishing, 135 pages, CHF 38.70 (in French).

PHOTOS: EPFL/ALAIN HERZOG | DR

How scientists prepare expeditions in remote environments

Scientific expeditions require months of planning before scientists can acquire the first data. BY HECTOR GARCIA MORALES

In 2020, Julia Schmale was stranded in the icy Arctic for four months.

"We are always tempted to collect as many samples as possible, but we have to face reality." Banc-Prandi.

A bark cuts through the Arctic silence, waking Anna up. She slept only three hours after collecting the last sample. Anna reaches for her rifle, exits the tent and steps onto the midnight ice. She pets the guard dog she rented a few days earlier. It might be a false alarm, but she scans the darkness for polar bears, hoping her training pays off. She cannot afford to lose the samples. Nor her life.

This situation was no accident. It was the culmination of months of planning that Anna Carratala Ripolles, a scientist at the EPFL Laboratory for Environmental Biology, underwent for an expedition to collect bacteria from Greenland's pristine lakes. Fieldwork offers scientists firsthand information about how the elements under study behave in a real environment, which is much more complex than in the lab. "Lab work can give you the answer under specific conditions. Fieldwork is what provides meaningful answers in complex natural environments," explains Carratala.

Months of preparation

Behind every research expedition are months of preparation. At that stage, scientists need to solve many open questions before they can collect their first samples and data. "The preparation of big icebreaker expeditions often begins a decade before the scientific work itself can start," says Julia Schmale, who leads the EPFL Extreme Environments Research Laboratory and conducts expeditions in polar environments to study climate-relevant properties of aerosols. "First of all, we define our goals and which tools and methods we are going to use to obtain the results," says Guilhem Banc-Prandi, scientific director of the EPFL Laboratory for Biological Chemistry and director of the Translational Red Sea Center.

Scouting and adaptability

Research teams take scouting trips to the region before deciding how to proceed. "We go scout, do some test observations, talk to the people and arrange everything before the intensive field observations can start." explains Schmale, who calls this "logistics rather than science." But even following the most detailed plan, the reality of the environment hits, and scientists face unexpected adversities: from lost scientific material to harsh weather conditions or the threat of polar bears. For that reason, a key aspect researchers need to develop is adaptability.

"Fieldwork is what provides meaningful answers in complex natural environments." Anna Carratala Ripolles.

Often, scientists have to make pivotal choices about their data collection strategies without compromising the mission's goals. "As researchers, we always want to take as many samples as possible, but there is a reality that we have to confront," says Banc-Prandi. For that reason, before going on an expedition, researchers conduct a feasibility study where they establish the minimum amount of data needed. For Carratala, safety comes first: "We do our best with what we have."

Total freedom

All this preparation and fieldwork allow researchers to observe the direct impact of the technologies they implement and how they change the way these ecosystems are preserved and the policies that emerge. At the same time, what happens in extreme environments has a direct impact on our everyday lives. "I see that the transformation of the Arctic, even if it seems very far away, has a significant impact on the weather patterns we experience in Switzerland," explains Schmale.

In the Red Sea coral reefs, the lakes in southern Greenland or the Arctic ice, remote landscapes provide scientists with a unique way to connect with nature. "Expeditions often represent total freedom and being exposed to nature without much protection," says Carratala, who confesses that "my family is not aware of many things I do in the field." Finally, all the preparation and risks paid off, and those nights on guard rewarded her with "the magical display of the northern lights, dancing across the sky and reflecting on the still, dark waters of the lake." ■

PHOTOS: EPFL/JULIA SCHMALE | EPFL/GUILHEM BANC-PRANDI | EPFL/ANNA CARRATALA RIPOLLES

EPFL

AFTER 21 EDITIONS OF *DIMENSIONS*, WE ARE TURNING A PAGE BY BRINGING THE PRINTED VERSION OF THE MAGAZINE TO AN END.

THE EDITORIAL ADVENTURE CONTINUES IN A NEW FORM: DIGITAL THEMATIC DOSSIERS, MORE RESPONSIVE, ENRICHED AND ACCESSIBLE AT ANY TIME, TO CONTINUE SHINING A LIGHT ON EPFL'S MISSIONS IN **EDUCATION**, **RESEARCH** AND **INNOVATION**.

WE INVITE YOU TO CONTINUE READING AND TO DISCOVER UPCOMING PUBLICATIONS ONLINE ON OUR WEBSITE:

epfl.ch