SUMMER 2021 01

Dimensions

THE MAGAZINE FOR **EDUCATION, RESEARCH AND INNOVATION** OF EPFL

REALITY REVISITED

A survival guide to the digital twenties

Medicine. Artificial aorta reduces blood pressure **Interview.** Rodrigo Schmidt, Senior Director of Engineering at Facebook **Anniversary.** The Rolex Learning Center turns ten **Startup.** The new Swiss unicorn

EPFL

Switzerland

Switzerland you

Do you have an industrial or R&D project?
Do you work for a fast-growing company?
Are you in touch with visionary entrepreneurs?

Think Switzerland.

Greater Geneva Bern area (GGBa) is the official investment promotion agency for Western Switzerland, bringing together the cantons of Bern, Fribourg, Vaud, Neuchatel, Geneva and Valais. We advise and assist foreign companies active in innovative sectors in setting up business operations in the region. Our support is tailor-made, free of charge and confidential.

www.ggba-switzerland.ch
info@ggba-switzerland.ch

GGBa Invest Western Switzerland

Parallels

You cry into the space
Which has to separate you.

You cry as loud
Toward that other space
That you cut in half

As if you were
In all time the only ones
Unable to meet.

Eugène Guillevic, one of France's most well-regarded 20th-century poets, was born in Carnac in Brittany. Though he started publishing during the height of the surrealism, his first book, *Requiem* (1938), steered clear of the movement's tendencies and tactics. Instead of surrealist images, Guillevic's poetry favored natural objects, spare diction and simple presentation and owed a debt to the fables of La Fontaine, which Guillevic knew by heart.

Martin Vetterli
President, EPFL

A new window on EPFL

In the middle of a challenging year, we have some good news: ***Dimensions***, the new EPFL magazine, has arrived. You're holding it in your hands. We're very proud, as it took endless surveys, conceptualizing, design trials, brainstorming and working groups to get it done. And it's all the better for it.

Dimensions is a joint venture between EPFL's communications team and the alumni unit. In fact, it's a merger of the former *EPFL Magazine* and the *Alumnist*, for those of you who remember. The result is an ambitious publication that moves away from an internal view of our School and our faculties. Instead, it aims to widen the window on EPFL and to make more of our work accessible to a broader public.

The new magazine will be published four times a year and distributed on campus, but it will also be sent to all EPFL alumni and partners, amounting to a projected circulation of over 35,000. Naturally, anyone can subscribe to it.

Each issue will feature an exclusive dossier on a societal topic, as well as the latest news, profiles and more. This inaugural dossier focuses on the multitude of worlds in which we increasingly live, and thus how deepfakes, digital twins, digital pedigree, game engines, and other forms of simulations affect research, education and other aspects of actual life.

Another highlight of this first edition is a revealing interview with Rodrigo Schmidt, senior director of engineering at Facebook AI. Schmidt is an EPFL alumnus and was one of the first people to be hired overseas by Facebook.

I would like to thank the minds behind this new magazine, and hope you find the first issue an exciting read. Feedback is always very welcome – both positive and negative, of course. ■

p. 20

p. 52

p. 19

PHOTO: OLIVIER CHRISTINAT

Architecture from every angle.
Between now and next spring, EPFL's Rolex Learning Center will hold a series of events to commemorate the iconic building's first decade.

p. 60


p. 55

Infographic.
Today, digitization makes it possible to create millions of molecular combinations, calculate the properties of the resulting materials and simulate their behavior.
p. 32


p. 48


p. 42

Dimensions 01

SUMMER 2021

NEWS

FOCUS

EPFL IN THE WORLD

CAMPUS

Pollution.
An ocean of plastic

In 2019, nearly 370 million tons of plastic was produced worldwide, including 58 million tons in Europe alone. Most of the plastic in Europe was used for packaging (40%), followed by construction (20%), car manufacturing (9%) and electronics (6%).

Around 11% of this plastic ends up polluting aquatic ecosystems. And most of it is made with additives to make it harder, more flexible and longer lasting. Some kinds of plastic will stick around for up to 400 years. As plastic decomposes, it usually breaks down into bits of microplastic (less than 5 millimeters long) and makes its way into aquatic, and eventually human, food chains.

A huge amount of effort will be needed to reduce plastic pollution. Essential steps include decreasing the amount of plastic waste we produce, managing such waste more effectively and remediating damaged environments. ■

Imitate

Francesco Stellacci, a professor at EPFL's Supramolecular Nano-Materials and Interfaces Laboratory, has been awarded a European Research Council (ERC) grant to develop a system that takes a circular approach to recycling plastic. His approach is to imitate the cellular mechanisms in which existing proteins are broken down to synthesize new ones. The difference is that, here, the molecules that will be broken down are polymers – the main ingredient in plastic. ■

Measure

EPFL's Central Environmental Laboratory issued a benchmark report in 2014 on the amount of microplastics in Swiss lakes. The researchers found that some places had pollution levels on a par with that in oceans. Today, scientists involved in the LéXPLORE research platform are studying how this pollution has changed since the report appeared and how water currents affect microplastic distribution. ■

lexplore.info

Recycle

EPFL spin-off DePoly, based in Sion, has developed an innovative method for recycling objects made from PET. The method involves using chemical reactions and light to break the polymer down into its two components: ethylene glycol and terephthalic acid. ■

depoly.ch

Reuse

Plastogaz, spun off from EPFL in 2020, has developed a system for turning plastic waste into methane for injection into gas grids. The firm also plans to develop systems for transforming various kinds of plastic waste into other compounds. The experts at Plastogaz are already working on a process for converting mixed plastics into naphtha, which in turn can be used to make new plastic. ■

plastogaz.com

Around 11% of plastic ends up polluting aquatic ecosystems.

© richcarey, iStock

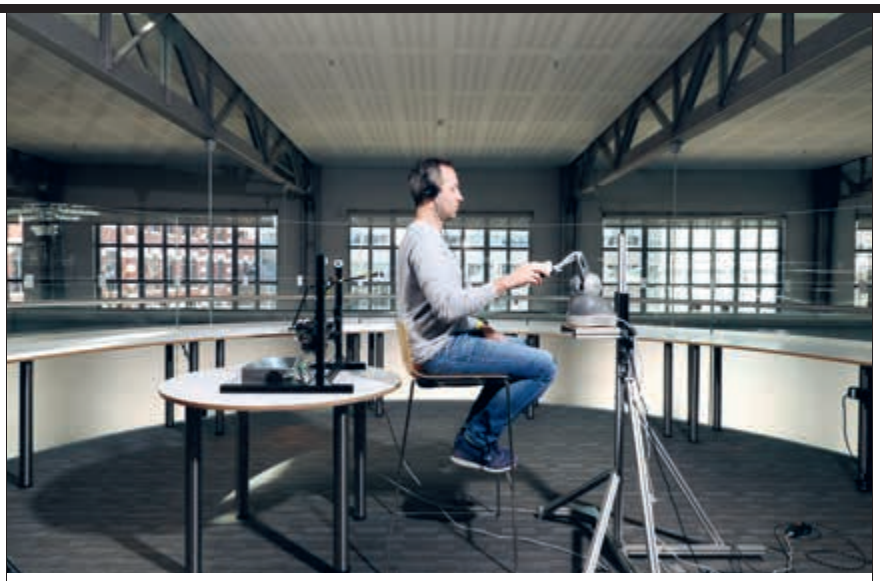
I help build sustainable
national roads.
I'm working for Switzerland.

Charles-Henri
Project Manager National Roads,
Civil Engineering

stelle.admin.ch

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Administration
Working for Switzerland



Scientists have identified, for the very first time, the neural networks in the brain responsible for presence hallucinations in healthy patients.

Neurosciences. Awakening "ghosts" in patients with Parkinson's

A brain test for evaluating patients' mental status involves awakening "ghosts" hidden in specific brain networks.

"We're developing something similar to a cardiac stress test, but instead of testing the heart, we're testing the brain," says EPFL neuroscientist Olaf Blanke. The brain stress test offers a new way of evaluating the onset of hallucinations in patients with Parkinson's disease. Blanke and his team have also found evidence of a promising biomarker for predicting the severity of the disease's progression. Their study involves 56 patients affected by Parkinson's who were recruited at several centers in Switzerland and Spain.
Parkinson's disease is well known for leading to slowness of movement, muscle stiffness and uncontrollable shaking of the limbs. But alterations of movement are far from being the only symptom of the disease. Roughly half of patients experience hallucinations of some sort, such as "presence" hallucinations. Peripheral vision hallucinations involving sightings of individuals, animals or spiders may also occur, as well as visual misperception of objects, or even fully colored and formed visual hallucinations.
A growing body of clinical evidence suggests that hallucinations may be precursors to the more severe mental and cognitive symptoms of Parkinson's. But hallucinations remain underdiagnosed. It may be that patients are reluctant to report them to their doctors, or that nonspecialist clinicians fail to ask about them or lack rigorous tools for assessing them.

Predicting the severity of the symptoms

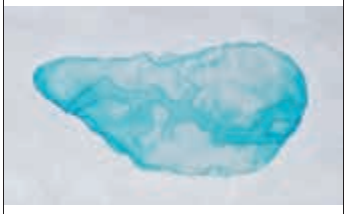
In a 2014 study, Blanke discovered that it was possible to induce presence hallucinations in healthy individuals within the setting of his laboratory. When subjected to a very robotic procedure, using specific movement and somatosensory signals, healthy individuals reported feelings of being accompanied by some sort of presence or person.
The scientists then tested the robotic procedure in a study of 26 patients with Parkinson's disease and obtained similar results. The findings allowed the team to identify for the very first time the neural networks in the brain responsible for presence hallucinations in healthy patients.
Building on that work, the scientists embarked on a third project involving a second group of 30 new patients with Parkinson's disease and were able to accurately predict the severity of the symptoms based on brain scans. ■

PHOTO: ALAIN HERZOG

HELP FOR PATIENTS WITH SPINAL CORD INJURY

Spinal cord injuries disrupt the mechanism by which the human body regulates blood pressure. A team from EPFL and the University of Calgary, Canada, have developed a treatment that allows patients to regain control of their blood pressure using targeted electrical stimulation of the spinal cord. No medication is required.
The team's findings build on research that has already enabled paraplegics to walk again through epidural electrical stimulation (EES). This time, the researchers delivered EES in the region containing the neural circuits that regulate blood pressure. The team also adapted the stimulation protocol in real time based on measurements taken by a blood-pressure monitor implanted in an artery. The monitor measures blood pressure continuously and, based on the values, adjusts the instructions sent to a pacemaker. The pacemaker in turn delivers electrical pulses to the spinal cord. ■

PRINT ME A PANCREAS



At first it's just a transparent shape on a computer screen – a small electronic replica of the human pancreas. Then, 30 seconds later, tissue emerges from a bioprinter, blood vessels and all, based on a sample of human stem cells. This amazing feat is possible thanks to new technology created at EPFL's Laboratory of Applied Photonics Devices and further developed by Readily3D. Their technology aims to develop a reliable living model of the pancreas for testing diabetes medications. ■

IN FIGURES

25.6%

SOLAR CELLS

A team led by EPFL has used a chemical tweak to push the power-conversion efficiency and operational stability of perovskite solar cells to 25.6% and at least 450 hours, respectively. The attractive structural and electronic properties of the perovskites have placed them at the forefront of materials research, with enormous potential for transforming a wide range of applications, including solar cells, LED lights, lasers and photodetectors. ■

Microfluidics. Identifying COVID-19 antibodies in tiny blood samples

Antibody testing is a powerful tool for tracking the spread of infection with SARS-CoV-2, the virus responsible for the COVID-19 pandemic. A group of scientists from EPFL, UNIGE and HUG have now developed a reliable and cheap antibody test that can analyze more than 1,000 samples simultaneously and requires only a small drop of blood, such as that from a finger prick.

The technology consists of a complex network of tiny tubes carved into a plastic chip about the size of a USB stick. To perform the assay, the researchers feed individual blood samples and test reagents through the channels of this "microfluidic" chip. If antibodies against SARS-CoV-2 are present in a blood sample, the antibody molecules generate a signal that is detected as a fluorescent glow under a microscope.

When the team tested blood samples from 155 individuals infected with SARS-CoV-2, the assay detected antibodies against the virus in 98% of cases. The assay is also extremely specific: it never detected antibodies against the virus in samples from people who had not been infected with SARS-CoV-2.

Because the microfluidic device is very small, the amounts of blood and reagents used are a fraction of those required for standard COVID-19 antibody tests. And running hundreds of assays on a single platform means that a person can perform more assays in less time, with potential cost savings in labor. ■

Alexandre Alahi and Lorenzo Bertoni came up with several possible applications for their program during a pandemic.

Computer science. 3D detectors measure social distancing

A team of EPFL researchers has repurposed an algorithm initially developed for self-driving cars to help people comply with social distancing requirements.

After spending several weeks reading up on how the COVID-19 virus is spread, the Visual Intelligence for Transportation Laboratory team at EPFL began to realize – along with the rest of the scientific community – that microdroplets play a key role in spreading the virus. They also realized that it's essential for people to maintain a distance of at least 1.5 meters if they're not wearing a face mask. Consequently, the researchers decided to tweak an algorithm they had designed to keep self-driving cars safely away from pedestrians, objects and other vehicles to provide a tool for social distancing.

EPFL's 3D detector, called MonoLoco, can easily be attached to any kind of camera or video recorder – even those sold by consumer electronics retailers – or to a smartphone. The detector uses an innovative approach that involves calculating the dimensions of human silhouettes and the distance between them. In other words, it estimates how far apart two people are based on their sizes instead of on ground measurements. Other innovative features of EPFL's algorithm are that it can identify a person's body orientation, determine how a group of people are interacting – especially whether they're talking – and evaluate whether they're staying 1.5 meters apart. That's all because it uses a different calculation method than existing detectors.

Several possible applications

What's more, MonoLoco keeps the faces and silhouettes of people who are filmed completely anonymous, because it measures only the distances between their joints (i.e., their shoulders, wrists, hips and knees). The algorithm takes a picture or video of a given area and converts the people's bodies into unidentifiable silhouettes sketched out with lines and dots. This information allows the algorithm to calculate how far apart the people are and their respective body orientations.

Possible applications of the technology during a pandemic include not only on public transport but also in shops, restaurants, offices and train stations – and even factories, since the algorithm would enable people to work safely by maintaining the necessary distance. Moreover, the distance requirement can be configured at up to 40 meters, whether between people or objects or both. Body orientation can also be configured. The researchers have published their algorithm's source code on the VITA website and are planning an initial deployment in Swiss postal buses through a joint project with Swiss Post. ■

PHOTOS: GRÉGOIRE MICHIELIN I ALAIN HERZOG

FAMOUS, BUT NO INFLUENCER

Thanks to their level of fame, celebrities are often considered to be influential. Indeed, many have used their status to campaign for various causes – consider Beyoncé's feminist activism or Leonardo DiCaprio's outspokenness on climate change. With this perceived influence, governments around the world regularly try to enlist celebrities as spokespeople in information campaigns.

But recent research from EPFL and UNIL has found that enlisting celebrities to change or influence people's opinions might actually be counterproductive, making an audience less empathetic toward the celebrity spokesperson rather than more.

In contrast to what was expected, a celebrity who had an opposing perspective was entirely unsuccessful in changing the respondents' previously held opinions. Even more interesting, an agreeing opinion voiced by a celebrity who was disliked also seemed to result in further entrenchment of prior beliefs. Overall, the findings appear consistent with people's tendency to surround themselves with those with whom they agree as a form of validation.

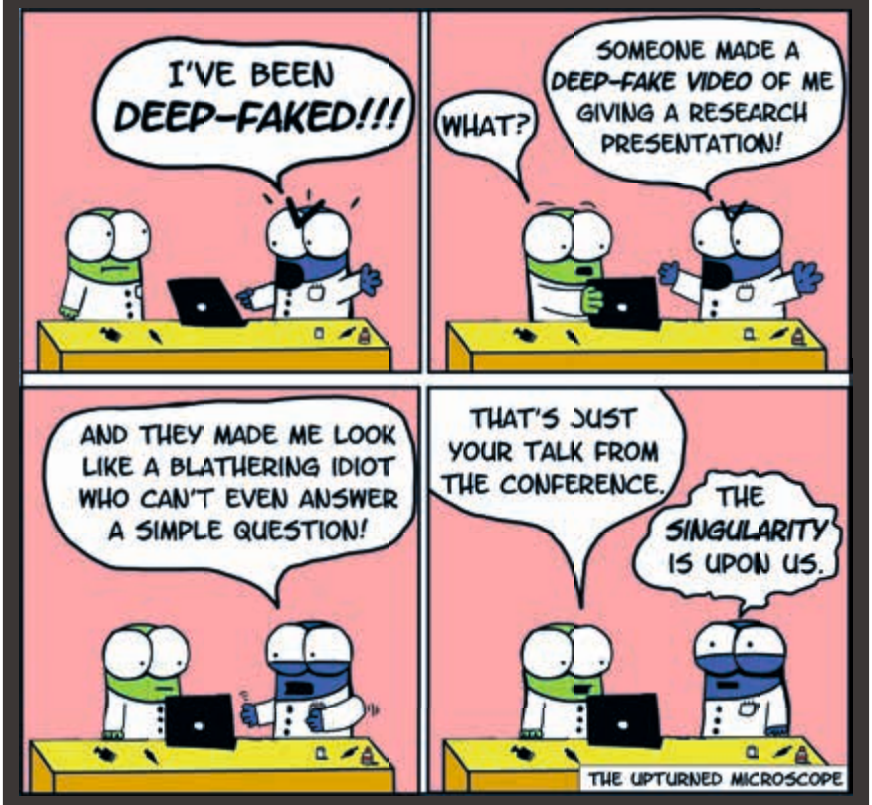
The researchers found a similar fortification effect with expert spokespeople, with respondents becoming further entrenched in their own opinion. The study showed that disagreement by an expert had a worse effect than disagreement by a disliked spokesperson, putting into question the perceived ability of experts to influence people in such situations. ■

The innovation

NEW DYE SHAKES UP SOLAR CELLS

EPFL scientists have developed a new dye for dye-sensitized solar cells, also known as Grätzel cells. The novel dye converts sunlight to electric power with high efficiency and is both simple and cheap to make. The dye also works exceptionally well under low-light conditions, which is key for self- and low-powered devices. ■

Cartoon Nik Papageorgiou



Environment. "If forests reach a tipping point, the climate impact will be huge."

The Amazon rain forest now emits more CO_2 than it absorbs, according to Charlotte Grossiord, an expert in forest ecosystems at EPFL. That could speed the pace of global warming.

The Amazon rain forest now emits more CO_2 than it absorbs. This reversal – confirmed by a study recently published in *Nature Climate Change* – marks a major milestone in the climate change process. And it's not good news. That's because tropical forests play an important role in keeping Earth's climate in balance, absorbing 25%–30% of the greenhouse gases emitted by human activity and serving as a brake on global warming. The Amazon alone accounts for half of the world's tropical forests. Charlotte Grossiord, an expert in forest ecosystems and head of EPFL's Plant Ecology Research Laboratory, spoke with us about the mechanisms behind this shift.

"Tropical forests play an important role in keeping Earth's climate in balance."

Charlotte Grossiord, head of EPFL's Plant Ecology Research Laboratory

Why should we be worried about this tipping point in the Amazon?

It's a critical issue. Over the past five to ten years, scientists have seen a clear decrease in the amount of carbon being absorbed by tropical forests like the Amazon. Until now, they have been absorbing more carbon than they emit. But once these forests are no longer able to remove as much carbon from the atmosphere as previously, that will accelerate the process of climate change.

Some people refer to this chain of mechanisms affecting the climate as a positive feedback loop. Is that what we're seeing here?

Yes, disappearing forests are a positive feedback loop. If more and more CO_2 is emitted into the atmosphere while ecosystems absorb less and less, the process of global warming will speed up, forests will absorb even fewer greenhouse gases, and so on. It's a big, vicious circle. For the Amazon, we can't really say whether the tipping point has already passed or is just around the corner. But it will certainly accelerate the pace of climate change. That doesn't mean it's too late to do something about it. We can still protect these ecosystems, which are also very important for the water cycle and biodiversity.

How do forests function as carbon sinks?

The trees of a forest remove CO_2 from the air through photosynthesis, converting it into sugar and using it to grow. Trees subsequently release some of this carbon back into the air through respiration, but most of it is held inside them and in the soil. When trees are chopped down, especially old ones, the carbon accumulated over the years or even centuries goes back into the air. That also happens when trees die as a result of fires and droughts, which are occurring more frequently. So it's a combination of factors that are bringing us to the point where forests emit more greenhouse gases than they absorb. ■

PHOTOS: JEAN-DAVID DÉCOPPET AND ALEJANDRA HAUSER I ALAIN HERZOG I DHLAB EPFL

URBAN DIGITIZATION

The ScanVan project, which lasted four years, developed a new technology to digitize cities. A collaboration between EPFL, the HES-SO Valais-Wallis and the University of Zurich, with funding from the Swiss National Science Foundation, the project was tested in Sion, offering a 3D model of the Valais capital. The technologies developed make it possible to envision scanning an entire city at regular intervals, thus creating a 4D representation of the city (3D + time).

Most existing scanning systems either use expensive laser-based systems or photogrammetric approaches based on standard photographic cameras. These methods are not error proof and therefore require several rounds of scanning. The ScanVan team developed an omnidirectional spherical acquisition system, associated with a dedicated algorithm that guarantees highly efficient scanning and photogrammetric computing. The 360-degree camera produces spherical images in regular increments while mounted on a moving vehicle (the ScanVan). In practice, the ScanVan need only pass once through a given street to acquire sufficient visual material for a 3D reproduction. ■

The innovation

QUANTUM COMPUTING: COLD CHIPS CAN CONTROL QUBITS

A specially designed chip to control qubits can operate at extremely low temperatures, and opens the door to solving the "wiring bottleneck." Researchers from EPFL and engineers from QuTech in the Netherlands and from Intel Corp. jointly designed and tested the cryogenic chip and made an important step toward a scalable quantum computer. ■

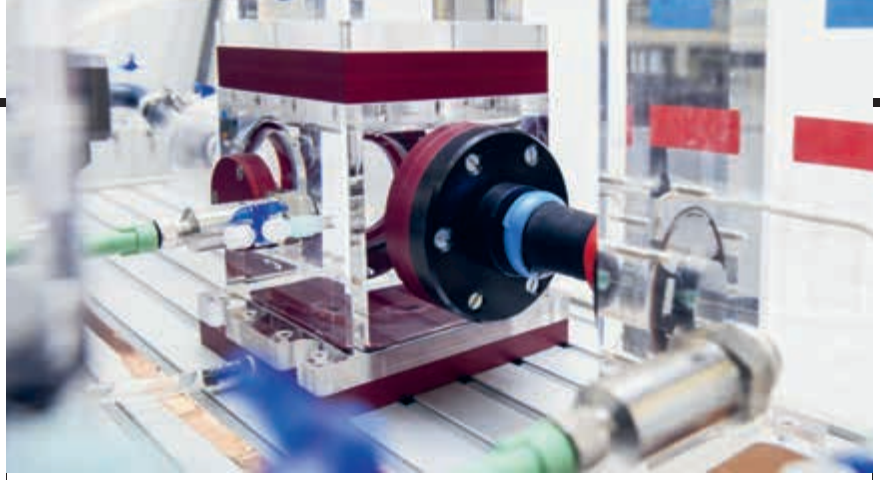
Health. Artificial aorta reduces blood pressure

Engineers at EPFL's Center for Artificial Muscles have developed a silicone aorta that takes a load off patients' hearts.

"Over 23 million people around the world suffer from heart failure. The disease is usually treated with a transplant, but because donated hearts are hard to come by, there is an ongoing need for alternative therapies. With new developments in cardiac assistance systems, we can delay the need for a transplant – or even eliminate it altogether," says Yves Perriard, head of EPFL's Center for Artificial Muscles. He and a team of around ten other engineers have been working on a new cardiac assistance technology over the past four years.

The human aorta is naturally elastic. It expands as blood is pumped into it from the heart's left ventricle, and then contracts to distribute the blood to the rest of the body. But in patients suffering from disorders such as heart failure, the heart has to work harder to accomplish this cycle. To ease the burden on the heart, EPFL engineers have designed an artificial aorta made of silicone and a series of electrodes. Their device is implanted just behind the aortic valve and amplifies the aorta's efforts, working like an "augmented aorta." When an electrical voltage is applied to the device, the artificial aorta expands to a diameter that's larger than the natural aorta. The advantage of the system is that it reduces the pressure on a patient's heart. The idea isn't to replace the heart, but to assist it.

To validate their system, the engineers built a simulator consisting of pumps and chambers that replicate the blood flow and pressure within a human heart. However, the real challenge lies in the manufacturing step. "We started from scratch and had to develop a new production process



PHOTOS: EPFL | FÉLIX WEY, WERNER SIEMENS STIFTUNG

to manufacture the new silicone-based tubular device. At the same time, the performance was drastically reduced compared to a single-membrane system," says Yoan Civet, a researcher on Perriard's team. "We had to troubleshoot the problem due to the multilayered structure and then come up with a solution."

The research team has filed a patent for their technology. The hope is that their discovery can be used to treat other medical conditions, such as urological disorders, that require a similar approach. ■

RESEARCH

This research was carried out under a joint initiative by ETH Zurich, the University of Bern and EPFL. The consortium has received a 12-year, CHF 12 million grant from the Werner Siemens Foundation to develop a cardiac assistance system, a urology system and a facial reconstruction system, all based on flexible actuators.

NEW HYDROGEL REPAIRS TEARS IN TISSUE

The body's soft tissues can be torn under many circumstances, for example, during a ski accident, a car accident or an accident in the home. Moreover, surgeons often have a hard time binding the tissue back together, and surgery doesn't always produce optimal outcomes because the repaired tissue usually doesn't heal properly.

Researchers at EPFL have come up with a novel family of hydrogel compounds that have two key advantages: the materials can be injected anywhere in the human body, and they show high intrinsic adhesion with no extra surface treatment. The hydrogel is injected in liquid form, but then sets when a light source is applied, enabling it to adhere to the surrounding tissue. ■

Join our innovation journey

Want to bring your ideas to life and accelerate your personal and professional growth?

Join us for an epic 6 month journey.

The Accelerator
Powered by Nestlé R+D

Climate. Rivers and streams emit more ☼ CO_2 at night

Streams and rivers – "running waters" – emit 27% more CO_2 at night on average than during the day.

Researchers are starting to get a clearer picture of the role that running waters play in the global carbon cycle. A team of EPFL scientists who previously showed that mountain streams and rivers emit more CO_2 (the main greenhouse gas) than previously thought have now made an important new discovery together with international colleagues. They show that CO_2 emissions from running waters are substantially higher at night than during the day. The finding suggests that calculations of how much CO_2 is released by these waters to the atmosphere have been biased too low, leading to incorrect estimates of their contribution to the global carbon cycle.

Researchers long thought that running waters were less of a factor in global carbon fluxes than the oceans, for instance. However, stream and river networks receive massive amounts of terrestrial organic carbon, which the water decomposes in a process that ultimately produces respiratory CO_2. Calculating just how much of this CO_2 is released into the atmosphere is very difficult due to the complexity of the networks that drain the continents. Until now, researchers have been basing their estimates primarily on measurements taken manually during the day.

That's where the scientists spotted the calculation bias. They found that 90% of existing measurements were made between 8am and 4pm. By comparing these measurements with data collected continuously by automated sensors, they discovered that CO_2 emissions reached their peak during this 8am to 4pm window just 10% of the time.

The scientists used automated sensors from 66 rivers around the world – including in previously underrepresented areas such as the Congo, the Amazon, the Arctic and various mountain ranges – to supplement diurnal measurements with measurements taken at night. Thanks to their meticulous approach, they found that CO_2 emissions were 27% higher on average during the nighttime hours. These results show how using automated sensor networks and large-scale environmental data sets can unravel yet unseen dynamics of stream ecosystems.

This difference is due to several factors. The main one relates to photosynthesis. Much of the CO_2 produced in rivers and streams is absorbed by photosynthesis during the day, reducing the amount that gets released into the atmosphere. Other factors that explain fluctuations in CO_2 emissions over the course of 24 hours include the vegetation, canopy shading, altitude, temperature, slope and turbulence of the water. ■

PHOTO: SBER / EPFL I ALAIN HERZOG

Researchers long thought that running waters were less of a factor in global carbon fluxes than the oceans.

DRONE SWARMS AVOID OBSTACLES

Flying in a swarm enables drones to cover larger areas and to collect a wider range of data, since each drone can be equipped with different sensors. One reason drone swarms haven't been used more widely is the risk of gridlock within the swarm. An EPFL team has developed a predictive control model that allows drones not only to react to others in the swarm but also to anticipate their own movements and predict those of their neighbors. Tests of the model show that swarms of drones are thus able to navigate cluttered environments quickly and safely. ■

HOW CELLS' POWER HOUSES MAKE THE CUT

Mitochondria, the energy providers of our cells, split in half to multiply within the cell. They also cut off their ends to get rid of damaged material. That's the take-away message from the latest research by EPFL biophysicists who are investigating mitochondrial fission. It's a major departure from the classic textbook explanation of the life cycle of this well-known organelle, the powerhouse of the cell.

Regulation of mitochondrial fission is important in understanding human diseases such as neurodegeneration and cardiovascular dysfunction, which are both associated with overactive mitochondrial fission. ■

In the media

Corriere della sera, 25 May 2021

"I look at the clouds and think of new equations."

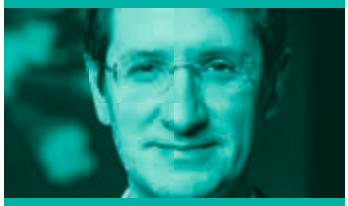
Maria Colombo, professor of mathematics at EPFL

Wired, 24 May 2021

"The coral is a gift of nature. Humanity has done nothing to deserve this, but we have it."

Anders Meibom, professor of biological geochemistry at EPFL

Open letter, 3 May 2021



"We are gravely concerned about the increasing criminalization and targeting of climate protestors around the world."

Athanasios Nenes, professor of environmental engineering at EPFL, together with 400 international scientists

Microtechnology. Lasers and virtual reality to revolutionize watch-crystal engraving

EPFL engineers have teamed up with luxury watchmaker Vacheron Constantin to develop an innovative system that uses lasers to create 3D sculptures within sapphire watch crystals.

Can a craft as old as watch-crystal engraving still be modernized? That's no trivial question, especially for traditional watchmakers like Vacheron Constantin, which was founded all the way back in 1755. The challenge is how to bring the craft into the 21st century, enabling artisans to use lasers to engrave watch crystals with the aid of a virtual reality headset to guide them.

A team of EPFL engineers located at Microcity in Neuchâtel worked with Vacheron Constantin for two years to develop a high-tech approach to watchmaking. The team employs high-intensity, ultrashort laser pulses – the same technology that won the Nobel Prize in Physics in 2018 – that are capable of changing the properties of a material. The discovery of these pulses opened up entirely new avenues of research. "Until then, it was impossible to work inside materials," says Yves Bellouard, associate professor at EPFL and one of the engineers. "I spoke with Richemont" – the company that owns Vacheron Constantin – "about how we could combine this technology with craftsmanship techniques, and applying it to watch engraving seemed like the perfect choice."

Emmanuelle Maridat, an engraver at Vacheron Constantin for the past 12 years, thought it was a great idea. She was excited about the opportunity to transform her profession by adding this new dimension. But laser engraving turned out to be a complicated endeavor, especially in terms of controlling hand movements in virtual space. It's not easy to etch lines deep inside a crystal using only a tiny beam of light and a digital pen. And the lines are too small to be seen with the naked eye. The research team tried several different viewing devices for their system: first a binocular device, and then a computer screen, before they finally settled on a virtual reality headset. But the headset still needed to be tweaked further.

The biggest difficulty, Maridat found, was not having any physical resistance as she moved the pen. "In my work, it's not just what you see and the shapes you perceive, but also your interactions with the materials – when you touch them, the resistance you feel on your cutter as it moves through metal and etches some of it away to create designs. With the laser, I didn't have any of that and lost my bearings," she says.

The various people working on the project faced a steep learning curve. The engravers had to get accustomed to using the high-tech tools – and, in the process, help improve the system – and the engineers had to think like craftspeople and find a way of restoring the physical link and the feeling of resistance. ■

PHOTOS: ALAIN HERZOG | DR

LESYA **SHCHUTSKA**

Tenure-track assistant professor, High Energy Physics Laboratory

"Pictures can be deceiving: a smile for the camera while climbing, but never again! The void beneath had me shaking the entire time."

"It took courage to add a cat to the unstable, peripatetic life of a researcher – but it was totally worth it! The cat even traveled with me and my family to a physics conference (photo post successful cat experience)."

In my life

1985
Born in Russia

1995
Read my first physics book *Physics for Entertainment* by Yakov Perelman

2002
Won a bronze medal at the International Physics Olympiad and entered the Moscow Institute of Physics and Technology (MIPT) without taking the entrance exam

2008
Started a PhD at EPFL to develop a detector to precisely measure cosmic rays and find traces of dark matter in the universe

2019
Awarded a Young Experimental Physicist Prize by the European Physical Society

"I got captivated by physics! It was love at first sight."

In my lab

2017
Got an ERC Starting Grant and started my group at ETH Zurich

2019
Moved to EPFL and came back to the LHCb collaboration at CERN

Sara Celani, doctoral assistant in my lab, won the best poster award at the Joint Annual Meeting of the Swiss and Austrian Physical Societies

Sara's "bestest" poster.

Lesya Shchutska's lab is searching for new particles, e.g. heavy neutrinos, elementary particles that have not yet been shown to exist experimentally.

On my agenda

What I want to do sooner (rather than later) is get together with my Phystech (MIPT) friends for sailing vacation where we solve math and physics problems under the sails (which hasn't been possible lately for obvious reasons).

REP REX

ITY TED

A survival guide to the digital twenties.

ILLUSTRATION BY LAURENT BAZART

THE DEEPFAKE ARMS RACE
PAGE 24

SIMULATED WORLDS
PAGE 26

SARAH KENDERDINE: "YOU SHOULD BE ABLE TO MOVE THROUGH A WORK OF ART"
PAGE 30

What might it be like to live in a simulated world? How close might we be posed in 2003 by Nick Bostrom, a Swedish-born philosopher at the University reality is, well, not real as we know it, but rather that the universe is

Whatever the reality, we are entering the hyper-digital twenties, where augmented, virtual and digital innovations will impact almost every aspect of our lives. From today's augmented reality glasses to the mixed reality Microsoft HoloLens, it is now possible to experience virtual objects that have become part of the real world.

These innovations offer many advantages. Digital twins already help engineers and architects make buildings stronger and will likely find use in other fields. In medicine, for example – where digital twins savvily combine AI and personal data – they have begun to transform the way health care is provided.

"Digital twins can cut health-care costs because they let doctors detect drug intolerances ahead of time and spot diseases before they reach the chronic stage. They can also reduce treatment errors, which are the third-leading cause of death worldwide after cancer and cardiovascular disease. All this implies considerable cost savings," says Adrian Ionescu, head of EPFL's Nanoelectronic Devices Laboratory.

However, as with many AI applications, digital twins that may become digital clones raise as many ethical and legal

From personal abuse and reputational damage to the breakdown of democratic politics through the manipulation of public opinion, deepfakes are increasingly in the spotlight for the harm that they might cause to individuals and society as a whole. Tanya Petersen discussed these issues with **Aengus Collins**, deputy director and head of policy at EPFL's International Risk Governance Center.

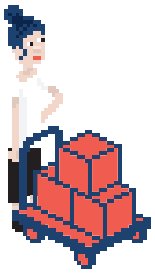
DEEPFAKE CHALLENGE

Will deepfakes become the most powerful tool of misinformation ever seen? Can we mitigate, or govern, against the coming onslaught of synthetic media?

Our research focuses on the risks that deepfakes create. We highlight risks at three levels: the individual, the organizational and the societal. In each case, knowing how to respond means investigating to better understand the risks of what and to whom. And it's important to note that these risks don't necessarily involve malicious intent. Typically, if an individual or an organization faces a deepfake risk, it's because they've been targeted in some way – for example, nonconsensual pornography at the individual level, or fraud against an organization. But on the societal level, one of the things our research highlights is that the potential harm from deepfakes is not necessarily intentional: the growing prevalence of synthetic media can stoke concerns about fundamental social values like trust and truth.

Can we prioritize, and if so how and where should we focus our energy on avoiding harm from deepfakes?

In our research we have suggested using a simple framework involving three dimensions: the severity of the harm that might be caused, the scale of the harm and the resilience of the target. We argue that this three-way analysis suggests that individual and societal harms should be the priority. Many organizations will have existing processes and resources that can be redirected toward potential deepfake risks. For individuals, the severity can be very high. Think about the potential lasting consequences for a woman targeted by nonconsensual deepfake pornography and the resilience required to deal with that. In terms of societal impacts, worries are rising about dramatic risks, such as the undermining of elections, but there is also the risk of a quieter process of societal disruption: a low-intensity, low-severity process that nevertheless leads to systemic-level problems if deepfakes chip away at the foundations of truth and trust.



MATERIALS SCIENCE: SIMULATION REPLACES EXPERIMENTATION
PAGE 32

HOW HEALTHY IS YOUR DIGITAL TWIN?
PAGE 34

Online version:
go.epfl.ch/RealityRevisited

to finding out, or do we live in one already? The Simulation Argument, first of Oxford, has had scholars ever since grappling with the idea that our perhaps a computer simulation. **BY TANYA PETERSEN**

questions as they answer. Sabine Süsstrunk, professor and head of EPFL's Image and Visual Representation Lab, says that AI and deep learning can't reason, but they can detect patterns much better than humans. "I would trust an AI system that has been trained on millions of mammograms to assist a doctor in detecting my breast cancer," she says. "But should we use artificial intelligence to suggest if a person is more likely or not to commit a crime or should be given a mortgage?" According to Süsstrunk, AI is only as good as the data that are used to train it. "If we let these systems make decisions," she says, "we're in trouble, because a lot of data is biased. There's not going to be a bias on breast cancer: you either have a tumor or you don't. Nor, for example, on soil quality: it's either good soil or bad soil. But AI has no legitimate role in policy or other subjective decision-making processes in business, politics or society."

But new worlds don't necessarily need to be full of digital clones and virtual realities. Do many of us already live in mirrored or alternative existences thanks to deep-and-shallow fakes? We are constantly exposed to digitally generated fake people and fake news, developed using deep learning and much simpler low-tech methods. To what extent do these fakes create virtual information realities? How will societies evolve when we can no longer rely on our senses, or physics, to determine whether something is real?

Despite being used in everything from public health campaigns to education, and in culture, deepfakes are now also notorious for their use in pornography, hoaxes and fraud. How do we even begin to think about regulating something that we may not be able to detect? And what are the legal implications of deepfakes in our globalized world?

The digital world of tomorrow raises a host of other philosophical questions that go far beyond our current dabbling in the technology. Why are we building second versions of realities, and for whom? Are we about to achieve the implied utopia of virtual reality for ourselves, or are we actually building "mirror worlds" for machines to better learn to navigate the human environment? What are some of the key technological breakthroughs that make these mirrored realities possible? Explore photo-realistic computer graphics and games as social meeting places, such as mega concert venues, and synthetic data.

To take a cue from *The Matrix*, "sit back and enjoy the ride" while you explore with us the future of mirrored worlds, deepfakes, digital twins and everything in-between. ■

TO TRUST AND TRUTH

But computers don't have values, so are deepfakes a technical problem or a fundamental societal problem brought to the surface with scale and accessibility?

At this stage the two are inextricable and I don't think it works anymore to say simply it's a human problem or it's a technical problem. Finding a common vocabulary or frame of reference for shaping the impact of technology on societal values is one of the biggest challenges both for policymakers and for developers of technology. Of course, technology is a tool but values can affect or distort the making of the tool in the first place. I think we see that tension quite prominently at the moment in debates around AI and bias.

This mix of technology, societal values, the interaction between the two, the biases of tech developers and globalization is incredibly complex. Where should we begin in thinking about the governance of deepfakes, and is it even possible?

It is incredibly complex. Innovation is moving at an unprecedented pace and the policy process is struggling to keep up. There's no simple lever we can pull to fix this, but there is quite a bit of work being done to make the regulatory process more agile and creative. Also, even though it can take time for policymakers to get to grips with emerging technologies, they can subsequently move quite quickly. For example, there has been a lot of movement on data protection in recent years, and developments with AI and social media platforms may be starting to come to a head. Policymakers are catching up and are starting to draw some lines in the sand. Maybe some of these precedents will help us to avoid the same mistakes with deepfake technology. ■

Stories of fakes, forgeries, fortunes and folly have intrigued people throughout the ages, from the Athenian Onomacritus, who around 500 BC was said to have been a forger of old oracles and poems, to Shaun Greenhalgh, who between 1978 and 2006 infamously created hundreds of Renaissance, Impressionist and other art forgeries, amassing more than a million euros and ultimately spending time in prison. BY TANYA PETERSEN

THE DEEP-FAKE ARMS RACE

At the beginning of the digital twenties, with increasingly easy access to the AI and machine learning that create deepfakes, as EPFL professor Touradj Ebrahimi says, "we are at a tipping point. We have democratized forgery, and once that has happened, trust disappears."

Deepfakes are a synthetic media in which a person, or thing, in an existing image or medium is replaced with someone or something else's likeness to create fake content. They are developed using deep learning methods and involve training generative neural network architectures, such as autoencoders or GANs – generative adversarial networks.

DEEPFAKES IN THE GARDEN OF GOOD AND EVIL

Despite exploding onto the scene only four years ago, deepfakes are now notorious for their use in nonconsensual celebrity and revenge pornography, fake news, hoaxes and fraud. But there is a positive side too.

The technology has been used in everything from public health campaigns to education and cultural installations. In late 2020 the former professional footballer David Beckham was digitally transformed into a 70-year-old man for the Malaria Must Die So Millions Can Live campaign. Historical figures have been brought back to life in museums, for example, Salvador Dalí "appearing" at the Salvador Dalí Museum in St. Petersburg, Florida.

In entertainment, deepfake technology is used to create locations and to enable "ghost or hologram acting." In the 2019 film *Star Wars: The Rise of Skywalker*, for example, Carrie Fisher was featured as Princess Leia three years after the actor's death.

THE END OF THE SUPERMODEL

In another corner of EPFL, Sabine Süsstrunk, professor and head of the Image and Visual Representation Lab in the School of Computer and Communication Sciences, demonstrates her latest work.

"We took the pretrained StyleGAN2 model and found the semantic vectors that create the eyes or mouth or nose, refining them so we could edit locally. Say you are creating a fake image and you like it, but you don't like the eyes. You can use another fake reference image and start changing them. Now we can even change mouths and eyes and ears without needing a reference image. I can easily modify a face from serious to a smile, from big eyes to small, nose up, nose down."

A key potential use of these deepfakes is advertising. As Süsstrunk says, it might be the end of the supermodel. "These are fake people pretending to be a fake something. You have no copyright issues, no photographer, no actor, no model. We can't do the body yet, but that's just a matter of time."

It's these kinds of images that Ebrahimi's research is targeting. As head of the Multimedia Signal Processing Laboratory in the School of Engineering, he has worked in compression, media security and privacy throughout his career. Four years ago he also began focusing on a new problem – how AI can be used to breach security in general. Deepfakes are a clear example of this.

A GAME OF CAT AND MOUSE

"As the problem is caused by AI, I wondered whether AI can also be part of the solution. Can you fight fire with fire?" he says. "We create deepfakes and detect them, making the algorithms challenge each other, getting better in what they do. But it's an arms race, or a game of cat and mouse. And when you're in that game, you want to make sure you're not the mouse. Unfortunately, we are the mice and this game is not winnable beyond the short term."

In addition to detection, Ebrahimi has also started working on the idea of provenance, the issue that brought down master forger Shaun Greenhalgh in the early 2000s. In digital media it's an approach in which metadata is embedded in content when it's created, certifying its source and history. One industry initiative is the Coalition for Content Provenance and Authenticity (C2PA), led by Adobe, Microsoft and the BBC. In parallel, Ebrahimi is working with the JPEG Committee to develop a universal, open-source standard under the International Organization for Standardization (ISO). Provenance won't prevent manipulation, but it should transparently pro-

vide end users with information about the status of any digital content they encounter.

TECHNOLOGY VERSUS SOCIETY

Süsstrunk agrees that detection is a short-term game, and supports provenance, adding that her most recent deepfakes would be undetectable because the digital assets contain no artifacts. She would also like to see the conversation focused as much on the philosophical as on the technical.

"We need to get more sophisticated in explaining what digital and AI actually mean. There is no intelligence in artificial – I'm not saying we won't get there, but at this point in time we are misusing the terminology. If somebody creates a deepfake, there's no computer system trying to screw with you. There's a person with either good or bad intent behind it. I truly believe that education is the answer – this technology is not going away."

"Often these deepfakes will be shared in closed social media groups that we don't have access to. There's a whole closed world that is a conduit for any kind of fake information that the rest of us will know nothing about. That is not a technical discussion anymore, but one that includes societal values and the regulation of tech companies."

Looking ahead, Ebrahimi is concerned about a lack of provenance or standardization activity beyond visual information. "Recently, we were asked by Swiss television to create a deepfake of the Swiss President Guy Parmelin, and those who detected that it was a deepfake did so from the audio, not the video. Even if you have perfect audio and a perfect video, the synchronization between the two is extremely difficult to handle. I want to deal with deepfakes in a multimodal way, to address the relationship between audio and video. I'll also be working on the tools for the security of provenance – if you can forge the content, you can forge the metadata. So this will be critical to making that approach work." ■

“Ever have that feeling where you’re not sure if you’re awake or still feeling sometimes, Neo. In “The Matrix”, right at the beginning of the movie, realness of his everyday reality, although he has seen nothing of the Matrix from a dream state? Is he, or are we all, maybe just experiencing a shadow

dreaming?” Guess we all have that Neo already has some doubts about the yet. How do you tell actual perception world? **BY ROLAND FISCHER**

SIMULATED REALITY

It’s a surprisingly old thought. We hardly had to wait for virtual reality (VR) to come along or Hollywood to dream up this dystopian semireligious tale: humans being kept in an unconscious state by intangible evil machines. The “dream argument” is (at least) as old as Western thought, formulated in antiquity by Plato and Aristotle. And in *Meditations*, Descartes famously wrote, “On many occasions I have in sleep been deceived by similar illusions, and in dwelling carefully on this reflection I see so manifestly that there are no certain indications by which we may clearly distinguish wakefulness from sleep that I am lost in astonishment.”

In a more contemporary form, as “simulation theory,” the idea has been particularly popular in recent decades, especially

in Silicon Valley circles. Its proponents include major tech figures, the most famous perhaps being Elon Musk. "If you assume any rate of improvement at all, games will eventually be indistinguishable from reality," Musk recently said in a podcast, before adding: "We're most likely in a simulation." The idea: Some higher life-form runs a simulation – the motivations behind this differ – and we are nothing more than artifacts in this simulated world. The evolution as an experiment, the world a petri dish. We are made to believe that we exist – but actually, we are not even a dream. We are bits and bytes, that's all. Reality is somewhere else, on a server farm in a different dimension maybe.

Sounds a bit like *Second Life*. Remember *Second Life*? The simulated world made featuring clumsy graphics and oversaturated colors, where people wandered around as avatars? "*Second Life* is still there, actually," says Jean-François Lucas, external collaborator at EPFL's Urban Sociology Lab and expert for digital cities, the sociology of innovation as well as virtual worlds and video games. He studied the phenomenon back in the day and has since turned to other interests, but he estimates the number of regular users is still around 50,000. "There's a range of different motivations to spend time in such virtual spaces," he says, one of them a very social one – it's about meeting people. He thinks that such second versions of the world will always be complementary; they will never replace the "first" version. He doesn't believe that "we could build a perfect representation of the world, perfect for every single one of us." What would perfection mean in that context, anyway? A perfect copy or a perfected, upgraded version of the more or less defective world out there? This is all getting very philosophical again, as in Luis Borges's short story *On Exactitude in Science*. In the story, Borges imagines the quest for a perfect world map: "In time, the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it."

THE MIRROR WORLD IS TAKING SHAPE

Point for point, pixel for pixel. What if it's not really a coincidence that simulation theory has attracted such a following in the years since *The Matrix*? Because, in fact, we are actually building these simulations of the world – for real. The mirror world is slowly taking shape. The term "mirror world" was first coined by Yale computer scientist David Gelernter and made famous by Kevin Kelly, founder of *Wired*, when he put it on the cover of the March 2019 issue of the magazine.

The mirror world is actually more than a map, and is not just an updated version of *Second Life*. In his *Wired* piece, Kelly wrote of "emerging digital landscapes" that will feel real: "they'll exhibit what landscape architects call placeness." What he meant is that in this second reality, overlying the one we know, representation of things will be more than mappings of the real counterpart. "A virtual building will have volume, a virtual chair will exhibit chairness, and a virtual street will have layers of textures, gaps, and intrusions that all convey a sense of 'street.'"

GAMING COMPANIES AT THE FOREFRONT

Science fiction? Recently, a range of companies have come up with very impressive mapped worlds, some of them representations of ours, others dreamlands. There's a strikingly common point with all these companies: they all have to do with the gaming industry. The first reason for that is obvious. The technology behind games has evolved so rapidly over the last decade that suddenly game environments are starting to feel like whole worlds. And thanks to artificial reality (AR), some gaming experiences are actually spilling over into the real world. Imagination is merging with – or actually becoming – reality. And as users, we are actively helping to build these simulations: Niantic, the company behind *Pokémon Go*, is currently building a 3D map of the world, hand in hand with its player base. As John Hanke, founder of Niantic, told *Wired*: "If you can solve a problem for a gamer, you can solve it for everyone else."

It's thus not really surprising that the entertainment industry is behind some of the most daring developments in world simulations. The Unity engine, first developed strictly as a platform for games, is continuously extending its range to other applications – in 2019 Disney used it to create backgrounds for *The Lion King*. And the blockbuster game *Fortnite* recently launched a series of big live concerts. The biggest one, by Travis Scott, attracted more than 12 million viewers. It might not be so far-fetched to imagine movies and games converging into one and the same genre soon.

Wenzel Jakob is not entirely convinced, however. Jakob, who leads the Realistic Graphics Lab at EPFL's School of Computer and Communication Sciences, has helped develop some of the algorithms used in rendering these digital realities. "Yes, we have become very good at rendering photo-realistic images – you can see that in the cinema." But this process is resource-heavy and expensive, says Jakob: "It can take up to eight hours for a single image." Hollywood can do it, but to achieve the same level of photo-realism in games would require another quantum leap in rendering algorithms. Nonetheless, watching the latest demos using Nvidia's ray-tracing technology (a novelty that "shook the world" – at least Jakob's) and Unity's Unreal Engine 4 feels like

How to solve complex inverse problems – and make the world a better place

For a computer scientist like Wenzel Jakob with a strong mathematical interest, algorithms are more than just lines of code. They aggregate long sequences of mathematical operations whose behavior can be controlled and modified using mathematical tools for surprising and unforeseen applications. That's also the basic idea of a neural network, which can be thought of as a kind of "template algorithm" that could become any number of different things. The mathematical enabler behind all of this is a cunningly clever method called reverse-mode differentiation, also known as backpropagation in the context of AI. It boils down to running the code in reverse and adjusting it along the way, turning the template into something actually useful. This idea extends far beyond neural networks. For example, Jakob's previous research focused on methods of producing photo-realistic images, a classic application of "forward" simulation of physical equations. Running such simulations in reverse turns out to be an astonishingly fruitful approach for many complex problems. Potential applications range from extracting information from medical images to analyzing large chunks of satellite images in climate science. Suddenly, a mathematical field that previously mainly served the needs of the entertainment industry has become a treasure trove of useful tools "to make the world a better place," as Jakob puts it. If simulations (of light effects, but also many other things) are "forward-thinking," then going in the opposite direction – from an image or a resulting constellation back toward its genesis – offers plenty of insight into the inner workings of that specific topic. ■

a glimpse into this future. "Games are maybe ten years behind, it's probably only a question of time," says Jakob. Meanwhile, he's moved one step further already (see box).

The second reason why development of the mirror world is being pushed by the gaming industry is much less intuitive. It has to do with AI. Nvidia might have started their graphics processing unit business mainly in the gaming industry sector, but it has developed into a crucial provider for AI hardware. In what looks like yet another instance of worlds converging, the company recently announced its plans to build a "metaverse": "Every single factory and every single building will have a digital twin that will simulate and track the physical version of it. Always," said Nvidia CEO Jensen Huang in an interview in *Time*. These twins will not only serve as testing grounds for software. According to Huang, every code and its function will first be simulated and optimized in the digital world before being downloaded into the physical version. It will also become a more and more valuable training ground for AIs.

LAYERS OVER LAYERS OVER LAYERS

I first came across this idea at Applied Machine Learning Days in 2020. Danny Lange, vice president of AI and Machine Learning at Unity Technologies, gave a fascinating talk titled "Simulations – the New Reality for AI" at the SwissTech Convention Center. He explained how real-time 3D video gaming technology can be used to generate "practically infinite amounts of synthetic training data whether for supervised learning in computer vision or unsupervised reinforcement learning." Anyone familiar with the bottleneck of collecting enough quality data for the training process will realize how much this could change AI paradigms in the future.

So maybe we're doing this for the machines rather than for us. Whoever benefits most, the result will be total interconnectedness, Kelly believes: "Everything connected to the Internet will be connected to the mirror world. And anything connected to the mirror world will see and be seen by everything else in this interconnected environment." That might in turn give machines acting in the real world superhuman abilities. They will have a networked superperception: when a robot is finally able to walk down a city street, it will not see our world, but the mirror world version of that street. It will have devoured previously mapped contours of the city landscape and will be able to merge thousands of sensor perceptions. It will be able to look around corners and through walls, because other robot eyes will already have been there. Simulations overlaying synthetic data overlaying the Internet of Things.

Sounds a lot like a robot overlord tale from Hollywood. Or some techno-utopian vision of an über-world. Jean-François Lucas knows the routine: "We keep reactivating old myths about some super-reality; it's basically the same story over and over again in different disguises. Technology has advanced, but the narration pretty much stayed the same."

Other tales sound familiar too, but strike darker chords. Remember the famous *Black Mirror* episode "Be Right Back," a modern version of Frankenstein? Again, fiction seems to become reality, as some companies are starting to offer customized chatbots imitating loved ones that have passed away. And with the recent – and truly astonishing – progress of language models (GPT3 as the current state of the art), we can expect to engage deeply with virtual characters in games as well as in our day-to-day realities. As we tend to live more and more of our social lives on digital platforms, these characters won't actually need an embodiment. Machines are already responsible for the majority of social media content. We know that, and we tend to believe we can live without bots easily, but that is bound to change in the years to come. So, inevitably, our reality will feel more and more like a mixture of the real and the simulated.

That, by the way, touches on the eternal problem of VR: How far away from the real can simulated worlds shift? Some say the actual breakthrough will come with AR – in that case, we will have to wait for the return of Google Glass or a competitor. Others already call it XR: mixed reality. But we still have to learn about these realities, and some valuable lessons might also come from the Immersive Interaction Research Group at EPFL, led by Ronan Boulic. A visit to his lab can be a strange experience. In *The Matrix*, Choi has a good answer to Neo's question, by the way: "All the time. It's called mescaline, it's the only way to fly." The mescaline of our days may well be VR goggles. Or at least they can give you pretty trippy experiences. Like seeing your hand as a digital copy, lying on a table, just the way it actually does in front of you. Except that if you lift your index finger, what you see is your middle finger going up. And vice versa. Try commanding the two fingers for a while, and something in your brain goes haywire. WYSINWYG: What you see is not what you get. The aim of the Immersive Interaction Research Group is a mixture of neuroscience and practical VR research, as doctoral student Loën Boban explains. How much "unrealness" can one tolerate in VR and still believe the simulation? The glove experiment, as simple as it is, shows that there's certainly no clear line to draw here. Boulic believes that given our current technological means, we are still "far away from the matrix." For him, the "hard frontier" is a mechanical system to actually act in: "Huge progress has been made in tricking the audiovisual perception channels, but that's only part of the felt reality; it's another story to simulate the senses of balance, body movement and interaction with the environment without risking actual pain." In other words: there's always a wall or a chair in the way when you want to dive into and run or fly around in realistic VR worlds. And how do you simulate a steep hill climb if you're at home in your small apartment?

VIRTUAL WORLDS WITH NO EXITS

"Mirror worlds immerse you without removing you from the space," writes Keiichi Matsuda, former creative director for Leap Motion, a company that develops hand gesture technology for AR. "You are still present, but on a different plane of reality. Think Frodo when he puts on the One Ring. Rather than cutting you off from the world, they form a new connection to it."

That's a vision slightly different from the one science fiction writer Stanisław Lem imagined in 1964. In the sixth chapter of his highly readable collection of essays titled *Summa Technologiae*, Lem imagined a technology called "phantomatics" that "stands for creating situations in which there are no 'exits' from the worlds of created fiction into the real world." No red pill, that is. But would that be all that bad if the illusion were pleasurable?

What can a person connected to a phantomatic generator experience? Everything. He can climb the Alps, wander around the Moon without a spacesuit or an oxygen mask, conquer medieval towns or the North Pole while heading a committed team and wearing shining armor. He can be cheered by crowds as a marathon winner or the greatest poet of all time and receive a Nobel Prize from the hands of the Swedish king; he can love Madame de Pompadour and be loved back by her.

Sounds great, no? But we are back to the dream argument. Will we even want to keep living in a deficient reality if there's a much better simulation? And could we be tricked into believing that the simulation is actually real? Loën Boban is a bit at a loss when a visitor brings up the topic. A specialist in robotics, control and intelligent systems, she does not understand the fears; rather, she sees an incredible opportunity: "We could create a world where everybody has superpowers; we could visit places we otherwise would never have the chance to see; we could have close connections with people far away." She doesn't believe that this upgrade would be a bad thing. Indeed, she can well imagine exchanging our real experience of the world with this virtual one. But until then, there's a lot of basic research to be done. "I would be very proud and very happy if I could contribute to the development of such a technology." ■

Sarah Kenderdine certainly has something to say about the state of the art(s) and the future of museums. For at least 20 years she has worked at the forefront of interactive and immersive experiences for galleries, libraries, archives and museums. We asked the current head of the Laboratory for Experimental Museology at EPFL about the aura of digital works of art and her upcoming exhibition Deep Fakes: Art and Its Double. **BY ROLAND FISCHER**

Is all art necessarily fake?
Well, no, of course not – but the tension between the real and the fake: that is certainly a very old topic in the arts.

Your next exhibition at EPFL Pavilions is titled *Deep Fakes: Art and Its Double*. I suspect you are not only referring to the digital buzzword and the political minefield of audiovisual fakery.
It's a play on these topics for sure. But if I know one thing from my own professional experience, it's this: fakes – or, to use a less provocative term, replicas – have the capacity to evoke deep emotional responses. We do not need to be confronted with the original work of art to trigger this reaction.

Could you give us an example?
Take prehistoric treasures in caves closed to the public for reasons of conservation. We were commissioned to do digital facsimiles based on the Mogao Caves, a UNESCO World Heritage site in northwestern China. The Pure Land projects traveled around the world and made the original site accessible in a way that would not have been possible locally. And we wanted to find ways the work could be experienced, not just looked at. Thus we created a kind of "embodied museography."

That of course brings up Walter Benjamin's essay *The Work of Art in the Age of Mechanical Reproduction.* There he famously argues that in the reproduction, the aura of an artwork is inevitably lost. What exactly was he talking about, in your opinion?
The aura is a nebulous concept. I would understand it mainly as the way an artwork affects you. But I know this aspect of the artwork is not exactly lost when it is reproduced digitally, and I actually think Benjamin has been misinterpreted here all along. Bruno Latour and Adam Lowe have found a way of rethinking the concept of the aura in a more contemporary context. They call it "migration of the aura." I prefer to talk about the proliferation of aura.

So it can migrate into the digital sphere as well?
It depends of course how it is done. If you just digitize works of art and put them online, they will easily get lost in the noise and the speed of the digital world. I want to find different solutions, digital experiences that actually involve the viewer actively.

Can this go beyond the classical museum experience? Can it bring the viewer closer to the artwork?
I am sure of that! Just imagine a Louvre visit. If you go to see the *Mona Lisa*, you will probably never actually see it, or just from a distance, because there are so many other people in the museum space. Thus, my work is all about the repositioning of the viewer: I want the experience of an artwork to be interactive and immersive – you should be able to move through the works.

How do you see the potential of virtual reality for museums?
As it is used now, with head-mounted displays, it is a completely isolating experience. I am much more interested in building situations with groups of people who share an experience. The social interaction, to me, is the core of the museum experience: the interpretation of the works is done between the people. This is how art is discussed; this is how it comes to life.

How do you see the current museum situation then? Is the digital challenge accepted?
COVID certainly had a big impact here: museums will have to redefine their relation to their audiences. And, of course, there's so much more to this challenge than just the exhibitions as such: this concerns school programs, outreach departments and so on. And on top of the COVID crisis there's a total shift in narratives in connection with #BlackLivesMatter and similar challenges to formerly authorized narratives. I am convinced that the digital has a important role to play in the democratization of art. But the structures for this change in many museums are quite glacial. The question of the digital should be located right at the heart of curatorial decisions, not in the communications department. Young curators who understand this are slowly taking over, but this shift takes time.

How do you see the situation in Switzerland?
We will see quite a shift here as well, I am sure. There are about 1,100 museums in Switzerland in total, most of them rather small: 75 percent of these museums get fewer than 5,000 visitors per year. What role do these museums serve in their community, where they certainly are important? I see some interesting challenges here, also for the digital – it is certainly not enough to just put databases of the collections online or to have someone film the museum to enable virtual museum tours. Community engagement is vital and is the key.

We have talked a lot about the potential of digital representations of objects – do you see dangers as well? Are you personally afraid of the rise of the fake?
Well, we know that this development has real dangers. The technological empowerment can go both ways, of course – we can use the tools to create new experiences or we can manipulate people through fake versions of the world. In the art world we have developed best practices that ensure one can always tell the difference between "real" and "fake."

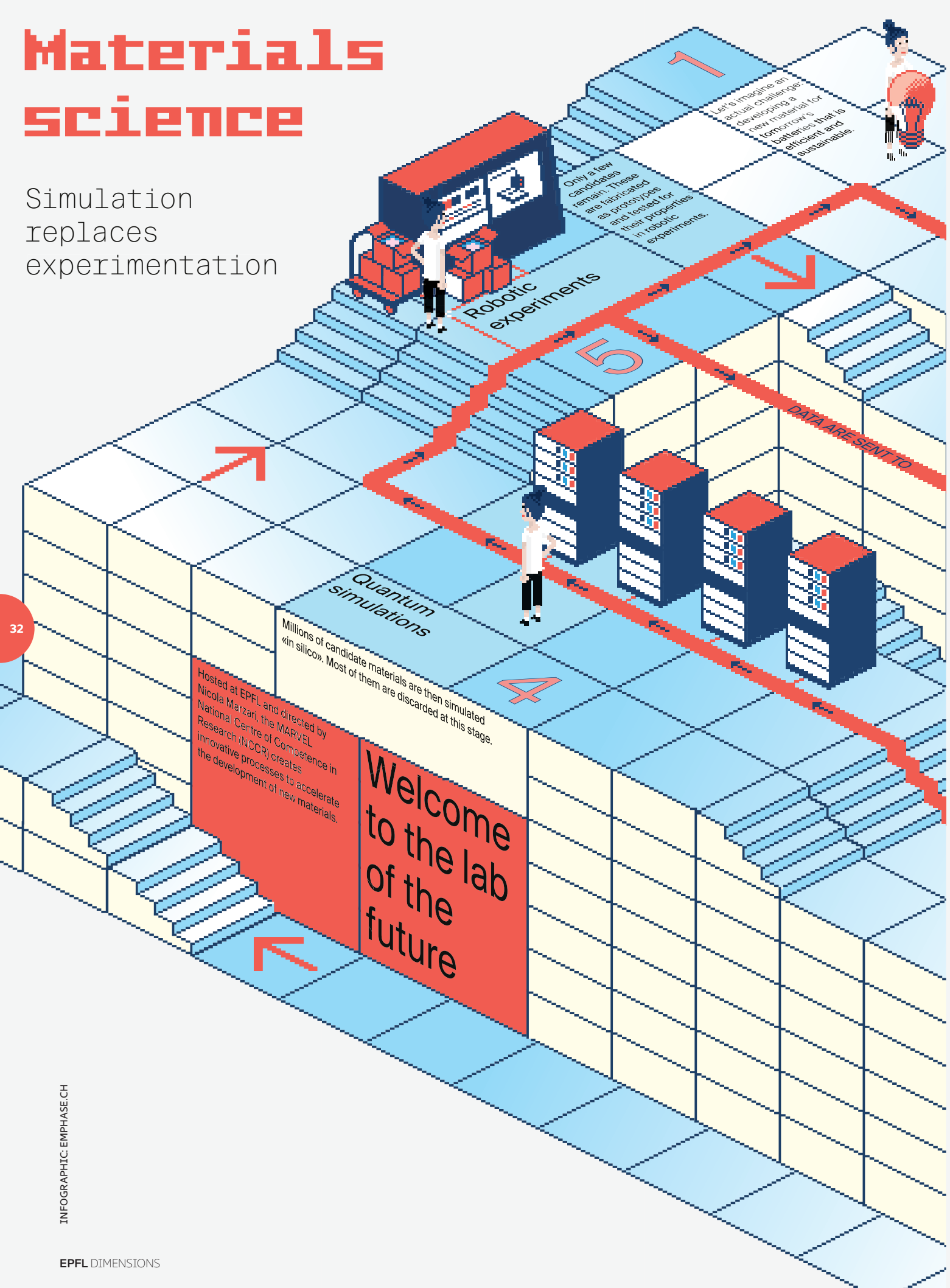
The perfect "immersion" is not the aim then, for the future?
Not necessarily. I am very aware that much of the technology and knowledge I use comes from the world of computer gaming. As a creator of works of art, I have the responsibility not to seduce the user in the same way as a game experience does. Art is more than just entertainment. ■

"Deep Fakes: Art and Its Double", 16 September 2021 – 6 February 2022, EPFL Pavillons, EPFL Campus, epfl-pavilions.ch


"YOU SHOULD BE
ABLE TO MOVE THROUGH
A WORK OF ART"

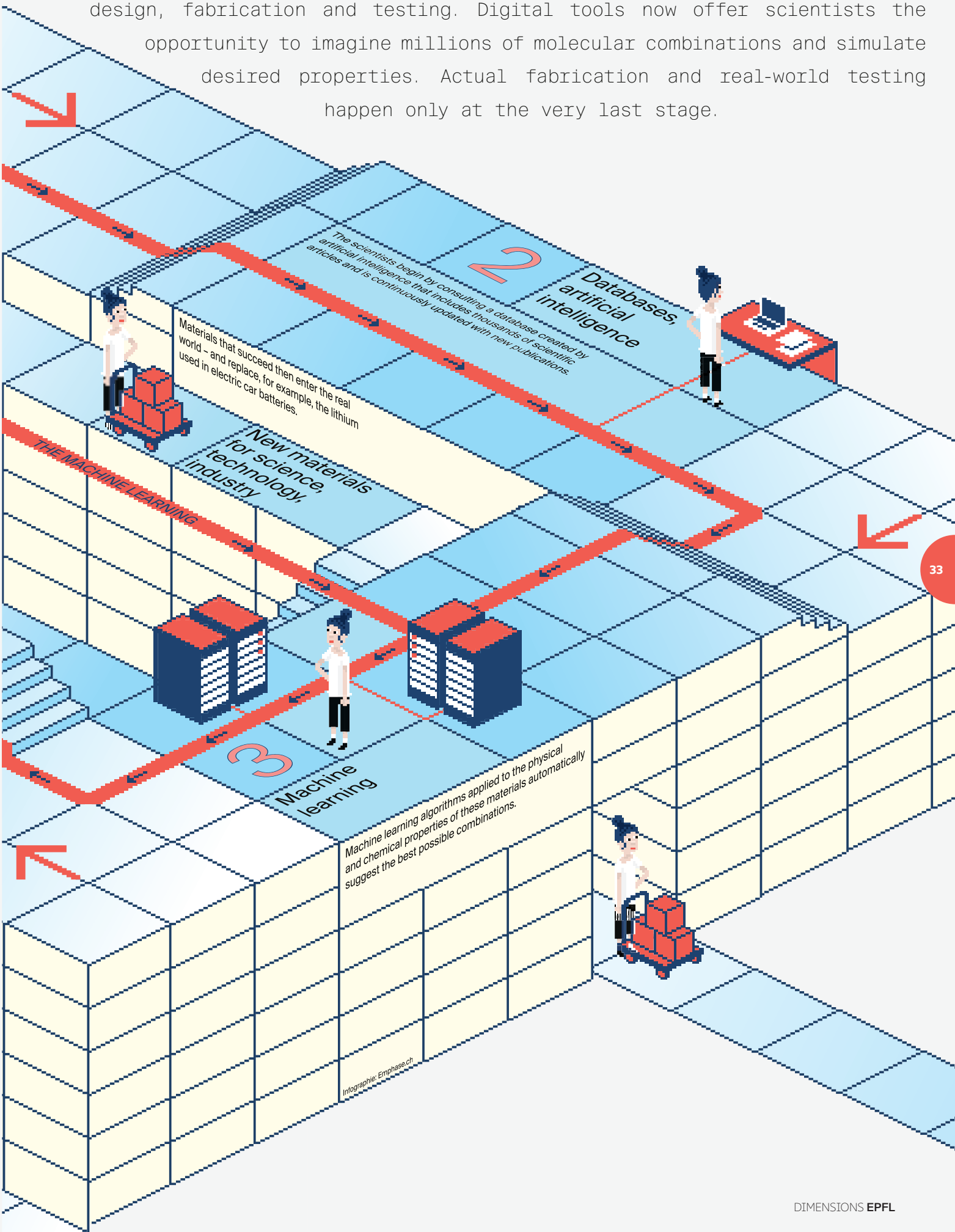
Materials science

Simulation replaces experimentation



INFOGRAPHIC: EMPHASE.CH

Research on new materials traditionally involves a long, iterative process of design, fabrication and testing. Digital tools now offer scientists the opportunity to imagine millions of molecular combinations and simulate desired properties. Actual fabrication and real-world testing happen only at the very last stage.



HOW HEALTHY IS YOUR DIGITAL TWIN?

Digital twins – a savvy combination of artificial intelligence and personal data – have already begun to revolutionize the way health care is provided. But they raise a lot of ethical and legal questions, especially given the vast amounts of medical data that must be collected to train artificial intelligence algorithms. So should we be worried about the eventuality of a digital clone? We spoke with experts from a variety of fields to find out. **BY VALÉRIE GENEUX**

Imagine there is a virtual copy of your body out there – a sort of clone, but in the digital world. And imagine that this clone encapsulates your full medical record: age, height, weight, preexisting conditions, pulse, organ activity, cholesterol level, genetic predispositions and more. That's the idea behind digital twins. They convert patients' medical data into mathematical formulas which are then fed into AI algorithms and computer programs. They work in real time and run not just on the medical data of the patient being treated but also on the data generated by all other digital twins.

The goal is for doctors to use these virtual models to make predictions and deliver personalized health care. For instance, doctors could use a patient's digital twin to detect a hidden cancer, test out various treatment protocols, observe the corresponding responses and select the best protocol for that particular individual.

Scientists believe that digital twins stand to revolutionize the practice of health care and take much of the mystery out of how to keep patients well. Digital twins have already been (or are in the process of being) developed for specific organs; one for the entire human body could be ready within 15 years. But behind this technological prowess lie several ethical questions, such as how exactly the virtual clones will be used and how patients' personal data will be protected – especially if the twins are developed by the private sector.

ACCURATE VIRTUAL MODELS

Digital twins have potential beyond the field of healt care – virtual replicas have already been made of an array of objects, from engines and machines to entire cities. Engineers use these 3D computer models to predict the behavior of objects by conceptualizing the relationship between the physical and virtual worlds. "These models have shown to be capable of effectively replicating an object's entire life cycle, from its production and use through its demolition or recycling," says Frédéric Kaplan, head of EPFL's Digital Humanities Laboratory.

But when it comes to health care, digital twins offer a number of advantages. Adrian Ionescu, head of EPFL's Nanoelectronic Devices Laboratory, explains: "Digital twins can cut health-care costs because they let doctors detect drug intolerances ahead of time and spot diseases before they reach the chronic stage. They can also reduce treatment errors, which are the third-leading cause of death worldwide after cancer and cardiovascular disease. But for a digital twin to be accurate and reliable, it has to be developed from high-quality data. That's one of the biggest challenges we'll face going forward," he says.

The AI algorithms used to create digital twins can also generate new data based on existing data sets. That means the algorithms will be able to fabricate virtual patients. One day, panels of such AI-born patients could replace the humans used to test new drugs and run clinical trials. This method already has a name: in silico testing. What's more, digital twins can give indications about a patient's family members based on the patient's own medical history. That could be useful in detecting genetic disorders.

TWIN EYES AND HEARTS

While a full-body digital twin is still a way off, some companies and public-sector research institutes have already created twins of specific organs. In France, the INRIA has developed a model heart to help doctors design therapies for patients suffering from heart failure and to assist with surgery for ventricular tachycardia. INRIA scientist Maxime Sermesant explains: "With our system, cardiologists can generate a digital twin of a patient's heart in around 30 minutes based on the results of a CT scan. And our system can save these surgeons a considerable amount of time, since they can test their procedure on a digital twin beforehand. They'll know exactly what to do once they get into the operating room." Sermesant is also the coordinator of SimCardioTest, an EU-funded research project to develop a digital twin of the heart for testing new therapies.

In Switzerland, Optimo Medical has come up with a digital twin to facilitate cataract surgery. To create the twin, an ophthalmologist takes measurements of a patient's eye and enters them into a computer program. According to Harald Studer, Optimo Medical's CEO: "Surgeons can adapt their procedures to each patient by testing them first on the model. The actual operations aren't performed until the procedure has been programmed correctly and run on the digital twin. This nearly eliminates the risk of making an incorrect move."

Engineers at Dassault Systèmes have developed a digital twin of cancer cells and the heart. They have also created a twin of the foot and ankle – comprising a complete reconstruction of the bones, joints, tendons, ligaments and soft tissue – and are working on one of the brain. "These types of models are always created in response to a specific need or problem to resolve. The one of the brain will be used to help patients who are resistant to epilepsy drugs, for example," says Patrick Johnson, VP Corporate Science & Research at Dassault Systèmes.

WAITING FOR FUNDING

Some scientists are still doubtful about the prospects for a full-body digital twin – but not EPFL's Ionescu. "We can already collect data on our genomes and metabolism, and evaluate how environmental factors like air pollution, diet and stress levels affect us. We've overcome the first hurdle, which was to find a way to collect all that data. That was possible thanks to advancements in micro- and nanotechnology. And now, with existing machine learning algorithms, we can mine the data for specific features. The next hurdle will be to develop a method for interpreting the data, which we'll do with artificial intelligence. But humans will always have the final say in making and implementing treatment decisions," he says.

One obstacle to the wider adoption of digital twins in health care is the broad range of skills they require along with a hefty amount of funding. That's also why many public-sector institutions like EPFL don't have specific R&D programs for digital twins, and why much of the development work is being done by the private sector. "To build a digital twin, you have to draw on knowledge from a host of different disciplines, from engineering and sensor design to machine learning and medicine," says Ionescu. "All the technology has already been invented, we just need to bring it all together. And for that, we need strong political will."

Jean-Gabriel Jeannot, a general practitioner in Neuchâtel, points to how things currently are on the ground. He believes that doctors and other practitioners are not yet ready to work with virtual clones. "Digital twins will struggle to gain acceptance unless health-care professionals get behind them. Even today, some doctors still use fax machines. Technology adoption in this industry will undoubtedly have to be driven by patients," he says.

THE AMBIGUITIES OF THE PRIVATE SECTOR

While it may sound appealing to have a digital twin undergo medical examinations for you, there are still many question marks surrounding this approach. Digital twins work by amassing reams of medical data to feed AI algorithms and make sure they run properly; the more data they have, the more accurate their predictions. For now, companies and hospitals developing digital twins use patient data only after getting their express written consent. But less scrupulous developers could take advantage of leaks in IT security systems to source data directly on the Internet.

"Public-sector entities could very well decide to partner up with businesses to develop and market digital twins," says Valérie Junod, a lawyer and law professor at the University of Lausanne. But in that case, what would happen to our medical data once they're in the hands of the private sector? Would they remain secure? And what would the consequences be if digital twins aren't developed in the interests of the public good, but for a profit motive?

Johnson believes that the solution will come from the businesses themselves: "We saw the same issue with bank account data. Banks, which are private-sector organizations, deployed major resources to make sure their customer data stay safe. It'll be the same thing in health care with digital twins. If a company can't guarantee full data protection, it won't have any patients."

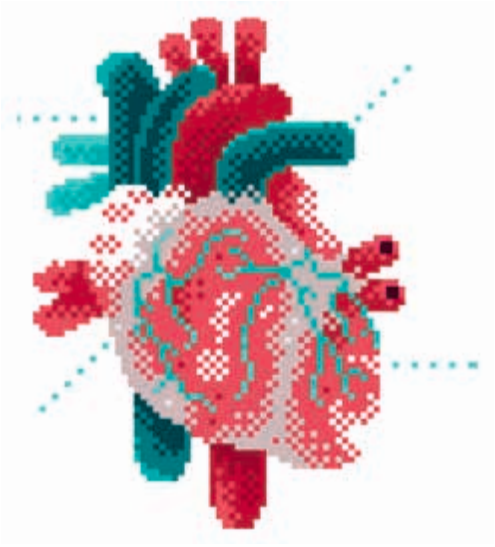
A "HEALTH-CARE INTERNET"

Ionescu acknowledges that digital twins carry an element of risk when it comes to storing medical data. "There are several possible solutions, but none of them is perfect. The current thinking among scientists is that the data will be stored on local servers at each hospital, or perhaps in a national database. But we're dealing with an international issue, and each country has its own policies. It would be good to have a pan-European medical database or maybe a 'health-care Internet' where data are stored and protected," he says. One thing is sure though – the cloud as it exists today does not meet the security standards necessary for digital twins.

Another problem with private-sector development of digital twins relates to the AI behind them. The businesses that own the code for the algorithms basically hold all the power over the technology. Experience has shown that algorithms are not neutral and reflect programmers' own cognitive biases. That means AI systems based on those algorithms are also somewhat biased. "Especially for health-care applications, it'll be crucial for scientists to be able to question and challenge the code. But if the code is owned by a business, how will they get access to it?" says Bertrand Kiefer, editor-in-chief of *Revue Médicale Suisse*. Today no one can argue with the choices made by AI algorithms or lodge complaints against their decisions. Machine learning is still a black box – and one that sometimes even the programmers and engineers themselves don't fully understand and can't explain.

THE RIGHT NOT TO KNOW

The health-care industry is no stranger to ethical questions. They often arise with regard to whether medical data should be sold for a profit, whether health-care provision should be considered a market with supply, demand and economic gain, and how cost–benefit analyses should be conducted for R&D, for example. An exhaustive list of ethical questions for digital twins is hard to prepare since we don't know the full extent of how they'll be used. And because the twins will generate predictions about a patient's health, doctors also need to consider issues related to patient information, and especially a patient's right to know and not to know. "Digital twins throw questions like that into the spotlight – not just a patient's right not to know, but also what should be done if a doctor stumbles across important information that wasn't mentioned specifically in the consent form," says Samia Hurst, a bioethics professor at the University of Geneva. "How can a doctor comply with a patient's wishes if the patient doesn't even want to be told the information? And what if the information also concerned members of the patient's family?" One idea Hurst has is to draw up a list of all the medical decisions for which a patient does and does not want to be informed of potential findings.



CALLING THEM TWINS IS MISLEADING

Perhaps society's fears about digital twins – and AI technology in general – are a bit overblown. According to Johan Rochel, cofounder of ethix, a startup that studies ethical issues in the digital era, it's important to use the right terms in order to play down worries that are probably unfounded. "Digital twins are nothing more than comprehensive medical files. The word 'twin' is merely a way to humanize the technology and tell a story based on an avatar. Databases and algorithms have been around for decades and hold great promise for personalized medicine. There's actually no real need to call them twins," he says. Ionescu adds: "Digital twins will never replace actual practitioners. They're just another tool in the toolkit."

A CLEAR PATH AHEAD

Scientists are optimistic about the potential for digital twins in health care, despite the fact that the human body is a complicated, multi-scale being with various ways of working and a myriad of connections among its organs. Businesses and researchers agree that model organs have already brought a lot to the field of medicine, and will only become more powerful and robust as time goes on.

Digital twins may seem like an abstract concept, but they will likely be part of the medical landscape within a few years. And given all the fears and concerns they raise, the future may hold some interesting twists and turns – including some that even AI wouldn't have predicted. ■

In-depth interview with Frédéric Kaplan, director of the Digital Humanities Laboratory, in the long-read format of this feature:
go.epfl.ch/RealityRevisited

DEEPFAKES AND THEIR IMPACT ON WHAT

Kelsey Farish describes herself as an actor who got lost on her way to dra- these interests that sparked her focus on publicity law and how images can

Now a London-based lawyer at international law firm DAC Beachcroft, Farish is one of Europe's leading experts on deepfakes and advises clients on media, privacy and technology issues. "When I first encountered the technology in 2018 or so, and started writing about it, it was a happy accident: now I'm one of the few lawyers who actually specializes in the issues that arise with deepfakes, in particular the personality rights and persona rights framework," she says.

Unwanted deepfakes clearly have a dark side. Shockingly, more than 90% of deepfake victims are women, who are subject to online sexual harassment or abuse through nonconsensual deepfake pornography. The motives range from "revenge porn" to blackmail. Deepfakes targeting politicians or political discourse make up less than 5% of those circulating online. This does change the debate around how we should approach or regulate deepfakes online.

Tim Berners-Lee, the inventor of the World Wide Web, has warned that the growing crisis of online abuse and discrimination means the web is simply not working for women and girls, and that this threatens global progress on gender equality. Farish believes that regulation of deepfakes online is not fit for purpose to protect women, and she is spearheading efforts to bring this debate to the forefront.

"The issue with regulating deepfakes really comes down to the tensions between expression and regulation, and unless there's a specific harm that's delineated, for example, defamation, fraud or child exploitation, to name a few, you really can't regulate it. So, for each and every deepfake that pops up, you have to look at it with a magnifying glass and say: OK, what's going on here?" Farish says.

Recently she gave testimony to the European Parliament's Science and Technology Options Assessment Panel on a comprehensive set of new rules for all digital services in the EU, including social media, online marketplaces and other online platforms under the Digital Services and Digital Markets Acts.

In the EU, individuals have the legal right to be forgotten, that is, to have private information removed from Internet searches and other directories under some circumstances. While this sounds positive, Farish recalls a conversation with

DEEPFAKES AND THEIR IMPACT ON

GENDER

ma school and ended up at law school instead. Yet it was the marriage of
be appropriated for commercial purposes or endorsement. **BY TANIA PETERSEN**

IDEAS

the panel regarding whether this existing legal right could be used to tackle malicious deepfakes.

"I first thought to myself, that's a great idea, just get the unwanted deepfakes taken down using a GDPR request. But then you have to ask, Who would women send this to? The person who made the deepfake in the first place? Say, a random guy in his mom's basement in Oklahoma? Or to Snapchat or Facebook directly? These platforms lack sufficient resources to quickly remove problematic posts. Facebook, for example, has 20,000 people working for it, moderating user-uploaded content, and yet we still have issues. And, from a more cynical perspective, it's arguably in Facebook, Twitter and Snapchat's commercial interests to keep crazy content online, because it drives advertising clicks."

In combination with education campaigns from the classroom to the boardroom, Farish believes from a legal perspective that an important step in the battle against nonconsensual and harmful pornographic deepfakes online would be to recognize the right of digital personhood, a move that would require support from social media companies.

"An individual should be able to exercise autonomy and agency over their likeness in the digital ecosystem without needing the trigger of privacy or reputational harm or financial damage. In an ideal world, anyone should be able to get images taken down that they don't consent to," says Farish. "This is a gendered issue and speaks to the wider problem of exploiting the images of vulnerable people, whether they're women or children, and people thinking that they can do whatever they want and get away with it. The right of digital personhood would need to be balanced against journalism and other freedom of speech considerations, but it could be a small paradigm shift," she says. ■

WOMEN

EPFL IN THE

Minnesota, US

In early 2021 **Christophe Beck** (Master's 1991) was appointed CEO of Ecolab, a leading provider of water purification, sanitation and infection prevention systems.

Switzerland

Nexthink, the new Swiss unicorn.

See page → 54

Paris, France

The European Space Agency selected **ClearSpace**, founded by EPFL alumni, to develop the first satellite for capturing and deorbiting space debris.

California, US

"Social networks could also become platforms for education," says **Rodrigo Schmidt** (PhD 2008).

See interview on page → 42

Florida, US

On 25 January 2021 a Falcon 9 rocket orbited the first five of 80 nanosatellites developed by EPFL spin-off Astrocast.

Gulf of Aqaba

A team of EPFL scientists has discovered that corals in the Gulf of Aqaba, along with their symbiotic algae and bacteria, are particularly resistant to higher temperatures.

See page → 52

WORLD

Potenza, Italy
EPFL architects are part of the team selected to restore **Musmeci Bridge** in Potenza. This two-stage project will aim to preserve and showcase the bridge's unique design.

Dyatlov Pass, Russia
A team of scientists from EPFL and ETH Zurich have identified the likely cause of the 1959 death of nine hikers in the Ural Mountains.

See page → 50

Iran
EPFL professor **Mohammad Khaja Nazeeruddin** won the 34th annual Khwarizmi International Award in fundamental sciences, given out by the president of Iran.

South Korea
Jo Yun-suk (PhD 2008) released his new pop album "Dancing with Water" in late 2020, under his stage name **Lucid Fall**.

Kenya
EPFL engineers have developed an oxygen concentrator that can withstand the extreme weather conditions in sub-Saharan Africa.

Tanzania, Kenya, Uganda, Nigeria, Senegal and Ivory Coast
Under the **"Excellence in Africa"** program – a joint initiative of EPFL and UM6P – a digital education center will be built at a university in each of these six African countries.

India
Swati Rastogi Mayor (Master's 2005) published her first novel, **"Une vie de non-dits,"** in 2020. The novel deals with the place of women in Indian society.

RODRIGO SCHMIDT

“I was among the very first people Facebook hired internationally.”

EPFL alumnus Rodrigo Schmidt has a unique insight into Facebook and Instagram: over the last 15 years, he’s been director of engineering at both. **BY ARNAUD AUBELLE**

PHOTOS: DR

How did you manage to join Facebook as a young EPFL graduate?
I'm originally from Brazil and went to EPFL for my PhD in computer science. I graduated in early 2008 and spent a few more months at EPFL conducting postdoc research funded by an innovation grant. I really wanted to stay in Switzerland, but my options were limited and the opportunities there were not the same as in bigger high-tech clusters. So I interviewed with Microsoft, Intel and Yahoo! Labs in Barcelona and a few others. And then there was this startup, Facebook, with only a few hundred employees. At the time, they were not hiring internationally, so they wouldn't pay for my plane ticket to California for an interview. But it happened that I was already going to the US for a conference in Seattle, so they said: "Okay, we'll pay for your ticket from Seattle to Palo Alto." I got the job offer on my trip back to Switzerland, and officially started at Facebook in October 2008. A friend of mine who also graduated from EPFL, Alok Menghrajani, and I were among the very first people Facebook hired internationally.

Now you're a senior director of engineering at Instagram. What brought you to Instagram and what is your role there?
I was hired by Instagram twice, actually. The first time was in 2013, a year after the company was acquired by Facebook. I was a happy Instagram user myself and wanted to join the company, so I offered to help. At the time Instagram was growing tremendously, and its engineering systems still had a lot of room to grow. For example, the content recommendations made to people were not personalized, and some simplistic solutions based only on the number of likes allowed the proliferation of low-quality content, like memes. Even the fact that the user feed was time-based made it too easy for some accounts to game it – you just had to keep posting content all the time to reach the top of your audience's feed. I helped create our "data and personalization" team to improve our product with better data and machine-learning systems. As a result, Instagram now offers a richer, more personalized experience. The culmination of that vision was the launch of ranked feed and Stories in 2016. It felt like the end of a chapter for me, and I decided to leave the company. But after a brief stint with another startup, I returned to Facebook. I came back to Instagram in 2018 to oversee our engineering efforts across all monetization, shopping, content discovery and tools for creators. The overall vision of our product group, called Interests, is to help people connect with things they love. We are responsible for many products like Ads, ShopTab, Creator Studio, IGTV, Search, Explore, to name a few.

"What sets Instagram apart is that it's an 'interests' network in the broadest sense."

Of Instagram's one billion active accounts, 200 million are selling products. Is Instagram becoming more of a marketing network than a social network?
I believe Instagram is a balanced blend! A huge part of why people engage with Instagram is still very social – take Stories, for instance. The main thing most people come to Instagram for is still friends and family. But the whole idea of Instagram is that you can connect with your interests in the broadest sense – so family and friends of course, but also your interests in cooking or sports, for example. That's probably what sets Instagram apart: it's above all an "interests" network. And because it's focused on interests, there is more space for commercial content in general, even outside of paid ads, by creators, interest accounts or regular people. A couple of years ago, my wife and I renovated our home. We saw furniture we liked on the interior design accounts we followed on Instagram, but we had to buy the furniture elsewhere since back then you couldn't shop on Instagram. It makes sense that today you can tap on a picture, select the product you want and buy it directly. We basically streamlined something that already existed.

How will Instagram be able to keep up that success as new competitors emerge?
I genuinely believe Instagram still has a lot of scope to grow. Smartphones will only get better, just as technology like augmented reality is improving by the hour and will definitely play a key role in the way we connect with each other. Shopping on Instagram is just in its infancy. We're investing a lot in the personal experience people have in the platform. We can still improve Instagram's features for helping people create content. To give you an example, I have many friends and family members who are active on Instagram but don't share much content themselves. Stories went a long way, but we can still find new ways to make content creation as easy as we made content consumption. New

PROFILE

1978
Born in Brazil

2008
Graduates from EPFL with a PhD in computer science

Joins Facebook

2013
Appointed director of engineering at Instagram

2016
Joins a startup

2018
Back to Instagram as senior director of engineering

April 2021
Named senior director of engineering at Facebook AI

features such as Reels, which was released in 2020 and lets users record 15-second multi-clip videos, is a step in that direction with content that's lighthearted and fun.

Why do you think Europe in general, and Switzerland in particular, has not been able to produce a company like Facebook or Instagram?
I don't think you can point to a single reason. For a business to succeed, you need all the various elements: education, money, talent, investors and opportunities. There is obviously money in Switzerland, and the educational system is top-notch. Both EPFL and ETH Zurich are excellent, and I would definitely want my kids to study in Switzerland! But there are fewer companies and opportunities, so retaining talent can be hard. In my case, I wanted to stay in Switzerland and so did my wife, but we couldn't find the opportunities we were looking for. Silicon Valley has it all, and its ecosystem is now self-sustained, which is extremely hard to replicate.

One of the most challenging aspects of social networks is moderating content and monitoring its relevance.
Yes, this is a major focus area across our entire company and we take integrity extremely seriously. We review suspicious content and remove posts that violate our policies. But since there are millions of Facebook and Instagram users around the world, we need a system that is scalable – we obviously can't check every single post manually. Where computer engineering, and more specifically machine learning and AI, can help is in making the process automatic by building in classifiers and models that spot malicious content automatically, be it fake news, pornography, violence – the list is long. The catch is that the smarter our technology becomes, the smarter the malicious-content producers also become, because they quickly learn how to engineer work-arounds. So you have to outsmart them every step of the way. What makes me optimistic is that, thanks to how machine learning and technology are evolving, our models are becoming extremely robust.

Let's take the example of deepfakes, since that's the feature topic of this issue. What technology are you using to combat them?
Just to be clear, not all deepfake content is necessarily bad. Some creative media can rely on deepfake technology to create an interesting effect without misleading the audience. But if some content was manipulated through deepfake to spread misinformation, there needs to be a way to identify it's false. The most promising technology to help achieve that, in my opinion, is machine learning. It's possible to build classifiers that identify fake videos based on huge collections of real and fake media. The problem is that if given enough time, deepfakes could end up being as good as real videos. But for now that's only theoretical; in practice there are always small things that signal a video is fake. You don't always know what those signals are, but good models will notice there's something wrong. And they do so in an extremely efficient way, even if they can't pinpoint what exactly that something wrong is. Another technology that helps now and can help even more in the future is certificates. Even if deepfakes become very hard to identify, digital certificates could be used to validate which videos are real.

"Augmented reality is improving by the hour and will definitely play a key role in the way we connect with each other."

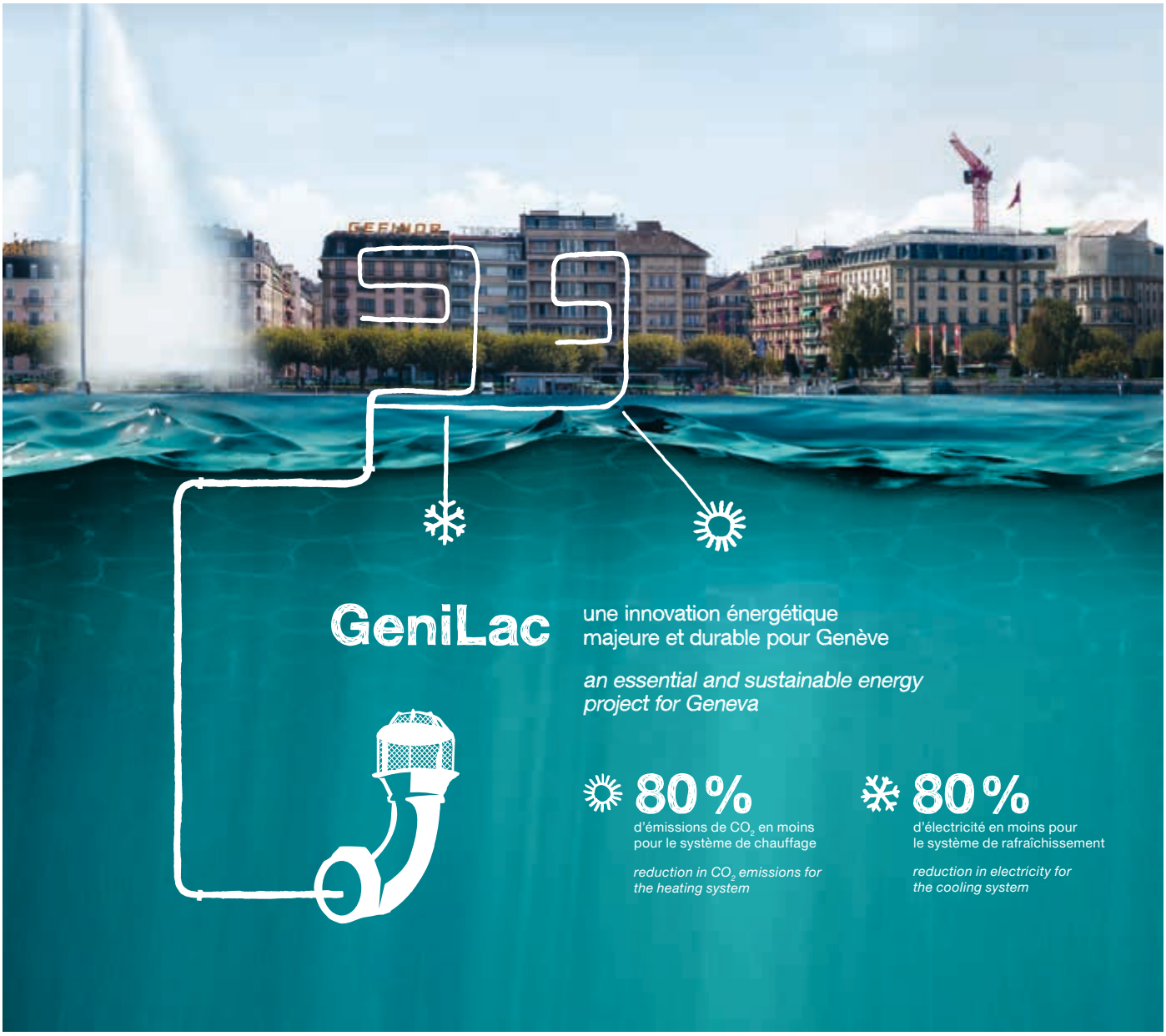
Another key issue is personal data protection, and it's one users are paying more and more attention to. How has that affected your job as an Instagram engineer?
Both Facebook and Instagram deal with highly personal data, so it affects my job significantly. We address data protection at every level, from the most basic – like what servers we use and where they're located – to the products we offer; that is, the settings and tools that let users manage the confidentiality of their data and content. And we have several security checks at every level. That makes our work more complicated and meticulous, which is a must given the responsibility we have.

How would you like to see social networks evolve over the next ten years?
I tend to be very utilitarian in my preferences, so I love messaging tools like WhatsApp and Messenger. Such communication systems can be extremely powerful in a world where more people are working remotely. I would like to see social networks extend their utility and become places where you don't just consume content, but also get things done. I mentioned being able to shop now on Instagram, for example, and social networks could also become platforms for education, where users expand their knowledge. In terms of technology, features like augmented reality – as seen in the trend for AR glasses, for example – and →→→

#rejoindreSIG

c’est construire ensemble la Smart City au service du mieux vivre

#choosingSIG means creating a Smart City for better living together



www.sig-ge.ch

SIG

even virtual reality will certainly play a key role in creating more engaging content.

As we discussed earlier, today there is greater awareness of the ethical responsibility that comes with being an engineer. How can we better prepare the next generation for this?
I've been too far removed from academia over the past ten years to know how things are taught today, but ethics was definitely not a topic covered enough when I was a student. Engineers and product developers are given a great deal of latitude, so it's essential that they understand their ethical responsibility – and education has a key role to play here. It would help to have more courses on social responsibility, product thinking and product empathy, for instance. And it's not just at universities: companies need to be accountable as well. At Facebook, we have an extensive onboarding program and employees undergo training throughout their careers on privacy, integrity, social responsibility and more. The goal is to make sure people really own the product they're working on and understand the responsibility that comes with it.

"Engineers and product developers are given a great deal of latitude, so it's essential that they understand their ethical responsibility."

You've been in the Bay Area for almost 15 years now. How has the region and its tech industry changed over the years?
One change I saw during my time here was that the center of gravity has shifted a little from the South Bay to San Francisco. When I first came here, San Francisco was not as popular as it is today with the tech community, which concentrated further south. Around 2010, many tech companies started locating their headquarters in the city rather than in Silicon Valley. Of course, the South Bay is still the main tech hub with the headquarters of Facebook, Apple, Google and others. But we have seen a kind of shift. The influx of tech companies into San Francisco has brought younger people and some life back to the city, which is very enjoyable.

Do you still have ties with the EPFL community? If so, which kind?
I'm still in touch with many friends from EPFL and with my PhD supervisor, Willy Zwaenepoel, the former dean of the School of Computer and Communication Sciences. Here in San Francisco, I'm in contact with Swissnex. But my connection with EPFL has faded a little over time, so it's great to be in touch again now. The last time I was in Switzerland was nine years ago, and I've been wanting to go back ever since. I can't wait! ■

Since this interview, Rodrigo Schmidt has been named senior director of engineering at Facebook AI.

IN SHORT

One piece of advice I wish I had received as an EPFL student.
Don't worry too much! Good paths always emerge with a little bit of exploration and perseverance.

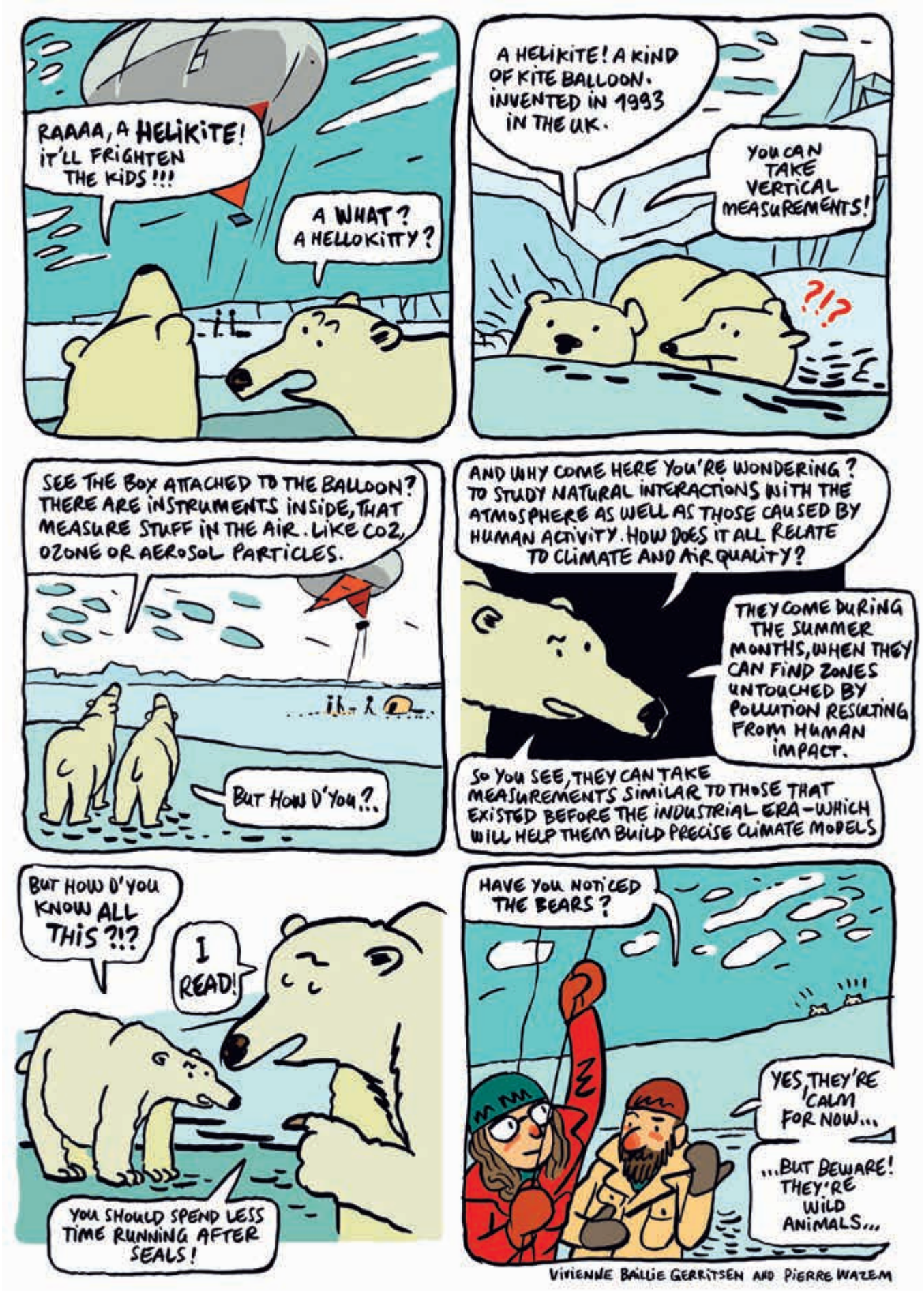
One EPFL spot I miss.
The top floor of the BC building, where I used to read scientific articles with the view of the mountains.

One place I love in Switzerland.
Zermatt is absolutely magnificent!

One place I love in California.
Yosemite is almost as magnificent as Zermatt.

One discovery made during lockdown.
I learned how to make sourdough bread, including my own starter.

One value I would like to pass on to my daughter.
Curiosity, being inspired and motivated to explore and learn new things.


RAAAA, A HELIKITE! IT'LL FRIGHTEN THE KIDS!!!
A WHAT? A HELLOKITTY?
A HELIKITE! A KIND OF KITE BALLOON. INVENTED IN 1993 IN THE UK.
YOU CAN TAKE VERTICAL MEASUREMENTS!
?!?
SEE THE BOX ATTACHED TO THE BALLOON? THERE ARE INSTRUMENTS INSIDE, THAT MEASURE STUFF IN THE AIR. LIKE CO2, OZONE OR AEROSOL PARTICLES.
BUT HOW D'YOU?..
AND WHY COME HERE YOU'RE WONDERING? TO STUDY NATURAL INTERACTIONS WITH THE ATMOSPHERE AS WELL AS THOSE CAUSED BY HUMAN ACTIVITY. HOW DOES IT ALL RELATE TO CLIMATE AND AIR QUALITY?
THEY COME DURING THE SUMMER MONTHS, WHEN THEY CAN FIND ZONES UNTOUCHED BY POLLUTION RESULTING FROM HUMAN IMPACT.
SO YOU SEE, THEY CAN TAKE MEASUREMENTS SIMILAR TO THOSE THAT EXISTED BEFORE THE INDUSTRIAL ERA - WHICH WILL HELP THEM BUILD PRECISE CLIMATE MODELS
BUT HOW D'YOU KNOW ALL THIS?!?
I READ!
YOU SHOULD SPEND LESS TIME RUNNING AFTER SEALS!
HAVE YOU NOTICED THE BEARS?
YES, THEY'RE CALM FOR NOW...
...BUT BEWARE! THEY'RE WILD ANIMALS...
VIVIENNE BAILLIE GERRITSEN AND PIERRE WAZEM

Johan Gaume and Alexander Puzrin executing a proof of concept of the Dyatlov case in Davos, Switzerland.

Using science to explore a 60-year-old Russian mystery

Researchers from EPFL and ETH Zurich offer a plausible explanation for the mysterious 1959 death of nine hikers in the Ural Mountains. **BY RÉMI CARLIER**

When an unknown caller rang EPFL professor Johan Gaume's cell phone in early October 2019, he could hardly have imagined that he was about to confront one of the greatest mysteries in Soviet history. At the other end of the line, a journalist from New York asked for his expert insight into a tragedy that had occurred 60 years ago in Russia's northern Ural Mountains and that has since come to be known as the Dyatlov Pass incident. Gaume, head of EPFL's Snow and Avalanche Simulation Laboratory (SLAB) and a visiting fellow at the WSL Institute for Snow and Avalanche Research, had never heard of the case, which the Russian public prosecutor's office had recently resurrected from Soviet-era archives. "I asked the journalist to call me back the following day so that I could gather more information. What I learned intrigued me."

On 27 January 1959, a ten-member group consisting mostly of students from the Ural Polytechnic Institute, led by 23-year-old Igor Dyatlov, set off on a 14-day expedition to the Gora Otorten mountain in the northern part of the Soviet Sverdlovsk Oblast. All were seasoned cross-country and downhill skiers. At that time of the year a route of this kind was classified Category III – the riskiest category – with temperatures falling as low as –30°C. On 28 January, one member of the expedition, Yuri Yudin, decided to turn back. He never saw his classmates again.

When the group's expected return date to the departure point, the village of Vizhay, came and went, a rescue team set out to search for them. On 26 February they found the group's badly damaged tent on the slopes of Kholat Syakhl – "Death Mountain" – some 20 km south of the group's destination. The group's belongings had been left behind. Further down the mountain, beneath an ancient Siberian cedar tree, the rescue team found two bodies clad only in socks and underwear. Three other bodies, including Dyatlov's, were subsequently found between the tree and the tent site; presumably they had succumbed to hypothermia while attempting to return to camp. Two months later, the remaining four bodies were discovered in a ravine beneath a thick layer of snow. Several

PHOTOS: JAMANI CAILLET | COURTESY OF THE DYATLOV MEMORIAL FOUNDATION

had serious injuries, such as fractures to the chest and skull.

What exactly happened?

The Soviet authorities opened an investigation to determine the causes of this strange drama, but closed it after three months, concluding that the death of the hikers was due to a "compelling natural force." In the absence of survivors, the sequence of events on the night of 1 to 2 February is unclear to this day. It has also led to countless more or less fanciful theories, from murderous yeti to secret military experiments.

This is the mystery that Gaume was confronted with. The most plausible theory, put forward by the Russian public prosecutor's office after the investigation was reopened in 2019 at the request of the victims' relatives, is that an avalanche took the group by surprise. But the lack of evidence and a number of odd elements failed to convince many Russians. "I was so intrigued that I began researching this theory more deeply," says Gaume. "I then contacted Professor Alexander Puzrin, chair of geotechnical engineering at ETH Zurich, whom I had met a month earlier at a conference in France."

Gaume, originally from France, and Russian-born Puzrin worked together to comb through the archives, which were opened to the public after the fall of the Soviet Union. They also spoke with other scientists and experts about the incident, and developed analytical and numerical models to reconstruct the avalanche that may have caught the nine victims unaware.

"The Dyatlov Pass mystery has become part of Russia's national folklore," says Puzrin. "I was quite keen to do it, especially because I had started working on slab avalanches two years earlier. My primary research is in the field of landslides. I study what happens when a certain amount of time elapses between when a landslide is triggered and when it actually occurs."

According to Gaume and Puzrin, that is precisely what happened in 1959: the hikers made a cut in the mountain's snow-covered slope to set up their tent, but the avalanche didn't occur until several hours later.

Bridging the gaps in the investigation

"One of the main reasons why the avalanche theory is still not fully accepted is that the authorities have not provided an explanation of how it happened," says Gaume. In fact, there are a number of points that contradict the theory. First, the rescue team found no obvious evidence of any avalanche or debris. Moreover, the average angle of the slope above the tent site – less than 30 degrees – was not steep enough for an avalanche. Also, if an avalanche occurred, it was triggered at least nine hours after the cut was made in the slope. And finally, the chest and skull injuries observed on some victims were not typical of avalanche-induced trauma.

"One of the main reasons why the avalanche theory is still not fully accepted is that the authorities have not provided an explanation of how it happened."

Johan Gaume, head of slab at EPFL

In their investigation, published in *Communications Earth & Environment* – a new journal from *Nature Research* – Gaume and Puzrin attempt to address these points. "We use data on snow friction and local topography to prove that a small slab avalanche could occur on a gentle slope, leaving few traces behind. With the help of computer simulations, we show that the impact of a snow slab can lead to injuries similar to those observed. And then, of course, there's the time lag between the team cutting into the slope and the triggering of the event. That's the main focus of our article. Previous investigators have been unable to explain how, in the absence of any snowfall that evening, an avalanche could have been triggered in the middle of the night. We had to come up with a new theory to explain it," says Gaume.

"If they hadn't made a cut in the slope, nothing would have happened," says Puzrin. "That was the initial trigger, but that alone wouldn't have been enough. The katabatic wind probably drifted the snow and allowed an extra load to build up slowly. At a certain point, a crack could have formed and spread, causing the snow slab to release."

Both scientists are nevertheless cautious about their findings, and stress that much about the incident remains a mystery. "The truth, of course, is that no one really knows what happened that night. But we do provide strong quantitative evidence that the avalanche theory is plausible," Puzrin says.

The two models developed for this study – an analytical model created by ETH Zurich for estimating the time required to trigger an avalanche, and SLAB's numerical model for estimating the effect of avalanches on the human body – will be used to better understand natural avalanches and their associated risks. Gaume and Puzrin's work stands as a tribute to Dyatlov's team, who were confronted with a "compelling force" of nature. ■

Dyatlov's group on 1 February 1959 on their way to Kholat Syakhl.

Northern Red Sea corals pass stress test with colors

EPFL scientists are beginning to understand why corals in the Gulf of Aqaba, along with their symbiotic algae and bacteria, resist higher temperatures particularly well.

BY ANNE-MURIEL BROUET

Even under the most optimistic scenarios, most of the coral reef ecosystems on our planet – whether in Australia, the Maldives or the Caribbean – will have disappeared or will be in very bad shape by the end of this century. That's because global warming is pushing ocean temperatures above the limit that single-cell algae, which are corals' main allies, can withstand. These algae live inside coral tissue for protection and, in exchange, provide corals with essential nutrients produced through photosynthesis. The algae contain a variety of pigments that give coral reefs their famous colors. So if the algae are lost, the corals turn white by a process known as coral bleaching. But in spite of the real threat caused by global warming, corals in the Red Sea look set to keep their vibrant colors.

"We already knew that corals in the Gulf of Aqaba, at the northern tip of the Red Sea, are particularly resistant to higher temperatures. But we wanted to study the full molecular mechanism behind this resistance," says Romain Savary, a postdoc at EPFL's Laboratory for Biological Geochemistry (LGB) and lead author of the study, which appears in May in *PNAS*. What the scientists found was telling: the corals, as well as the algae and bacteria they live in symbiosis with, can withstand average temperatures some 5°C higher than what they typically experience. And despite the severity with which climate change is taking place, it's unlikely that Red Sea temperatures will rise more than 5°C by the end of the century. "This gives us real hope that we can save at least one major coral reef ecosystem for future generations," says Anders Meibom, head of the LGB.

Taking it in stride

To conduct their study, the scientists subjected Gulf of Aqaba corals to a range of heat stresses, including the higher temperatures likely to occur in the coming decades. The average maximum monthly temperature in these waters is currently around 27.0°C, so the scientists exposed coral samples to temperatures of 29.5°C, 32.0°C and 34.5°C, over both a short time period (three hours) and a longer one (one week). The scientists measured the gene expression of the corals and the symbiotic algae both during and after the heat stress test, and determined the composition of the microbiome residing in the corals.

"The main thing we found is that these corals currently live in temperatures well below the maximum they can withstand with their molecular machinery, which means they're naturally shielded against the temperature increases that will probably occur over the next 100 or even 200 years," says Savary. "Our measurements showed that at temperatures of up to 32°C, the corals and their symbiotic organisms were able to molecularly recover and acclimate to both short- and long-term heat stress without any major consequences." This finding offers genuine hope to scientists – although warmer waters are not the only threat facing this exceptional natural heritage.

Never before have scientists conducted a genetic analysis of coral samples on such a broad scale, and their results reveal how these heat-resistant corals

PHOTO: ROMAIN SAVARY

respond at the most fundamental level – that of gene expression. They can also be used as a basis for identifying "super corals." According to Meibom, "Romain's research gives us insight into the specific genetic factors that allow corals to survive. His study also indicates that an entire symphony of genetic expression is at work to give corals this extraordinary power." This finding sets a standard for what "super coral" gene expression looks like during heat stress and recovery. But could Red Sea corals one day be used to repopulate the Great Barrier Reef? "Corals are highly dependent on their surroundings," says Meibom. "They can adapt to new environments only after a long, natural colonization process. What's more, the Great Barrier Reef is the size of Italy – it would be impossible to repopulate it artificially."

Sailing toward the future

The scientists' work was made possible thanks to two unique research tools: the Red Sea Simulator, developed by the Interuniversity Institute for Marine Sciences in Eilat, Israel; and the Coral Bleaching Automated Stress System, developed by a team of researchers in the US. The EPFL team's findings have laid the groundwork for a much more ambitious project that will be led by the Transnational Red Sea Center, which was set up at EPFL in 2019. This new project will kick off this summer and take place over four years. "We'll sail the entire Red Sea – some 2,000 km long – on the research vessel Fleur de Passion, owned by our partner Fondation Pacifique," says Meibom. "The goal will be to map the heat tolerance levels and the diversity of all the different types of corals found in these waters. Water temperatures rise as you head further south on the Red Sea, with a 5°C–6°C differential between the northern and southern tips. That's what makes it a perfect real-world laboratory for studying these ecosystems. It's as if you're sailing toward the future as you head south." What does that glimpse into the future tell us? Some corals in the southern Red Sea are already starting to bleach. Savary believes there's just one solution: "We have to protect these corals and shield them from local stressors, which are mainly sources of pollution and physical destruction. That way we can keep a stock of "natural super corals" for potentially recolonizing areas that have been hit particularly hard by climate change-induced heat waves." ■

EPFL spin-off Nexthink goes unicorn

With $180 million in its latest financing round, the leader in software for managing employees' digital experience has reached a $1.1 billion valuation, making it EPFL's second unicorn after MindMaze.

BY CÉCILIA CARRON

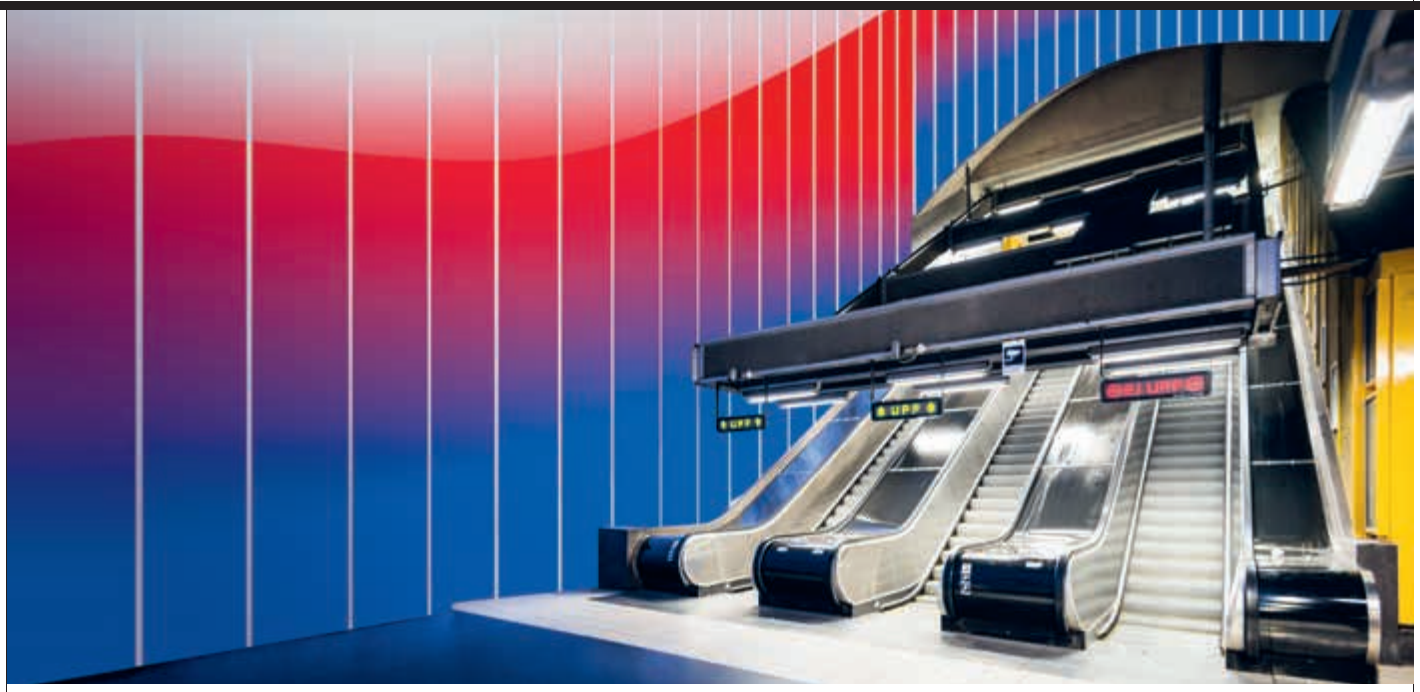
EPFL President Martin Vetterli and Patrick Hertzog, cofounder of Nexthink.

Nexthink, the leader in digital employee experience (DEX) management software, has announced a $180 million Series D financing round, boosting the company's valuation to $1.1 billion. Permira led the February 2021 round through its Growth Opportunities Fund, alongside existing investors, including Highland Europe and Index Ventures. In addition to the investment, which makes the EPFL spin-off the newest Swiss unicorn, the company has also announced the appointment of Bruce Chizen, former CEO of Adobe and senior advisor at Permira, to Nexthink's board of directors. The Series D round will be used to accelerate Nexthink's innovation, rapid growth and expansion, particularly in the US.
"A huge congratulations to Nexthink, a leader in digital employee experience management and the future of work, on becoming a unicorn company – one of only four Swiss-based startups to achieve this milestone," says EPFL president Martin Vetterli. "I am proud to see another EPFL success story. Nexthink was cofounded by our EPFL alumni Pedro Bados and Patrick Hertzog, and employs many (20–30) collaborators from EPFL."

Digital workplace revolution
"The rise in remote working has dramatically accelerated the need for digital employee experience, as a big part of all the interactions that employees have with companies are now digital," said Pedro Bados, CEO and cofounder of Nexthink. "We see a huge opportunity ahead of us to redefine the future way in which companies will provide digital workplaces to their workforce. Bruce is a terrific addition to the team. At Adobe he transformed the way people work by providing delightful experiences to millions of software users. Now we can do the same with the employees of thousands of companies around the world."

> **"I am proud to see another EPFL success story. Nexthink was co-founded by our EPFL alumni Pedro Bados and Patrick Hertzog, and employs many collaborators from EPFL."**
>
> Martin Vetterli, EPFL President

Solving problems in minutes
Nexthink provides the most complete DEX platform to IT teams to discover, monitor and proactively improve the digital services they provide to their employees. Nexthink's award-winning platform provides IT with a cloud-native solution that enables unprecedented insight into employees' daily experiences of technology at the device, application and network level. The solution's unique event-level visibility and advanced visualizations make troubleshooting dramatically easier, empowering IT teams to continuously improve employees' digital experiences, solving problems in minutes instead of days.
The Swiss company now has close to 700 employees and plans to reach 900 by the end of 2021, hiring in all major locations in the US, Europe and India. During 2020 Nexthink continued its hypergrowth, crossing the $100 million milestone in annual recurring revenue, adding 180 customers and reaching 1,000 worldwide (including 200 of the Global 2000). A total of 11 million employees around the world are using its solution. In addition, in October Nexthink was recognized as a leader in end-user experience management in the *Forrester New Wave: End-User Experience Management, Q4 2020* report. ■



Enerdrape turns underground heat into heating

The geothermal panels developed by Enerdrape, an EPFL spin-off, can turn underground structures like tunnels, subway stations and parking lots into clean energy sources for heating and cooling systems in buildings. **BY CLARA MARC**

Underground structures are an excellent, yet untapped, source of clean energy. Such structures – including tunnels, subway stations and underground parking lots – generate enough energy to help heat and cool buildings. By replacing some of the fossil fuels currently in use, underground structures can sharply cut CO_2 emissions. "Buildings are huge polluters," says Margaux Peltier, Enerdrape cofounder and CEO. "Those in Switzerland rely on fossil fuels for over 50% of their heating needs and account for over 40% of the country's CO_2 emissions."

Enerdrape's geothermal panels are designed to make full use of underground energy sources. "There's no other technology like ours out there," says Peltier. "Today's systems are designed for use in new buildings, but not to be incorporated into existing ones." Her company, which recently won the 10th annual Startup Champions Seed Night, has developed modular panels that contain tiny tubes with a heat-exchange fluid running through them. The fluid captures geothermal energy and transfers it to where it can be used. The panels can be installed in just about any type of underground structure easily and at a low cost – turning it into one large heat exchanger. While the panels generally won't be able to cover all of a building's heating needs on their own, they can be used alongside other forms of energy to reduce direct CO_2 emissions by some 80%. What's more, they can provide a stable power supply all year long, regardless of weather conditions.

Pilot tests in a Lausanne parking lot

Peltier came up with the idea while conducting research on energy-production systems for tunnels at EPFL's Laboratory of Soil Mechanics. She then fleshed out the idea during her Master's project. "I saw that Switzerland has lots of tunnels and other underground structures, but that existing geothermal technology – which is designed for new buildings – can't be used in them. That means the underground heat is not being exploited to its full potential," says Peltier. She therefore worked in association with Lyesse Laloui, professor and head of the Laboratory of Soil Mechanics, and Alessandro Rotta Loria, a postdoc in the lab at the time, to design the panels, create prototypes and test the technology. She then pitched the idea, sought funding to create a startup and secured a BRIDGE Proof of Concept grant from the Swiss National Science Foundation.

The company will soon conduct pilot tests in a Lausanne parking lot, with other pilot tests likely to follow. Its founders hope to complete their first fundraising round by year-end. The proceeds will be used to hire additional staff and move out of the EPFL lab and "into the real world," says Peltier. "The pilot tests will be crucial steps in assessing and improving our system." Enerdrape is looking for other companies to work with to install its panels, and is preparing for its market launch. ■

PHOTOS: NEXTHINK | ENERDRAPE

TOGETHER WITH YOU WE ACHIEVE EXCELLENCE

Every day, governments, companies and millions of people rely on us to protect the integrity and value of their currency, personal identity, products and brands. Building the Economy of Trust, contributing to a world more secure for its citizens, is our purpose and motivates us everyday.

SICPA

Enabling trust

JOIN SICPA : INNOVATIVE TECHNOLOGIES PROTECTING YOU EVERY DAY !
SICPA offers multiple career paths in advanced sciences and technologies as well as other business functions.
Join our multicultural staff and contribute to a safer and more secure world for all.

APPLY ONLINE www.sicpa.com/careers

REJOIGNEZ SICPA: LA TECHNOLOGIE ET L'INNOVATION À VOTRE SERVICE !
SICPA propose plusieurs parcours de carrière dans les sciences et technologies les plus innovantes, sans compter les nombreux métiers attitrés à l'entreprise. Rejoignez nos équipes multiculturelles et contribuez à un monde plus sûr pour tous.
POSTULEZ SUR www.sicpa.com/careers

Students. Space experiments on top of Mount Pilatus

This is the third year of the IGLUNA project, and each year is different from the last. After doing their field campaigns in person in 2019 and online in 2020, the student teams will follow a hybrid approach in 2021.

IGLUNA is a student research project run every year by Space Innovation with the backing of the European Space Agency. The field campaign for this year's edition – involving 220 university students from around the world – will be held on Switzerland's Mount Pilatus from 16 to 25 July 2021. The 12 student teams will demonstrate the remote-controlled systems they've been developing since September 2020, which are intended to allow humans to live in extreme environments such as the Moon. To create their technology, the students worked closely with space industry experts, businesses and R&D centers. Teams that can travel will install their prototypes at the top of Mount Pilatus and test them remotely from the Swiss Museum of Transport in Lucerne. The field demonstrations will be open to members of the public, who can either attend in person or follow the 12 presentations online. This year's batch of innovations includes a rover that hunts for water, a method for growing plants at extreme temperatures, an inflatable lunar habitat and an augmented reality headset for venturing out into unknown territory. All these inventions hold great promise for overcoming challenges both on Earth and in outer space.

Moon-grown fruits and vegetables

EPFL's GrowBotHub team is representing our School at IGLUNA this year as in prior years. The team's goal is to develop a smart, robot-driven system for astronauts to grow and harvest fruits and vegetables on the Moon. The system uses aeroponics, which is an aboveground agricultural process that entails spraying plants with the necessary nutrients. The EPFL team will use the IGLUNA field campaign to test new features they've added to their prototype. ■

Learn more at:
space-innovation.ch/igluna

Energy. Mini-fuel cell delivers maximum performance

A slew of applications, ranging from weather stations and mountaintop environmental sensors to remote pipeline surveillance systems, drones and even campsites, stand to benefit from a compact, long-lasting and eco-friendly power supply. With this in mind, INERGIO – a spin-off based at EPFL's Innovation Park and the product of 15 years of joint research between EPFL and HEIG-VD – has developed a compact fuel cell that is 80% lighter than similar systems on the market. With support from several startup funds, the company has just completed a prototype fuel cell that measures 25 cm long by 14 cm high and wide, and that can generate 25 W of continuous power. The next step for INERGIO will be to test its system with various companies in the Lake Geneva area and develop a pilot production line. ■

Environment. Biomass-based plastics

Petroleum derivatives are used to make all sorts of goods, such as plastics, textiles, smartphones, furniture and flavorings – like vanillin – not to mention cosmetics, detergents and pharmaceuticals. Guided by a determination to cut carbon emissions, Bloom Biorenewables, an EPFL spin-off, is working hard to rapidly market a technology originally developed at EPFL. Their discovery would enable manufacturers to use renewable carbon from biomass (i.e., wood or other plants) as a substitute for petroleum, particularly for making packaging plastics, perfume and marine biofuels. The €3.9 million in capital the company recently raised provides key resources for business development and serves as a sign of recognition from industry professionals around the world. ■

bloombiorenewables.com

SIGNS OF BURNOUT CAN BE DETECTED IN SWEAT

Prevention. Working in association with startup Xsensio, EPFL engineers have developed a wearable sensing chip that can measure the concentration of cortisol – the stress hormone – in human sweat. Their device may eventually help doctors better understand and treat stress-related conditions like burnout and obesity. The mini device has the potential to be placed directly on a patient's skin in a wearable patch. As such, it will be possible in the future to quasi-continually measure the concentration of cortisol noninvasively, precisely and in real time. ■

xsensio.com

SELF-HEALING COMPOSITES EXTEND A PRODUCT'S LIFESPAN

Materials. EPFL spin-off CompPair has developed a family of composites that repair themselves in just a few minutes and thus can lengthen a product's life span considerably. Studies have shown that the same sample of a CompPair composite can repair itself up to 60 times without changing its properties. The firm recently raised just under CHF 1 million in its first fundraising round – a milestone that will allow the young business to hire more staff, expand its premises and ramp up production capacity to support its market share. ■

comppair.ch

Memory formation: close encounters

Neuroscience. Strange, yet moving. The image seems to show two small aliens reaching out to each other with human-like emotion. Are they looking for love? Comfort? Tenderness? Their fluorescent bodies bring to mind the glowing orange tip of E.T.'s long, bony finger as he tries to "phone home."

The key to the photo lies deep inside our memory. It was taken by Lucie Dixsaut, a PhD candidate at EPFL's Laboratory of Neuroepigenetics (headed by Johannes Gräff), while she was studying a mouse's brain to better understand how memory forms. She removed some of the background features in the image to make it more artistic, and named it "The Memory Ghost." It shows the fleeting flashes of light, sitting above dark eye-shaped cavities and a violet arcade, that constitute memory inside the brain.

The image was taken by a fluorescence microscope of a sample just 20 µm thick and 1 cm wide. The bright spots of light are neuronal axons sending messages to the prefrontal cortex – the part of the brain where memory is stored. The red and blue areas indicate the brain's two hemispheres, and the violet-shaded areas and spots of the other hemisphere's color show the few places where a neuron "reaches out" to the other hemisphere.

"My research aims to identify how memory is formed. More specifically, I'm looking at how neurons in different regions of the brain communicate and at what point they're activated in the memory-building process," says Dixsaut. Her fundamental research is giving rise to new questions with each discovery she makes.

In 2020 Dixsaut's photo won an Audience Favourites award at Figure 1.A., a scientific art exhibition held every year in Lausanne. ■

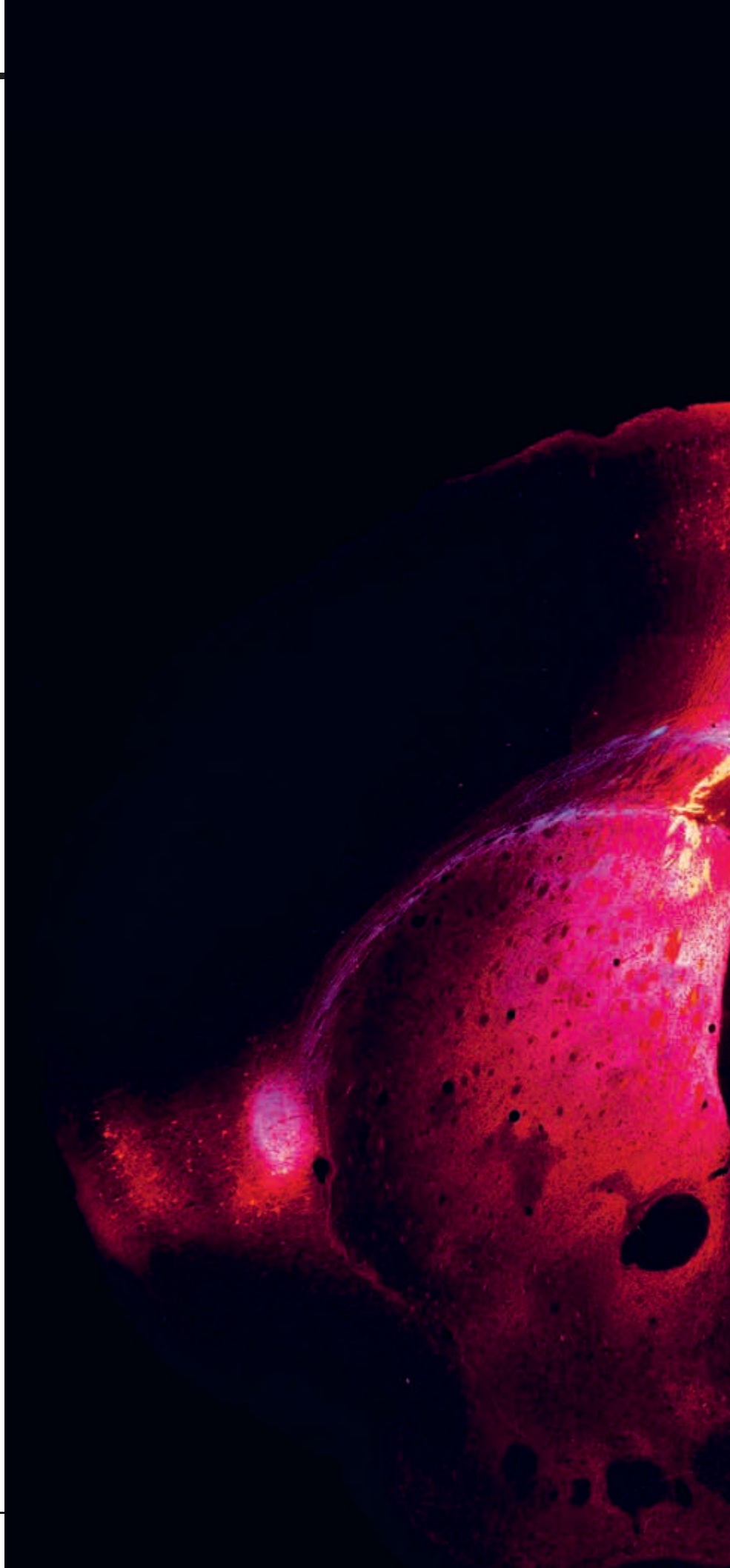
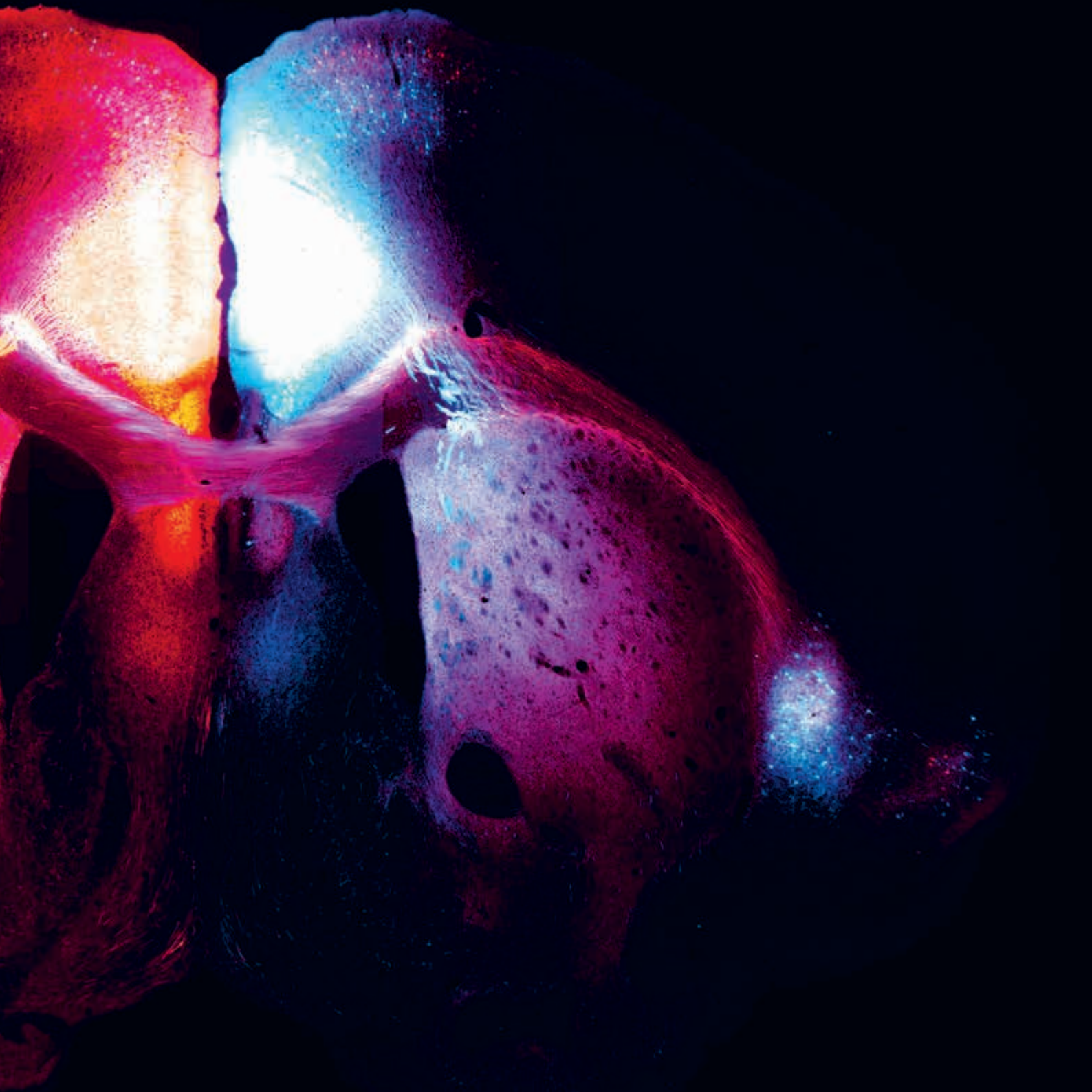


PHOTO: LUCIE DIXSAUT



DEFINING STUDENT-TEACHER RELATIONSHIPS

Science has shown that good student-teacher relationships in higher education create a positive learning environment. But though the importance of this emotional aspect is increasingly acknowledged, there has been no way to measure it objectively – until now. Roland Tormey, head of EPFL's Teaching Support Center, has developed a new tool for assessing the emotional aspect of student-teacher relationships called the Classroom Affective Relationships Inventory (CARI). In creating the CARI, Tormey drew on the work of psychologists Jennifer Jenkins and Keith Oatley, who have shown that social and emotional distance between people stems from feelings of affection and warmth, attachment and safety, and assertion and power engendered by their relationship.

CARI uses a questionnaire to measure these three dimensions on a seven-point scale that ranges from "not at all" to "very much." Students are asked to rate the extent to which they associate their instructor with 15 terms such as "impressive," "trustworthy," "influential" and "compassionate."

Tormey tested the questionnaire with 851 undergraduate students at EPFL. "The data showed that a three-dimensional model is effective in this approach," says Tormey, "and that there is a strong link between the emotional quality of the student-teacher relationship and the student's satisfaction with the class." ■

First decade of the Rolex Learning Center

10rlc.epfl.ch

Anniversary. The Rolex Learning Center, an architectural experience

EPFL's Rolex Learning Center will hold a series of events between now and next spring to commemorate this iconic building's first decade.

At the heart of EPFL's Lausanne campus lies the Rolex Learning Center (RLC) – a sleek, 20,000-square-meter building that houses some 500,000 publications, a bookstore, a restaurant, a bar, a 600-seat lecture hall, around 1,000 study places and large common areas. The center opened in May 2010 to serve students, researchers and the broader community, providing not just a forum for knowledge-sharing but also a laboratory for study and learning, a multicultural center, and a comfortable place to meet up and work.

The festivities to commemorate the RLC's tenth anniversary, which were postponed last year because of the pandemic, kicked off instead on 25 May 2021 at a ceremony attended by the building's architects, Kazuyo Sejima and Ryue Nishizawa, of the Japanese firm SANAA. The celebration will continue through spring 2022 with a series of special events. Each one will be an opportunity to discover (or rediscover) this timelessly contemporary building.

The RLC is instantly recognizable by its shallow inclines, the wave-like terraces winding around a series of internal courtyards and the barely visible pillars holding up the curved roof – all of which required novel construction methods.

Beyond its technical and material considerations, the RLC's distinctive topography – which comprises spaces that are at once separated and joined together – gives visitors an unparalleled architectural experience that engages all the senses. In an interview just before the RLC's opening ceremony, Sejima and Nishizawa explained their concept: "When you're at the top of a hill, for example, you might not be able to see the people on the next hill, but you can probably make out their voices. So even though you can't see the other place, your body still feels a certain connection to it. We drew on this sensitivity to effect a new way of relating which contrasts with traditional architectural designs based on walled-off areas, and which we hope will give visitors a new kind of architectural experience." Goal achieved. ■

Sign up for our news channel: go.epfl.ch/events-news

PHOTOS: ALAIN HERZOG | BEAT GYSIN, STUDIO KLANGRAUM, PHOTOMONTAGE

Concerts. A 45-meter-high sound pavilion generates surprising sonorities

Rohrwerk – from the German *Rohr*, "tube," and *Werk*, "work." Six composers, four musicians, two architects and one scenographer have created a 45-meter-high sculpture in the form of a giant tube. This sound factory is both a music pavilion and a musical instrument. Musical works with an extraordinary sound have been composed and will be performed between 21 and 23 September in and around the sculpture, which will be installed in one of the patios of the Rolex Learning Center on the EPFL campus.

The musical idea of a space made up of pipes is the brainchild of Swiss composer Beat Gysin. The architects from the Geneva firm Made In who designed the pavilion worked in close collaboration with Gysin. The walls of the pavilion are made entirely of tubes of various sizes. The specific dimensions of the pipes amplify certain frequencies and generate new combinations. The use of electronics allows precise control of acoustic parameters such as delay, reverberation and feedback. Some of the pipes can be played by attaching different instruments to them (such as a trombone, clarinet or trumpet) or by being struck with a mallet. In this way, the entire space and its materials become an instrument.

The mission of *Rohrwerk* is to bring contemporary music and the public closer together, and to explore synergies between science and art. Six composers have created sound pieces for the instrument. In the absence of musicians, *Rohrwerk* can also play recorded sounds.

The installation was already hosted at the Kunstmuseum Basel in September 2019 and will be on display in Zurich at the end of June 2021. *Rohrwerk's* realization and hosting at EPFL are made possible through the support of the College of Humanities (CDH-Culture). ■

From 21 to 23 September 2021
The original pieces created by the six composers will be played for the public.
Admission to these events is free.
Demonstrations and a roundtable discussion will also be held.
go.epfl.ch/rohrwerk

EPFL is hosting a series of free public concerts and demonstrations outside the Rolex Learning Center.

Dialogue. Learning from others, and vice versa

As part of the RLC's tenth anniversary festivities, EPFL is holding a series of talks called RLC Dialogues. In each of these talks, two experts from different fields will explore a variety of topics by seeking to answer the question "What can X bring to Y, and vice versa?" The discussion will be unmoderated. The goal is to promote cross- and interdisciplinary collaboration on issues related to architecture and the built environment. Three RLC Dialogues will be held this fall and two next spring, using a hybrid format with some participants attending in person at the Rolex Forum and others viewing the event online. ■

NEW BOOK TRACES THE RLC'S HISTORY

A lot has changed in a decade – including the practice of architecture. That's according to a new book by Christophe Van Gerrewey, an assistant professor of architecture at EPFL, published on the occasion of the Rolex Learning Center's 10th anniversary. Van Gerrewey's book walks us through the colorful history of this iconic building – a history that began well before the RLC was inaugurated in 2010, and that stands out due to the geography of the site as well as the Japanese origins of the building's architects, whose firm, SANAA, calls to mind Yemen's capital. Van Gerrewey illustrates how the RLC embodies a long-standing architectural tradition yet remains a resolutely contemporary building – and a reflection of our time. ■

Savoir supérieur, Le Rolex Learning Center de SANAA à l'EPFL depuis 2010, Christophe Van Gerrewey, 104 pages, EPFL Press.

TECHNORAMA MAKES A STOP AT EPFL

Technorama, a Swiss science center based in Winterthur, is holding an exclusive exhibit at EPFL made up of close to a dozen science and technology displays. The goal is to get visitors of all ages to explore both astonishing and everyday phenomena occurring in the world around us using all their senses. Technorama was created to spark children's curiosity and build their enthusiasm for engineering and the natural sciences. ■

Until 4 July 2021
www.epfl-pavilions.ch

Awards

Friedrich Miescher Award

The Friedrich Miescher Award is Switzerland's highest distinction for outstanding achievements in biochemistry. This year, one of the two winners of the award is **Andrea Ablasser**, associate professor of immunology at EPFL. Her research focuses on understanding how cells sense infection and cellular damage and on elucidating the associated signaling events. ■

Protein Society Award

The 2021 Protein Science Young Investigator Award has been given to **Bruno Correia**, assistant professor of bioengineering and director of the Laboratory of Protein Design and Immunoengineering at EPFL. His work combines computational science and experimental studies in the area of protein design. ■

Cloëtta Prize

The Cloëtta Prize honors scientists who have distinguished themselves in certain fields of medical research. The prize for 2021 was awarded to **Bart Deplancke**, professor at EPFL, and Anne Müller, associate professor at the University of Zurich. Deplancke's Laboratory of Systems Biology and Genetics aims at understanding genome organization, regulation, and variation. ■

Science festival. The environment takes center stage at this year's Scientastic

The eighth edition of EPFL's Scientastic science festival will be held on the Lausanne campus at the end of this year.

Every year, Scientastic introduces adults and children alike to the wonders of science and technology. After being postponed twice due to the pandemic, the eighth edition will be held in Lausanne at the end of this year. As originally planned, the number of visitors will be limited to allow for a secure event in compliance with current health and safety guidelines. This year's theme will be the environment, various aspects of which will be explored through activities for visitors of all ages.

Workshops, exhibits, talks and presentations

The festival will include six workshops for children aged 4 to 13, giving them an opportunity to conduct hands-on experiments with a playful approach. The goal is to teach them about the science behind environmental phenomena – and about science and engineering more generally.

At the "How Does It Work?" exhibit, visitors will learn about environmental factors that play a key role in how our climate functions. The exhibit will include fun, interactive modules explaining the phenomena that shape our planet, complete with discussions with young scientists.

Instructors from EPFL's chemistry and physics sections will give two lively presentations, unveiling secrets of their respective fields. EPFL researchers will also give talks on the work they're doing to address today's pressing environmental challenges.

Another highlight of the festival will be Imaginarium, a full-day workshop run by EPFL in conjunction with the Global Earth Horizon Talk student organization. Participants will be tasked with coming up with sustainable alternatives to current lifestyles. Two other organizations for promoting science among schoolchildren – SimplyScience and Science et Jeunesse – will hold demonstration booths at the festival, and local artist Etienne Krähenbühl will be on hand to display and discuss his work. ■

Autumn 2021
On the Lausanne campus.
Registration required.
scientastic.epfl.ch

PHOTOS: ALAIN HERZOG | EPFL-RESCO-VAUD+

Gaming. Swiss video games are part of our cultural heritage

Video games are an increasingly prominent component of popular culture. As such, they have been gaining wide recognition as a form of artistic creation, a social vector and an economic sector. GameLab UNIL-EPFL (which is linked to EPFL's College of Humanities) and Musée Bolo (situated on the EPFL campus) have recently begun work on a new project that will help preserve the distinctive Swiss contribution to the history of video games. The project, called Pixelvetica, is a collaboration with Atelier 40a, a Bern-based collective of conservation specialists, with support from Memoriav, a network for the preservation of Swiss audiovisual cultural heritage.

EPFL's prominent participation in the Pixelvetica project highlights the university's expanding role in managing digital sources. "Working with the complexity of video games gives us a valuable opportunity to develop broader, transferrable competence in the conservation of native digital objects," says Yannick Rochat of GameLab UNIL-EPFL.

Videogames as unique digital artifacts

Video games are extremely rich cultural objects. They comprise several different elements, each of which poses distinct conservation challenges. For example, the material interface between the player and the game must be physically maintained. This includes the data carrier, the machines that read the data and the handheld controllers. At the same time, the source code must also be extracted and archived on a stable medium, along with metadata to ensure long-term traceability.

It is not only the game itself that must be preserved but also the cultural practices that emerge around it. Promoting and distributing a game requires an elaborate commercial apparatus. Once a game has been released, active players also spontaneously construct their own social spaces and systems of communication. Print publications and social media offer a documentary record of these ephemeral commercial and social structures. Written sources thus provide precious insight into the gaming experience and help situate a given game in a specific historical context. ■

pixelvetica.ch

Some iconic Swiss video games

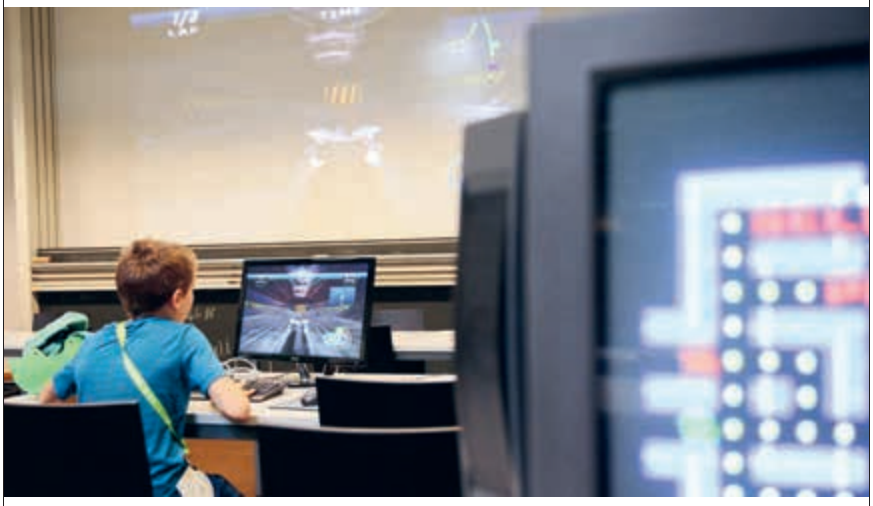
Bact. Published by Epsitec-System around 1981 for the Smaky 6 personal computer.

FAR: Lone Sails. Developed by Okomotive and published by Mixtvision in 2018 for all recent platforms.

Farming Simulator. Developed by GIANTS Software and published by Focus Home Interactive, from 2008 to the present.

Speedy Blupi. Developed and published by Epsitec in 1998 for Windows.

Traps 'n' Treasures. Developed by Nightingale Productions, published by Starbyte Software and Krisalis Software in 1993 for the Amiga personal computer.



Museum Night 2017.

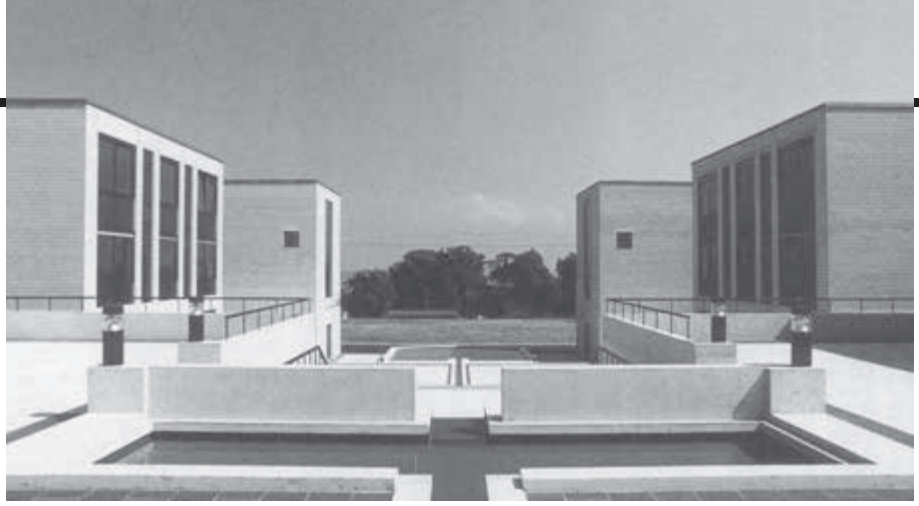
MASTER'S IN SUSTAINABLE MANAGEMENT AND TECHNOLOGY

EPFL has launched a new joint Master's program in Sustainable Management and Technology to prepare the next generation of students for leading the transition toward a more resilient, sustainable and inclusive economy. The Master's is offered by the multi-institutional initiative Enterprise for Society Center (E4S). The new Master's program will be open to engineering and management students with a scientific background in September 2021. ■

www.e4s.center

VENDING MACHINES FEATURING LOCAL PRODUCTS

Students at EPFL's Lausanne and Neuchâtel (Microcity) campuses, and at the HES-SO Valais-Wallis campus in Sion, can now choose from a range of sustainable, healthy and local snacks at their campus vending machines. The machines have been introduced as part of a pilot project to provide locally sourced, sustainably packaged products that adhere to high quality and nutrition standards and are suitable for different kinds of diets. The pilot project will run until the end of August and is being carried out by EPFL in association with the Vaud+ certification agency and the Dallmayr vending machine manufacturer. If the pilot project proves successful, the machines will be installed at all EPFL campuses starting in September. ■



Monograph. A vibrant quarter-century of architecture in Vaud

In a new monograph, Bruno Marchand and Pauline Schroeter document 25 years of architecture in the canton of Vaud, from 1975 to 2000.

A winegrower's hut, a transformer substation, a 250-unit housing development, a high school, a wood-fired boiler room, an arsenal, a church and a prison. Dozens of building renovations, transformations, refurbishments and redevelopments – not to mention new town squares, roads, lakefronts, footbridges, stairways and elevators. And, finally, the expansion of three major universities: UNIL, EPFL and CHUV. This, in a nutshell, is what's covered in a new book by architects Bruno Marchand, professor emeritus at EPFL, and Pauline Schroeter, an EPFL scientist. Across nearly 500 pages, illustrated with both black-and-white and color photos, the authors present a quarter-century's worth of architectural gems in the canton of Vaud.

The mid-1970s was a time of great upheaval, particularly in the wake of the oil crisis and the end of modernism in the architectural world. The year 2000 was mostly a symbolic year, but nevertheless meaningful, as it marked the end of the effects of the real-estate market crash of the mid-1990s. "I was under the impression that not much was built during this time," says Marchand. "Instead, I discovered that – unlike during the period covered by our first book, when most construction took place in large urban areas – this time many structures were built in the suburbs and elsewhere. Especially after highways started to arrive in 1964. A second surprise was that there were an equally large number of conversion and renovation projects, for either older buildings or those from the '50s, '60s and '70s," he says.

The period is basically split in three separate phases corresponding to the 1970s, 1980s and 1990s. The first was a genuine time of crisis, but very interesting because it signaled the advent of several new societal issues, such as environmental awareness, heritage preservation and a concern for energy efficiency. The 1980s were dominated by projects to build large institutional buildings and facilities,

Selection of books from *L'Intégrale* bookstore at EPFL lintegrale-livres-epfl.ch

HOW ENGINEERS THINK

Engineering. In this engaging account of innovative triumphs, Guru Madhavan examines the ways in which engineers throughout history have created world-changing tools, from ATMs and ZIP codes to the digital camera and the disposable diaper. At once personal, practical and profound, Applied Minds charts a path to a future where we borrow strategies from engineering to find inspired solutions to our most pressing challenges. ■

Applied Minds – How Engineers Think, by Guru Madhavan, 272 pages, W. W. Norton & Company.

THE UNIVERSE OF OPPORTUNITIES

Space. We are starting to see the first real progress in space exploration in the private sector, and many jobs are becoming available, right now, in this fascinating new field. With companies set to take both professional astronauts and well-trained passengers into space as early as summer of 2021, this book will prepare you to take your place in the exciting world of space exploration, whether as an investor, owner, employee or enthusiast. ■

Cosmic Careers, by Alastair Storm Browne and Maryann Karinch, 256 pages, HarperCollins Leadership.

ALL ABOUT ALICE, BOB AND EVE

Quantum computing. Quantum computing is a beautiful fusion of quantum physics and computer science, incorporating some of the most stunning ideas from 20th-century physics into an entirely new way of thinking about computation. In this book, Chris Bernhardt offers an introduction to quantum computing that is accessible to anyone who is comfortable with high school mathematics. He explains qubits, entanglement, quantum teleportation, quantum algorithms and other quantum-related topics as clearly as possible for the general reader. ■

Quantum Computing for Everyone, by Chris Bernhardt, 216 pages, MIT Press.

COUNTING WITH WOMEN

Equality. "I have been doing research in computer science at a very high level for over twenty years. As an entrepreneur in Deep Tech, I have also rubbed shoulders with investors, coaches, incubators and startups of all kinds," says Anne-Marie Kermarrec, professor of computer science at EPFL. "I am still too often one of the few women in the room. How can we put an end to the under-feminization of this sector, which is still very macho and reflects our society? With this book, I hope that women will be as attracted to computing as they are to medicine." ■

Numérique, compter avec les femmes (in French), by Anne-Marie Kermarrec, 240 pages, Éditions Odile Jacob.

PHOTOS: FROM THE BOOK

notably schools. This period can be characterized as postmodern, with a renewed focus on history and monumentalism and a return to a certain independence – architecture shook off the influence of other disciplines. It was also a time that saw a proliferation of public requests for proposals. During the 1990s, commissions fell off due to the slump in the real-estate market. Spending was reined in, and architects began to work more simply, often with only a single material. At the same time, artwork started to play a more important role in architectural projects.

This quarter-century was also memorable for the overwhelming use of sand-lime brick in the 1980s. This material appeared in every type of structure, overturning the idea that each material was associated with a specific use. "Rarely in the history of architecture have I seen a material that was so popular at a given moment in time," says Marchand. "Although sand-lime brick possesses a lot of advantages, I think it was a passing fad. Wood and concrete made a comeback in the '90s." ■

Architecture du canton de Vaud, 1975–2000 (in French), by Bruno Marchand and Pauline Schroeter, 464 pages, EPFL Press.

NOTEWORTHY ARCHITECTURAL PROJECTS

Vincent Mangeat's high school in Nyon, the École de la Construction in Tolochenaz by Patrick Mestelan and Bernard Gachet, and the Chéserex community center by Fonso Boschetti. "In addition to their architectural authority, these buildings express very different ideas of what an 'institution' is," says Pauline Schroeter. Two other projects also received significant attention: the Telecom PTT building by Rodolphe Luscher, adjacent to EPFL; and the Vaud Cantonal Archives by Atelier Cube. ■

NOTEWORTHY RENOVATION PROJECTS

"We made a distinction between renovations of historical buildings – such as Lausanne's Galeries du Commerce, which was converted into the Lausanne Conservatory by Longchamp & Froidevaux (left) – and what we call 'modern legacy works,' which include, for example, Nestlé's headquarters in Vevey, which were renovated by Jacques Richter and Ignacio Dahl Rocha," says Schroeter. ■

Wendy Queen's sponges

Head of the Laboratory of Functional Inorganic Materials at EPFL

I am Wendy Queen. I'm originally from South Carolina. I moved to Switzerland from the San Francisco Bay Area in May 2015 after I was offered a tenure-track position as assistant professor at EPFL Valais-Wallis. Since then I have led the Laboratory of Functional Inorganic Materials.

You might say that my work focuses on sponges, or at least materials that are somewhat like sponges. We call them metal-organic frameworks – MOFs for short – because, in fact, our sponges are made of metal and organic building blocks. At first glance, MOFs look more like powder. But when you get to know them, they have a lot in common with the good old kitchen sponges that one might use to wash dishes. MOFs are the most porous materials in the world. The pores range from half a nanometer to a maximum of five nanometers, about 50,000 times smaller than the diameter of a human hair. We design the sponges so that they can selectively soak up targeted molecules or ions in preference to others. As such, MOFs can be used to separate targeted species from gases or liquids. For example, we can specifically design them to remove heavy metals from water or carbon dioxide from the air.

I'm a chemist with a background in inorganic chemistry. During my scientific career, I have always been fascinated by the structure of materials, how they work and why they have this or that property. In fact, my love of structure is the reason I became so interested in MOFs. The materials are extraordinarily beautiful. If you look at their crystal structure, you see that the atoms are arranged in a very well-defined way. That order enables us to identify the structural features that give rise to desired properties in a given material.

I remember when I first became infatuated with MOFs. As a PhD student, I was designing new materials and studying their magnetic properties. For my postdoctoral fellowship, I wanted to learn new skills and expand my scientific horizons. In particular, I wanted to gain more expertise related to materials characterization. So I applied for a position at the NIST Center for Neutron Research in Gaithersburg, Maryland. There I had the chance to study materials in detail using neutron scattering techniques. In short, I began using neutrons to study the structure of MOFs, and I have hardly worked on other materials since.

I'm deeply interested in applying my science to solving globally relevant problems, like reducing energy consumption, cutting CO_2 emissions and improving water quality. At the moment, I can see that porous materials have the potential to make a powerful impact on the world, and this is one of the reasons that I continue to work with MOFs. ■

PODCAST

"Are you sure?"
go.epfl.ch/PodcastWendy

Wendy Queen and colleagues are developing sponge-like materials that collect specific substances from liquid and gas. These materials are actually crystals.

Subscribe to *Dimensions*, the EPFL magazine

Every quarter, discover a new thematic focus, an in-depth interview with an alumnus or alumna, the latest scientific highligts and innovation of the EPFL teams as well as stories about life of a unique campus in Lausanne and beyond.

By email: dimensions@epfl.ch or via our website: dimensions.epfl.ch

MASTHEAD

Publisher
EPFL Mediacom
Mirko Bischofberger

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

Editorial team
Arnaud Aubelle
Emmanuel Barraud
Anne-Muriel Brouet
Rémi Carlier
Cécilia Carron
Madeleine Dungy
Sandy Evangelista
Roland Fischer
Valérie Geneux
Giorgia Guglielmi
Julie Haffner
Nathalie Jollien
Celia Luterbacher
Clara Marc
Farnaz Moser
Nik Papageorgiou
Sarah Perrin
Sandrine Perroud
Tanya Petersen
Hillary Sanctuary

Proofreading
Marco Di Biase
Bill Gilonis

Translation
Scala Wells Sàrl

Illustrations
Laurent Bazart
(focus and cover)

Infographics
Emphase Sàrl, Lausanne

Comics
Nik Papageorgiou
Pierre Wazem

Editing
Giselle Weiss

Graphic design
EPFL Mediacom
Communication Visuelle
Marc Borboën
Ivan Savicev
Suzanne Setz

Print
PCL Presses Centrales SA, Renens
Print on certified Rebello «ange bleu" - 100% recycled paper, mat

Circulation
25,500 (Fr)
9,500 (En)

Publication
Published quarterly in March, June, September and December

Subscriptions
CHF 20 per year (4 issues), free for EPFL Alumni members

Advertising
EPFL Alumni
Rolex Learning Center
Station 20
1015 Lausanne
Switzerland
alumni@epfl.ch

Campus closed during health crisis © EPFL, Jamani Caillet