ETH zürich

NO. 3/2019

GLOBE

SMART FOOD

Harnessing new technologies to produce food more sustainably

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Peatland researchers play oxygen waiting game

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Julia Wysling: ETH alumna with a head for numbers

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Food affects us all

Joël Mesot, President of ETH Zurich

Few things affect us as deeply – and trigger as many emotions – as food. From the moment we are born, it is something we depend on. The Earth is currently inhabited by 7.7 billion people, a figure that is expected to climb to 9.7 billion by 2050. And all these people need to be fed. The question is, how can we produce this food efficiently while doing as little harm as possible to the climate and environment? The challenges are both numerous and complex, as highlighted in the IPCC's recent report on climate change and land. And that's why feeding the world must go hand-in-hand with sustainable land management and climate change mitigation.

The list of relevant topics ranges from drought-resistant plants and new breeds to the search for protein-rich meat substitutes and strategies for avoiding food waste. Smart farming can also help by increasing harvests and reducing the use of pesticides in agriculture. Researchers from many different academic departments and disciplines are already seeking solutions for the world's food system. Back in 2011, ETH Zurich opened its World Food System Center, a research centre that seeks to promote targeted cooperation with local and global industry partners. Taking this kind of approach is vital: firstly, because we need to come up with solutions along the entire value chain and, secondly, because we can only reap the benefits of new technologies if those technologies are also accepted by consumers.

We have chosen to dedicate this issue of the ETH magazine *Globe* to the diverse issues surrounding food and the search for sustainable solutions.

I hope you enjoy reading it!

Cover picture: gettyimages, iStockphoto / Editorial: Markus Bertschi

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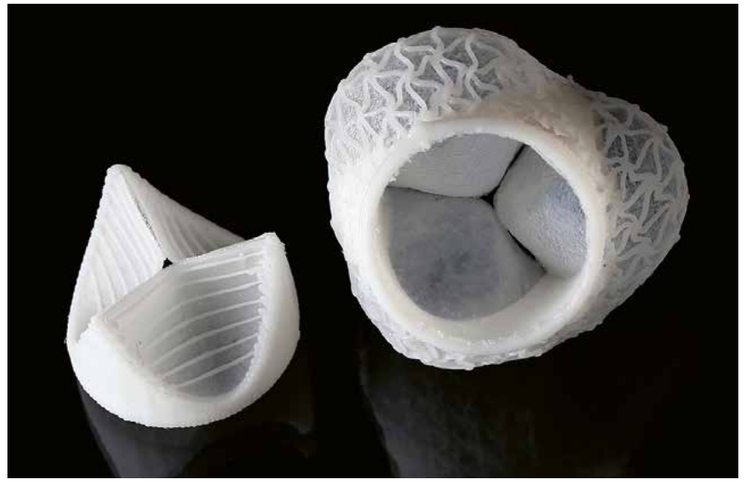
Images: Benjamin Hofer; Peter Rüegg; Annick Ramp

NEW AND NOTED

Medicine

3D PRINTING OF HEART VALVES

It is estimated that more than 800,000 people will require artificial heart valves in 2050. Researchers in André Studart's group at ETH Zurich and at the South African company Strait Access Technologies have now developed an artificial heart valve made of silicone, which is produced using 3D printers. The new model has several advantages over conventional heart valves: it is tailor-made for the patient, compatible with the human body without the need for drugs, and significantly faster to produce.



The valve flap (left) is reinforced with silicone threads. The implant also includes the aortic root (right).

Transport

DRIVERLESS CONGESTION

Current trends such as digitalisation and the sharing economy will fundamentally change mobility in cities: in the future, public transport will be electric, customised, and autonomous. The first driverless taxi services have already been launched in the US in a bid to create a mobility system with significantly fewer vehicles, lower emissions, and lower costs. Previous studies encouraged these hopes.

ETH researchers in Professor Kay Axhausen's group have now come to new conclusions, however. In a simulation, the team showed how Zurich's traffic volume might change if automated taxis were to be introduced at some point over the next two decades. Unlike previous studies, this simulation took into account supply and demand, users' individual behaviour patterns and user preferences regarding flexibility, costs and waiting times. This was based on a survey conducted in the canton of Zurich.

The results were surprising. They suggested that driverless taxis would not decrease the number of private vehicles on the road as long as automated private vehicles were also available – and that automated transport might even increase the number of kilometres driven. "The combination of high flexibility and the chance to make good use of time spent in the vehicle makes this form of mobility very attractive," says Axhausen. For this reason, he urges the authorities to regulate the introduction of self-driving cars.

Treatment plants clean our wastewater.

Environment

CLEAN WATER

Microcontaminants place a burden on our water courses, but removing them from wastewater requires considerable technical resources. ETH researchers have now developed a new approach: using multiferroic nanoparticles, they have succeeded in converting the contaminants into harmless compounds.

Images: Fergal Coulter; Shutterstock

NEW AND NOTED

Digital building technologies

THE ART OF CONCRETE COLUMNS

Nine mighty concrete columns dominated the townscape of the small Swiss mountain village of Riom this summer. They were erected as part of the Origen Festival of Culture, which brings unusual venues to life with new music and dance performances. The Concrete Choreography art installation was the brainchild of Benjamin Dillenburger, Assistant Professor of Digital Building Technologies. Backed by the NCCR Digital Fabrication, students of the Master of Advanced Studies in Digital Fabrication and Architecture used custom software to design the columns before 3D printing them in concrete. The process developed at ETH Zurich allows complex concrete elements to be fabricated automatically without the need for any formwork. It took around 2.5 hours to print each of the individually designed, 2.7-metre-tall columns.

The installation served as an attractive backdrop for dancers during the festival – and it provides a striking example of just how much aesthetic potential 3D printing holds for the future of concrete construction.

→ www.ethz.ch/concrete-choreography

Image: Benjamin Hofer

ETH GLOBE 3/2019

Deep geothermal energy

Dormant tunnel provides research windfall

This summer, ETH Zurich opened an underground rock laboratory in the abandoned Bedretto tunnel. This new facility will enable researchers to investigate ways of exploiting deep geothermal energy.

Some five kilometres in length, the Bedretto tunnel is a branch of the Furka base tunnel and was originally built to speed up construction work on the latter. At one time, it also figured in ambitious plans for a direct rail link between Wallis and Tessin. In view of the horrendous costs, however, the project was abandoned.

After many years of lying dormant, this major piece of engineering has now provided the scientific community with an unexpected windfall. Researchers from ETH Zurich recently opened a new test lab deep beneath the Pizzo Rotondo mountain, not far from the town of Airolo. The Bedretto Underground Laboratory for Geoenergies – the Bedretto Lab, for short – was established with the support of the Werner Siemens Foundation and other partners, both at home and abroad. The researchers' ambitious goal is to identify avenues that could lead to a real breakthrough for deep geothermal energy in Switzerland.

Initial test drilling in the Bedretto Lab

Major potential

The use of deep geothermal energy for power generation and heating purposes has major potential and occupies a key place within the Swiss Confederation's energy strategy. Switzerland aims to have a total of 12 geothermal power plants in operation by 2035, and a further 13 by 2050. Each will have an installed capacity of 20 megawatts – enough, in combination, to cover between 5 and 10 percent of the country's power needs.

Yet there are significant hurdles, both technically and financially. Working at a depth of four to five kilometres, pressure is applied to subterranean rock in order to fracture it and make it permeable. Only then can cold water be pumped down and brought back to the surface, via a second borehole, as heated water.

The use of pressure is essential to fissure the rock and make it more permeable to water. However, depending on the properties of the rock and the technique used to fissure it, this procedure can trigger larger shocks that are then felt on the surface as earth tremors. This was one of the reasons behind the abandonment of pilot projects in Basel and St. Gallen a number of years ago. Not surprisingly, levels of public acceptance tend to sink rapidly as soon as the ground starts to shake.

Realistic tests

As project manager Marian Hertrich explains, their work in the new lab focuses on what happens when rock is fractured underground. How do large fissures form? And what can be done to prevent any discernible earth tremors on the surface, let alone a full-blown earthquake? "The conditions here are ideal: we've got a good kilometre of overlying rock above us, so the overburden pressure is high," he says. "And we can follow events at close range."

In the rock lab back in Zurich, special presses are used to study rock samples under high pressure. "But you can't simply extrapolate the results of these experiments to a larger scale," Hertrich explains. "In the Bedretto Lab, we can conduct experiments under realistic conditions that approach those actually facing a geothermal power plant."

Before the team of drilling engineers, seismologists and geophysicists could get down to work, the tunnel itself had to be overhauled. "We had to secure the vault roof in some places and lay a new track," says Hertrich. "But now that has been completed, we can start the proper test work."

Right now, engineers are busy drilling 300-metre boreholes into the rock, spaced at intervals of several dozen metres. Once this work is over, water will be pumped under pressure into the boreholes in order to fracture the rock. A whole battery of instruments is on hand to measure what happens in the borehole and the surrounding rock. This should help the lab team to understand where and when critical faulting occurs.

Work at the lab will initially focus on four projects. One is in the area of basic research and looks at how underground rock behaves during an earthquake. The other three are concerned with concrete questions related to geothermal engineering. "All three projects are complementary," Hertrich explains. "In the Bedretto Lab, we're investigating the behaviour of the rock and also testing out new drilling techniques." This is because advancements in drilling technology are needed before deep geothermal energy can be used to generate power at competitive prices. "Drilling at those depths through such hard rock is a very complex and, of course, expensive business. We therefore need techniques that will make drilling through underground rock as efficient as possible."

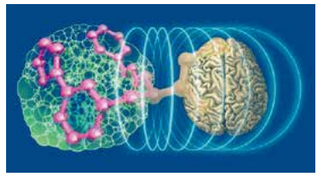
Once the boreholes have been drilled, the real work at the lab can begin. "We'll be trying to fracture the rock in such a way that the resulting heat reservoir can be used as efficiently as possible and without triggering any earth tremors that can be felt or will cause damage on the surface." Here, too, the crucial question is how best to manage this reservoir so that the heat can be used for as long and as efficiently as possible. "Ultimately, what we're after is a deeper understanding of the entire process, from the initial development of the geothermal source right up to its long-term exploitation," says Hertrich. "At every phase of the process, we need to understand as clearly as possible what's going on underground and how we can influence the behaviour of the rock in the way we want to." — Felix Würsten

Find out more about the project:
→ www.bedrettolab.ethz.ch

New ETH podcasts

Intelligence in a new light

Artificial intelligence and machine learning make us look at human intelligence in a new light. In this podcast, we discuss the advantages and dangers of artificial intelligence with ETH professors Benjamin Grewe, Simone Schürle and Thomas Hofmann. We take a look to the future and talk about new technologies, such as mini-implants to enhance the human brain. And we ask: how much has fiction already become reality?



Don't miss out on talent!

The Times Higher Education (THE) World Academic Summit is an event held at ETH Zurich that brings together managers from across the globe who work with talent. In this ETH podcast, Rector Sarah Springman and Professor Manu Kapur discuss how they find talented people and how talent, learning capacity and knowledge can be blended together.

Find out more:
→ www.ethz.ch/podcast

Image: Tibert Keller

Images: Frank Hyde-Antwi; Markus Bertschi, courtesy of Manu Kapur (montage)

Zukunftsblog

Sustainability

BIODIVERSITY: CRISIS OR OPPORTUNITY

Biodiversity is dwindling – and a crisis is looming. The good news, says Christoph Küffer, is that we can take action right on our own doorstep and turn this crisis into something positive for ourselves.

→ www.ethz.ch/zukunftsblog-kueffer-en

Christoph Küffer, *Privatdozent* in the Department of Environmental Systems Science

Digitalisation

CASH, CARD OR CRYPTO?

Now that the initial hype around cryptocurrencies has abated, Roger Wattenhofer thinks it's a good moment to give some serious thought to Bitcoin and co. – and how we'll be paying in the future.

→ www.ethz.ch/zukunftsblog-wattenhofer-en

Roger Wattenhofer, Professor of Distributed Systems in the Department of Information Technology and Electrical Engineering

Health

AVERTING A DIGITAL HEALTH CRASH

The medical sector has something to learn from the consequences of the Boeing aircraft catastrophes, warns Walter Karlen. In his Zukunftsblog, he points out parallels between aviation and medicine.

→ www.ethz.ch/zukunftsblog-karlen-en

Walter Karlen, Professor of Mobile Health Systems in the Department of Health Sciences and Technology

Images: Giulia Marthaler (2); courtesy of Christoph Küffer

In 2018, the Swiss Army was able to salvage several parts of the crashed Dakota, *including this propeller.*

Glaciology

PATIENCE IS A VIRTUE

In November 1946, a US Air Force plane crash-landed on the Gauli Glacier in the Bernese Alps. All passengers and crew survived, and the plane remained more or less intact. Afterwards, the president of the Swiss Glacier Commission, Paul Louis Mercanton, managed to persuade the Americans not to retrieve the crashed aircraft. Mercanton reasoned that the plane would be covered by snow and gradually sink into the ice. At some point it would then reappear, providing valuable insights into the movement of glacial ice.

It was only in the last few years that the Gauli Glacier relinquished its hold on various parts of the wreckage. For example, in summer 2018, a salvage operation succeeded in recovering a propeller, an engine block and parts of the wings. Based on model calculations, researchers at ETH Zurich's Laboratory of Hydraulics, Hydrology and Glaciology (VAW) have now come to the conclusion that it could take between 8 and 16 years for the plane's fuselage to resurface.

They also consider it unlikely that the fuselage will reappear where the other parts emerged. This would require a much faster ice flow than their calculations suggest over the past few decades.

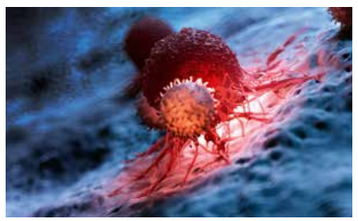
The researchers based their calculations on a combination of earlier observations, climate data and terrain models. In this way, they were able to calculate how fast the glacier could have moved over recent decades.

Cancer immunotherapy

SIMULTANEOUS TARGETING

Tumour cells have the ability to suppress the activity of patients' T cells, which play a critical role in the immune system. To do this, molecules on the surface of tumour cells interact with what are known as checkpoint molecules on the surface of T cells. Enzymes such as SHP-2 then transmit the checkpoint molecule signals within T cells to prevent the cells being activated.

Cancer researchers are therefore seeking ways to target this enzyme. A team of scientists at ETH Zurich and Aix-Marseille University has now shown that when SHP-2 is lacking, a related molecule, SHP-1, performs its role. Because these two enzymes can replace each other, the researchers believe that both must be targeted simultaneously.

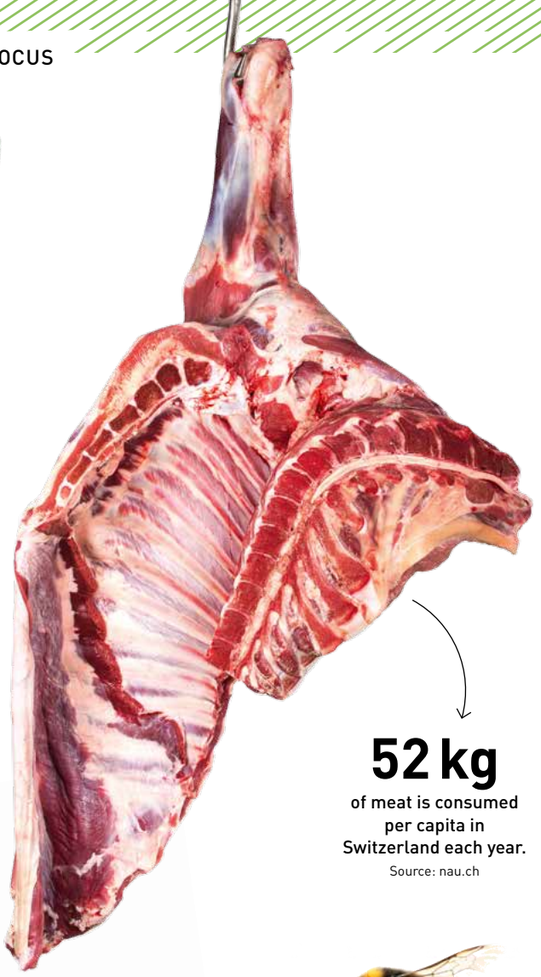


Cancer immunotherapy enables the body's own T cells (front) to eliminate tumour cells (dark red).

You can find more information on these topics and other research news from ETH Zurich at:
→ www.ethz.ch/news-en

Images: KEYSTONE/Peter Klaunzer; Shutterstock

1/3
of all the food produced in Switzerland ends up as food waste.
Source: foodwaste.ch



52 kg
of meat is consumed per capita in Switzerland each year.
Source: nau.ch

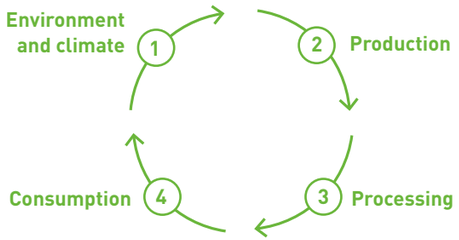
60%
of the 1,143 recorded insect species in Switzerland are endangered or threatened.
Source: naturwissenschaften.ch

9.7 bn
people will inhabit Earth by 2050
Source: UN

Our food: climate change, global population growth and biodiversity loss are a threat to our food system.

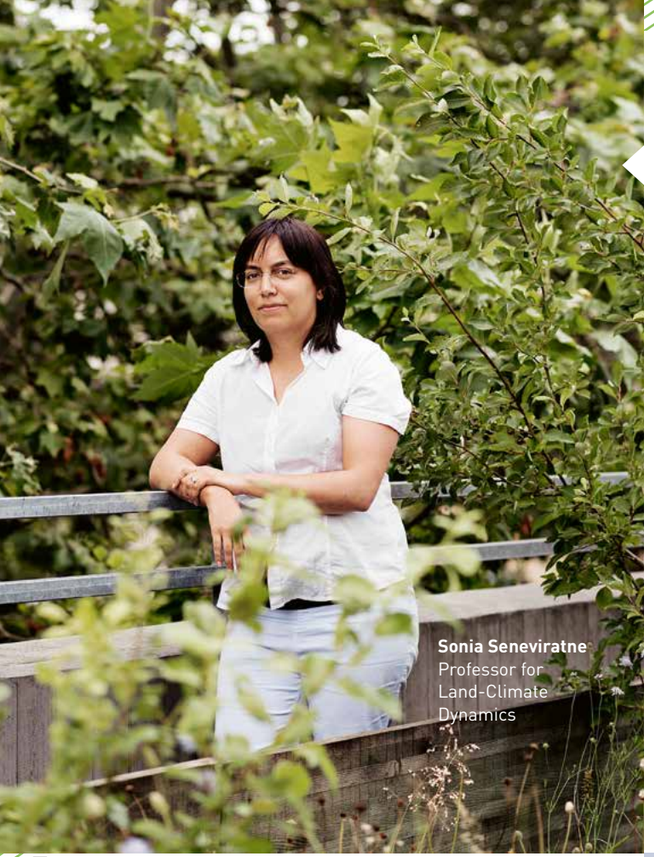
We need to take a more sustainable approach to what we eat and how we produce it. In its search for solutions, the ETH World Food System Center deploys cutting-edge technology to investigate the entire food value chain.

45%
of the planet's land surface is used for livestock farming.
Source: planted.ch



25%
less precipitation will fall in Switzerland by the middle of this century.
Source: CH2018

Images: iStockphoto (16)



Sonia Seneviratne Professor for Land-Climate Dynamics

ENVIRONMENT AND CLIMATE

"Food, climate and the environment are closely interlinked. Agriculture, for example, is heavily affected by climate change, but also emits large amounts of CO_2.

This situation poses significant challenges for food production. Earth has already warmed by an average of one degree Celsius – and extreme heat events are on the rise worldwide. Heavy rainfall has become more frequent in many areas, while the risk of drought is increasing in some of the world's most important agricultural regions. Even Switzerland is experiencing hotter, drier summers that put agriculture at risk. Moreover, a rapidly warming climate threatens biodiversity. And decreasing species diversity has a negative impact on natural resources such as fertile soils, clean water and insect pollinators, which form the basis of our food system.

Agriculture, forestry and similar forms of land use account for a net total of around 25 percent of global greenhouse gas emissions. Deforestation, artificial fertilisers, tillage and livestock production all play a part in this process. Emissions could be greatly reduced by adopting alternative soil cultivation practices such as no-till farming and, in particular, by switching to more vegetable-based rather than meat-based diets."

Erich Windhab Professor of Food Process Engineering

PROCESSING

"Nowadays, the food we eat can be processed and monitored at every stage of the value chain, from agricultural production to the biological uptake of nutrients in the human digestive system. Key steps include the separation and cleaning of raw materials, like the removal of mould-infected grains during harvesting; tailoring, preserving and packaging in industrial fabrication; as well as steps required to prepare foodstuffs for consumption in restaurant or catering facilities and homes.

The ultimate objective is global food security. That means securing access to safe, healthy and nutritious food for up to ten billion people in 2050. In environmental terms, we will then obviously no longer be able to afford inefficiencies such as food waste or the luxury of daily meat consumption.

New food processing technologies will help in the quest for alternative, more sustainable means of satisfying the growing demand for meat – for example with plant-based foods that are rich in proteins, fibres and micronutrients while appetising enough to persuade people to make the switch from meat. Ideally, we will also make use of high-quality components that arise as byproducts during the processing of other foods."

PRODUCTION

"We need to produce our food more sustainably. In my view, that means putting a greater focus on eco-friendly food to ensure we maintain key elements of life – such as biodiversity – for the long term. But food production methods also need to be economically viable and socially acceptable. That requires all sorts of adjustments to be made to different cultivation systems, products and farming regions – there's certainly no one-size-fits-all solution!

There are, however, plenty of signs that we are heading in the right direction. The growing impact of digitalisation – combined with advances in robotics and biotechnology – holds the potential to make agriculture more sustainable and conducive to life. Sensors and algorithms can turn agricultural data into a useful resource. Autonomous drones and robots can help deliver precisely calculated doses of fertiliser, crop protection products and irrigation based on the current state of vegetation. And plant breeding can boost disease resistance and improve crops' stress tolerance. Smart technology is the best way forward for the environment – but only if everyone is on board. People need to demonstrate a clear willingness to promote biodiversity and tackle climate change. With a more eco-friendly, transparent approach and prudent use of available data, we can boost consumer confidence in agriculture."

Achim Walter Professor of Crop Science

CONSUMPTION

"Humans are omnivores, and cultural norms dictate what's on the menu. Most consumers are conservative when it comes to food choices. It takes time for new foods to gain acceptance, especially when it comes to replacing meat with alternative sources of protein.

As a rule, meat is less eco-friendly than plant-based proteins. Yet demand for meat, in particular, will continue to grow due to population growth in developing countries. Meat consumption may have plateaued in Europe and North America, but it is still much higher than in developing countries. As soon as income rises in those countries, people will also start eating more meat.

Most consumers struggle to assess the environmental impact of different foods correctly. They tend to overestimate the impact of organic versus conventional food production, and underestimate the impact of animal proteins. For example, many people believe that conventional tofu is significantly worse for the environment than organic beef. That's why it's so important to make consumers more aware of the consequences of their food choices. Reducing our environmental footprint requires not just motivation, but also a full understanding of the facts."

Images: Annick Ramp (4)

Michael Siegrist Professor of Consumer Behaviour

With pitchfork and drone

With the advent of smart farming, agriculture has now entered the era of big data. Drones, robots and intelligent imaging should soon be boosting farmyard efficiency and sustainability. Switzerland's characteristic smallholdings could be one of the chief beneficiaries.

TEXT Samuel Schlaefli

A

At the Research Station for Plant Sciences in Lindau, postdoctoral researcher Helge Aasen is piloting a large, black drone with six rotor blades. The drone is helping him to determine the phenotype – that is, quantify the characteristics – of 350 or so different wheat varieties under trial cultivation. Using the drone, he can do this with a speed and level of precision that, until recently, would have been inconceivable. The drone carries a 6-kilogram payload comprising a range of high-tech equipment. A thermal imaging camera measures the temperature of the wheat when the drone is airborne. This enables Aasen to calculate the degree of water evaporation. Two hyperspectral cameras serve to determine chlorophyll levels and therefore plant productivity. An RGB camera generates a 3D model of the crop, accurate to a matter of centimetres. This is used to calculate stalk height and leaf area. The latter is a crucial indicator of the level of resistance to pests displayed by any wheat variety. What Aasen is showcasing here is the future of farming. Indeed, drones and all the various high-tech cameras could one day form part of basic farmyard inventory.

The fourth agricultural revolution

The research station in Lindau is the summer residence of the Crop Science group, to which Aasen belongs. It is here that Achim Walter, ETH Professor of Crop Science, and his team are working to bring about the fourth agricultural revolution – a revolution that he, along with fellow ETH academics, first proclaimed in a widely read opinion piece published by the journal *PNAS* back in 2017. There the authors predicted that agriculture in the 21st century would be increasingly determined by the smart use of data. Technology is by no means a new arrival to the farmyard. The 1990s saw the arrival of "precision farming", when equipment manufacturers introduced machinery fitted with GPS and infrared sensors as a means of boosting productivity. Yet "smart farming" – and all the systems this entails – promises to go one step further. With the help of sophisticated imaging technology, efficient machine learning and huge volumes of data, it won't be long before "intelligent" agricultural machinery is taking decisions autonomously.

Experts see big potential in smart farming. According to the FAO, between 20 and 40 percent of the world's grain harvest is lost to pests and disease, notwithstanding the use of some 2 million tonnes of pesticides a year. It is hoped that the smart use of data and new technology will help boost yields and, at the same time, substantially reduce farming's carbon footprint. On the basis of data gathered with drones, as in Lindau, it will be possible to target the use of fertilizer, pesticides, herbicides and fungicides much more precisely, with spraying restricted to only those areas that actually need it. Based on the studies now available, Walter calculates that savings of up to 90 percent could be achieved.

High throughput

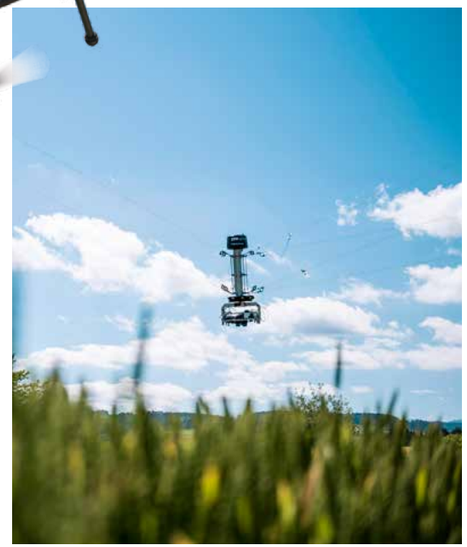
News of the work being done at the Lindau research station has spread within the international smart farming community. It is in Lindau that Walter has set up a unique field trial for determining plant phenotypes (FIP). The key piece of equipment is a sensor unit equipped with a laser scanner, multispectral cameras, an infrared camera and two spectrometers. Suspended from Kevlar cables strung between four high masts, this glides quietly above a test field measuring 100 metres by 130 metres. Growing beneath are various varieties of wheat, soybean, maize, buckwheat and forage grasses. Back in a control room equipped with monitors, the researchers use electric cable drives to manoeuvre the sensor unit to any position above the field. With the help of high-resolution colour, thermal and multispectral images provided by the sensor unit, they can monitor plant growth, photosynthesis and the ripening behaviour of the different varieties under cultivation. What's more – and this distinguishes Walter's set-up from others – plant characteristics can be monitored continuously without disturbing the crop below and in almost any weather conditions. And, unlike a drone with rotor blades, the suspended sensor unit doesn't create any wind turbulence that would make the plants move and thereby falsify the readings. For this reason, the FIP is also very useful for calibrating drone-based scanning methods.

The future of farm work

Flourish, a three-and-a-half-year EU project, has now looked at how drones might be used in future farming. An international team coordinated by Roland Siegwart, ETH Professor of Autonomous Systems, developed an autonomous tractor-drone system for the cultivation of sugar beet, a major crop in Europe. The drone iden- >

Drones

ETH is using a drone to quantify the characteristics of wheat varieties under trial cultivation. In future, this technology could help massively reduce the use of pesticides.



Field trial for determining plant phenotypes in Lindau

Images: Annick Ramp; Daniel Winkler

tifies weeds in the ground under cultivation and directs the tractor to the exact location. The tractor then crushes the weeds with hydraulically powered steel rams. This kind of robot would not only lighten the load for farmers but also make it once again economically attractive to destroy weeds mechanically rather than with a chemical herbicide. Flourish was completed in 2018. The tractor-drone system is now undergoing further development with the Bosch company Deepfield Robotics, which was also involved in the EU project.

"Drones are ideal for rapidly collecting data on crop conditions across a large area," Siegwart says. However, as he explains, processing sensor data in order to develop practical applications for agriculture is a lot more complicated: "Biological systems are diverse and complex. That makes our work more difficult." In Switzerland alone, for example, there are over 30 different wheat varieties under cultivation. Similarly, shadows from clouds and crop movement caused by wind can make it difficult to obtain accurate readings. In other words, it takes large volumes of data, sophisticated machine learning and lots of patience to develop autonomous systems that will function reliably. In the long term, Siegwart sees drones being used not only for data capture but also for crop spraying and other field work. Equipped with a spray and tank, autonomous drones could be used to apply fungicides and pesticides to only those plants that are actually infested. In order to advance the development of this and similar technologies, Siegwart and Walter are planning to set up a laboratory in Lindau, where agricultural scientists, biologists, robotics experts and computer scientists can all work together.

Who owns the data?

Smart farming offers great opportunities, but there are risks involved. For Nina Buchmann, ETH Professor of Grassland Sciences and co-author of the 2017 article, one key question concerns ownership of the data and what happens to it. "There's certainly a danger of becoming reliant on a small number of global players. As many countries as possible, including Switzerland, should therefore join forces to prevent this happening." Moreover, there is also the question of liability in the event of accidents involving drones or environmental damage stemming from wrong decisions made by autonomous systems. Who is then responsible? The farmer, the programmer or the manufacturer of the sensor system? And, finally, this all inevitably raises the question of whether, one day, there will be fully automated farms without the need for farmers. "That's certainly not my vision of smart farming," says Walter. "But here in Switzerland, in particular, digitalisation could help farming as we know it – small-scale, diverse, geared to quality – to hold its own on the international market, despite having reduced the use of fertilizers and pesticides."

The reaction in the farming community is mixed. As part of the Sustainable Economy national research programme (NRP 73) funded by the Swiss National Science Foundation, farmers were asked which applications would make practical sense and how willing they would be to accept the help of robots and drones out in the fields. "Some said they would shoot down any drone they saw flying over their land," Walter recounts. "But then others said, 'Cool! I fly a drone in my spare time, anyway. So why not use the images to improve my yields?'" ○

FOOD STUDIO FOR DIGITAL NATIVES

The ETH Studio AgroFood flagship project helps prepare students to meet the challenges of an increasingly digitalised food system. The aim is that the knowledge they acquire should flow directly into practical applications for the agro-food sector. The AgroFood Studio is being run by the World Food System Center during a pilot phase lasting two-and-a-half years. Innovation in Precision Agriculture, a Bachelor's course held in conjunction with the Crop Science group, ran for the first time in autumn 2018. Its purpose is to provide students with an introduction to the fundamentals of smart farming. The AgroFood Studio is coordinated by Eduardo Pérez and headed by a group including Nina Buchmann, Professor of Grassland Sciences, and Achim Walter, Professor of Crop Science.

ETH Studio Agro Food:
→ www.ethz.ch/eth-studio-agrofood

"Agriculture is becoming more diversified"

Farming faces significant challenges, from producing food sustainably to making a profit and living up to society's expectations – all against the background of a changing climate. ETH scientists met up with a farmer who uses integrated production methods to discuss whether technology can help.

INTERVIEW Martina Märki and Felix Würsten *IMAGE Annick Ramp*

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Mr Hunkeler, you have a farm near Lucerne, with cows, Mangalitsa pigs, crops and a livery stable. How do you think you will be running it ten years from now?
HANSPETER HUNKELER – I will have stepped aside by then, but my son will still be running the farm – and I think systemic interdependencies and the efficient use of resources will be more important than ever.

Will he also be using digital technologies?
HUNKELER – First he'll need to think about which type of production he wants and then decide which digital tools he's going to use. Digitalisation always comes at a cost, and you need to take systemic interdependencies into account. On our farm, I make a good profit from a herd of 24 cows on full grazing. If I were to buy a milking robot for the parlour, I'd need to double the size of the herd in order to make the same money. But then I wouldn't be able to run the farm with the same level of diversity that I do now.

In other words, "smart" farming means being less diverse?
ROBERT FINGER – Not necessarily. In Switzerland, agriculture has to produce food, but we also expect it to be sustainable and protect natural resources. The question is which dials we need to adjust to achieve that, especially when market conditions are changing all the time. First of all, we need to decide what kind of agriculture we want, and then we have to consider what kind of technology we need. It certainly won't be the technologies that farmers need in the US.
HUNKELER – In Switzerland, you can take the high-tech route in farming, but it needs to be organised on an outsourcing basis. Agricultural contractors with specialised fleets of machinery are one way of doing it.
BRUNO STUDER – Exactly. It's often the agricultural contractors who introduce new technologies into the system and motivate farmers to try something new.
FINGER – But the more complex the technology, the higher the cost of the machinery – and the more demanding it is to use. That's why for small farms, such as in Switzerland, outsourcing solutions can make sense. But they obviously also result in higher transaction costs. ›

"First of all, we need to decide what kind of agriculture we want."
Robert Finger

Discussing the future of farming (left to right): Robert Finger, Hanspeter Hunkeler and Bruno Studer.

STUDER – I'm convinced that the combination of new technologies, political pressure and external factors such as climate change will make our agriculture more diverse, and that this will occur on a variety of levels, including the production systems, the crops farmers grow and the genetic diversity of crops.

You talk about more diversity. But, viewed from the outside, agriculture seems to be getting more and more uniform...
STUDER – I don't think this is really true of the Swiss system. Compared to the massive monocultures grown in other countries, Swiss agriculture is still very diverse.
HUNKELER – But it's true that farming in Switzerland has become more uniform. We farmers have always been told that we need to specialise – either pigs or cows. The farmers who followed that advice and expanded their herds now rely on silage. And if they then fully automate operations in the cowshed as well, their crop rotation has to become pretty uniform in order to achieve the yields they need.

Does that also apply to organic operations?
HUNKELER – Organic farms also favour crop varieties that can be densely planted, because it keeps down the weeds. Which means the production areas see a decline in biodiversity. I'm convinced that this duality – one the one hand intensive production, and on the other hand areas reserved for promoting diversity – won't safeguard a variety of species. What we need are cultivation systems where the entire area is biodiversity-friendly.
STUDER – I see very positive signs. Twenty years ago, only a few varieties of wheat were grown here; today, there are dozens. What's more, we're seeing the return of other types of cereal such as spelt, as well as the emergence of alternative crops.
FINGER – A lot of things are being nudged in the right direction, whether by agricultural and environmental policy or the market. That said, many of the environmental goals in agriculture are not being met, and there's various reasons for that. Mr Hunkeler just argued that, if anything, digitalisation is likely to reduce biodiversity, but that's not a statement I would entirely endorse. We need to distinguish between individual cases.
HUNKELER – I'm not saying digitalisation automatically leads to a loss of biodiversity. But if you introduce it into dairy farming in the way I described, then that's exactly what you get. Yet I also see opportunities. If digitalisation can help farmers grow more mixed crops, that would be a big help. But as a farmer, I'd almost prefer to see new technologies being used in crop breeding. I'd like to have seed that is robust and that keeps the weeds down and converts nutrients as efficiently as possible.
FINGER – Plant breeding can do a lot, but it can't solve all the problems we face. It shouldn't be considered in isolation from the system as a whole. For example, we not only need more resistant varieties but also diverse cultivation systems that can help reduce disease pressure.

ROBERT FINGER: Professor of Agricultural Economics and Policy at the Department of Management, Technology, and Economics and the Department of Environmental Systems Science

HANSPETER HUNKELER: Farms according to the principles of integrated production in the canton of Lucerne and serves as an advisory board member of Vision Landwirtschaft

BRUNO STUDER: Professor of Molecular Plant Breeding at the Department of Environmental Systems Science

> **"Twenty years ago, only a few varieties of wheat were grown here; today, there are dozens."**
>
> Bruno Studer

As an expert on plant breeding, Professor Studer, you're involved in the public debate on genetically modified crops...
STUDER – Over the past 20 years, the pictures we've been given on GM crops have led to some very polarised views in society. However, the huge technological progress in this field – I'm thinking here of CRISPR/Cas – is now leading to the emergence of a more nuanced view. At the same time, people are seeing the impact of climate change in the field, and there's growing pressure within society for a reduction in the use of pesticides. The use of both traditional and new methods in plant breeding could make a real difference here.
HUNKELER – I think it's vital to avoid rejecting new technology simply because it's new. We should keep an open mind. In the area of plant breeding, especially, we will probably have to adapt more quickly than we once thought.

Could Switzerland, with its small-scale approach to developing and using technology, be a role model for other countries?
FINGER – Definitely. Small-scale agriculture is by no means unusual: there are lots of areas around the world in which farming is predominantly small-scale. By developing and applying new technologies that pave the way to a more sustainable form of agriculture, Switzerland might well have an exciting role to play on the international stage. ›

ETH has researchers from a whole range of disciplines working on the problems that agriculture faces. Is there a good dialogue between them?
FINGER – It's very important to take an interdisciplinary approach, as practised by ETH Zurich's World Food System Center in both its teaching and research. We're very much on the right track here.
STUDER – I think the dialogue is excellent. However, it's one thing for us professors to have a good exchange, but are we actually reaching farmers with our ideas?

> **"We need to approach things in a systemic way and act accordingly."**
> Hanspeter Hunkeler

As someone working on the practical side, do you get to hear about ETH research?
HUNKELER – Some things definitely do filter through. It's reassuring to hear that there's such as strong emphasis on a systemic approach here.

Society must also ask itself what kind of agriculture it wants. What's your impression of the public debate?
FINGER – The Swiss Federal Constitution clearly outlines what kind of agriculture we're aiming for. That's what farming and politics have to measure up to. What we're seeing right now is a big gap between society's expectations and the reality of agriculture. This, in turn, is reflected in a range of popular initiatives.
STUDER – In the media, farmers get blamed for everything imaginable. But nobody takes any notice of their achievements. That discrepancy bothers me.
HUNKELER – What disturbs me most of all is how the discussion gets simplified: small is good, big is bad; extensive farming is good, intensive is bad. Things are a lot more complicated than that. Even in nature, a high concentration of nutrients – in other words, the equivalent of intensive cultivation – is not automatically a bad thing. And you can't tell merely from the size of a farm whether it's producing in a sustainable way. Not enough people take the time to think about all the complex interdependencies.
FINGER – That said, there's still a lively debate here in Switzerland. All the various stakeholders are still talking to one another. And if you can't have a good debate and find solutions here in Switzerland, then where can you!

Could ETH play a more active role in this discussion?
STUDER – ETH should definitely be involved. But our priority is to communicate knowledge as neutrally as possible. I don't think it's really our job to try to determine the future of agriculture.
HUNKELER – What's important is getting ordinary farmers to think about things in a systemic way and act accordingly. Circular agriculture, farming that suits local conditions, resource efficiency and biodiversity – all these things require a systemic approach. And it also has to be worth it in financial terms.
FINGER – The research at ETH is creating the basis for the future of farming. That includes new technology, but it must also be informed by social, economic and political considerations. We need to put that across clearly. One key lever at our disposal at ETH is that we educate some of the people who go on to become key players in the worlds of agriculture, industry and politics. ○

SUPPORTING RESEARCH TO SAFEGUARD WORLD FOOD SUPPLIES FOR THE LONG TERM

As part of the World Food System Initiative, ETH Zurich and partners are working on solutions along the entire length of the food production chain. The aim is to establish the conditions for the sustainable production of high-quality, healthy food. The Future Food Initiative, which was launched by ETH Zurich together with EPFL and partners from industry, goes one step further. It aims to inject fresh impetus into Swiss research in the areas of nutrition and food production. Each year, it will provide funding for postdocs to pursue particularly promising lines of inquiry. Two initial projects will investigate alternative protein sources and the use of old crop varieties.

→ www.ethz-foundation.ch/en/world-food/

Dry run for cropping systems

To safeguard the long-term future of agricultural production in Switzerland, ETH and Agroscope are investigating how resistant the country's cropping systems are to drought.

TEXT Michael Keller

Image: iStockphoto

When deprived of water, **plants** can suffer embolism: air bubbles block the vascular system, so that the leaves wilt and may die.

The heatwave of 2018 was yet another warning to both farmers and the public on the effects of climate change: in the future, Switzerland will see less and less rain during the summer months. Given the prospect of longer and more frequent periods of drought, Nina Buchmann, Professor of Grassland Sciences, is concerned about the future of agriculture. She argues that drought and resulting crop failures pose an increasing threat to food production and asserts, "our agriculture is inadequately prepared". For her, the answer lies in a greater use of cropping systems that also deliver good, stable yields under dry conditions. At present, however, it is by no means clear which of the cropping systems common to Switzerland is the most resistant to drought.

Together with her team and colleagues from Agroscope, the Swiss centre of excellence for agricultural research, Buchmann is now aiming to find out. The research team is conducting a field experiment to investigate how well the common cropping systems in Switzerland react to sustained drought. Launched in 2017 and scheduled to run for three years, the experiment seeks to compare drought responses under conventional and organic cultivation with and without soil tillage – or, in the case of organic cultivation, with reduced tillage to keep weeds in check. The crops chosen for the experiment are maize, a mixed crop of peas and barley for forage, and winter wheat.

The project is funded through the World Food System Center's Mercator Research Program and the ETH Zurich Foundation, and is based on FAST, a long-term trial conducted by Agroscope, which for the past ten years has been studying the agronomic performance of these cropping systems.

Field experiments for agriculture
Out in the field, the ETH researchers use simple rainout shelters to keep the rain off and simulate drought conditions. The experiment itself is more complex. It comprises 4 different cropping systems applied to 32 plots, 16 of which are covered by a rainout shelter, while the rest are open to the sky. Each of the 32 plots is equipped with a device known as a PhenoCam, which captures images of plant growth hourly. Sensors in the soil and above ground measure a range of ecological and physiological variables. Four doctoral students are responsible for gathering the field data.

The experiment rests upon the hypothesis that organic production would be more resistant to summer drought than conventional agricul- ›

Rainout shelters to keep off the rain, and hoses to pipe away the water: by simulating summer drought conditions, researchers are investigating which production system best maintains good growing conditions during dry periods.

ture. Buchmann justifies this reasoning as follows: "We make this assumption because yields from organic production are known to be lower, so water consumption should be lower as well. You would also expect to find a greater presence of plant symbionts in the soil, such as nitrogen-fixing bacteria and mycorrhizae, both of which can favour greater resistance to drought and stress."

Various factors can influence the ability to withstand dry conditions. Researchers are therefore seeking to capture the performance of the crops, and also of the entire ecosystem and its services. Ecosystem services here include plant growth, the amount and quality of the crop yields, and the ability to withstand fungal infection and herbivory by insects. Fundamental soil characteristics such as soil fertility and the ability to decompose organic material are measured – as well as the presence of plant symbionts, the form in which different nutrients are available to plants, and how much nitrogen is being leached out of the soil. "We try to measure a lot of services, but using simple, established methods, so that we get the full picture and comparable results," explains Yujie Liu, who is working on a doctorate in Buchmann's group.

Embolism of plant vascular systems

The project also addresses a second assumption that cropping systems that involve less ploughing are better suited to withstanding summer drought. This is because less ploughing leads to a more stable soil structure, which should improve the availability of water and nutrients for the crops.

To test this hypothesis, Buchmann's team uses stable isotopes of hydrogen and oxygen to determine how much water is present at which soil depth and from which depth plants take up water. In addition, the researchers want to find out exactly how much the crops suffer as a result of the drought, and when this becomes critical for the plants. On a regular basis, Qing Sun, another doctoral student in Buchmann's group, heads out before sunrise to measure a specific physiological variable that tells her how much stress the plants experience as a result of the drought.

Plants have a vascular system to transport water through the stem. Evaporation from the leaves generates a suction that draws water from the tip of the root to the top of the plant. This creates a negative pressure in the vascular system, which can be measured. If the soil is dry, this pressure can increase to such a degree that the continuous water column in the vascular system breaks, leading to the formation of small air bubbles, which block the vessels. Depending on the location of this "embolism", one leaf may wilt or the whole plant may die. According to Sun, the team is mapping the fraction of vascular embolism over time. "Such measurements are very rare," she says. "They'll give us a better understanding of how plants react to drought stress under different cropping systems."

Waiting for the full picture

The experiment will run until the end of the coming year. Preliminary analyses suggest that cropping systems may have less impact on ecosystem services than originally assumed. Although the mixed crop of peas and barley appears to be more resistant to dry conditions when cultivated organically, it may well be that maize and winter wheat react differently. "We still don't have the full picture," Buchmann explains. For the time being, only the plants know whether there is one cropping system that is more resistant to drought than others – or whether each particular crop favours a specific cropping system. ○

Find out more about the project:
→ www.ethz.ch/wfsc-reload

Image: Qing Sun

Turning hype into real alternatives

Algae and insects are rich sources of protein for humans and livestock alike. Getting them on restaurant menus and into animal diet formulations still requires a lot of work – but it's worth the effort.

TEXT Corinne Johannssen

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"There's no doubt that the idea of using insects as food in Europe has caused some hype. But we need to be careful not to exaggerate the benefits of this solution over other options," says Alexander Mathys. Perhaps a surprising comment coming from an insect researcher, but this ETH Professor of Sustainable Food Processing has clearly done his homework.

For example, it is still unclear whether eating insects would actually reduce meat consumption: "In our part of the world, insects are an extra source of protein, a top-up. And our diet is already high in protein." What is clear from his sustainability assessments is that we should be eating fewer animal products due to their negative impact on our health and the environment. "The sensible approach would be to reduce the amount of meat we eat."

And there's another issue Mathys is concerned about: "Insect production will never be the sustainable solution we want as long as we keep raising them on high-quality feed that could be used for other purposes." Europe places clear restrictions on feed for insects cultivated as a food source, stating that the insects must be fed almost exclusively on plant products that are also approved as feed. In practice, this generally means mixtures based on rye or wheat flour.

In a joint project with Christian Zurbrügg from Eawag, Mathys and his doctoral student Moritz Gold are now planning to feed black soldier fly larvae with biowaste instead of cereal grain. The idea is to use insects to recycle biowaste more efficiently. "By using waste as an energy source, we're making use of one of the lowest-value waste ›

Insects

A sustainable meat substitute or an additional source of protein?

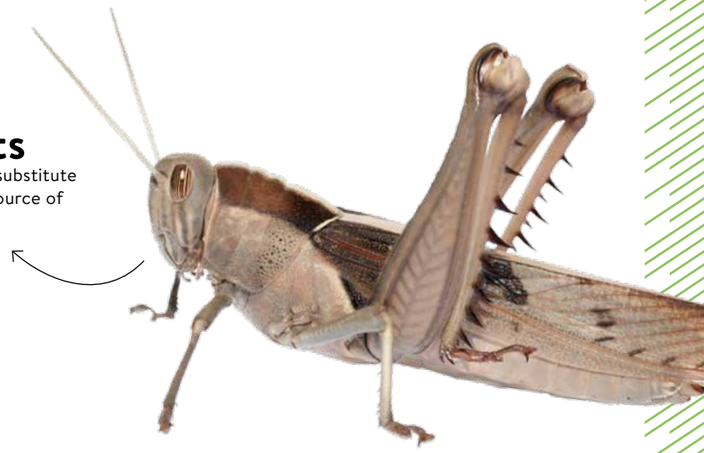


Image: Adobe Stock

Bon appétit!

Insects are still far from being a favourite food in Europe.

utilisations available," Mathys argues. Insects can give more value to waste by eating it and then becoming food or animal feed themselves.

Focus on the food chain

Yet there are still plenty of obstacles to overcome, including problems such as mould, pathogens, contaminated waste and heavy metals. The key question is what ultimately ends up in the food chain. "We need to guarantee safety in the value chain," says Mathys. To this end, he and his team are investigating whether larvae fed on biowaste show any biochemical or microbial contamination. Mould, for example, and pathogenic bacteria can produce potentially harmful toxins and may cause diseases. Other problematic substances in waste may end up accumulating in insect larvae and making their way into the food chain.

In order to improve their understanding of how these various issues tie together, Michael Kreuzer, ETH Professor of Animal Nutrition, has joined forces with Alexander Mathys and Eawag to carry out feed-related experiments on poultry at AgroVet Strickhof. Here insect larvae fed on municipal waste will be included in poultry feed. The partners at Eawag deliberately spike some of the larvae feed with controlled amounts of contaminants; the ETH researchers then feed these larvae to the poultry. After repeating this process for several weeks, they will test the poultry meat and eggs for contaminants.

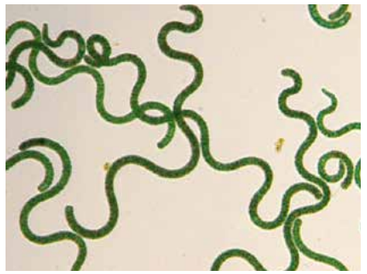
> "Microalgae are a promising source of proteins and unsaturated fatty acids."
>
> Alexander Mathys

Alternative to soya

While the team wait for the results, Kreuzer's doctoral student Maike Heuel is busy evaluating the data from another feeding experiment. Instead of being fed on high-grade cereal products, the larvae used in this experiment have been produced on waste discarded prior to, or during, the preparation of food, and on cereal by-products such as bran. One of the goals of Kreuzer's research group in this experiment is to discover whether soybean can be replaced by protein meal and fat from black soldier fly larvae. To find out, Heuel divided 50 laying hens into 5 groups, each of which received a different feed. The control group was fed on a conventional feed mix of cereals and soybean. The other groups received a mix of cereals, defatted protein meal and fat from two groups of insect larvae fed in different combinations.

The researchers are still waiting for the final results. "But it's already clear that we can completely replace soybean with insect meal without any loss of productivity. That means one egg a day, which is the maximum a hen can produce!" says Kreuzer. The team has yet to complete its analysis of other parameters such as the yolk content, protein composition and fatty-acid profile of the eggs.

Finding ways to replace soybean is particularly attractive to organic producers. "Organic farmers use large quantities of soybean. It may be organic, but it's still soybean!" says Kreuzer.



Blue-green spirulina microalgae provide not only proteins and lipids but also a valuable colourant.

This is because synthetic amino acids are not permitted in organic poultry production, so organic farmers have to use a feed richer in protein in order to meet the requirements of laying hens.

Algae as a replacement for meat

Algae are also rich in protein. Mathys enthusiastically advocates their use as a sustainable alternative: "Microalgae are a very promising source of protein and unsaturated fatty acids." In some types of algae, protein accounts for up to 70 percent of the dry mass, and they have all the essential amino acids. Yet there are also downsides, including the low level of technology readiness and minimal economies of scale, all of which results in higher costs. The fact that algae is green also poses major challenges for the food industry. "Eating a green algae steak as a one-off might seem fun, but long term we need to come up with more versatile solutions," says Mathys.

Colour may be problematic when it comes to green algae, but it's a valuable property in the case of spirulina microalgae. Spirulina blue is a high-grade product that fetches high prices. However, it requires great care to extract it without damaging it. This is the first step in what is known as cascade extraction, a process by means of which closed-cycle, algae-based biorefineries might one day be developed. A number of doctoral projects in this field are already under way in Mathys's group.

Once the delicate dye has been obtained, it can be processed by more vigorous means such as higher temperatures, thereby enabling the entire protein content to be extracted. "This can be used to produce meat substitutes, for example," says Mathys, who is currently collaborating with the start-up company planted (see infobox). Next it's time for the lipids, which are often even more stable. Unsaturated fatty acids are one of the most interesting forms of lipid due to their health benefits. Finally, whatever is leftover can be used as a source of energy, a carbon source or fertiliser.

Mathys's team are conducting a detailed analysis of the individual products. "We're paving the way for these products to be incorporated into the food system," he says. And the indications are that this will end up being a lot more than just hype. ○

You can hear more from Alexander Mathys in the ETH podcast:
→ www.ethz.ch/podcast

MEAT FROM THE VEGETABLE PATCH

The founders of the start-up company planted feel it's high time to offer an alternative to cheap meat from intensive livestock farming: a plant-based chicken alternative made of pea protein. Compared to normal chicken meat, "planted chicken" reduces greenhouse gases and land use by about two thirds, requires about half as much energy and contains no cholesterol, hormones or antibiotics.
Co-founder Lukas Böni has been awarded an ETH Pioneer Fellowship to assist with setting up the company. This also means that the start-up benefits from ETH expertise and infrastructure, including access to a pilot plant at ETH Zurich, where it can run production trials. Planted currently supplies around 20 selected restaurants in Switzerland.

Find out more:
→ www.planted.ch

Images: iStockphoto, Lukas Böcker

A transdisciplinary approach to the food crisis

Food supply chains are at risk from economic, political and climate shocks – especially in developing countries. That's why Johan Six and his team are searching for ways to make food systems more resilient.

TEXT Samuel Schlaefli

During our interview via Skype, Johan Six, Professor of Sustainable Agroecosystems, is sitting in a bland office in Nairobi, the capital of Kenya. That's where Six, a soil scientist, is spending his sabbatical – close to his project partners in Kenya and several other African countries. He is experiencing firsthand how climate change is increasingly threatening farmers' ability to ensure food security: "In western Kenya, the short rainy season was almost non-existent last year," he explains. "Many fields lay fallow, with serious consequences for the supply of food staples." Six's research topic is resilience – in other words, a system's ability to return to equilibrium after an extreme event – and he insists on the need for a shift in focus: "In the discussion surrounding sustainable food supplies, people often pay too little attention to the resilience of the overall food system."

Research involving those affected

As part of the AERTCvc project, funded through the Coop Research Program of the World Food System Center and the ETH Zurich Foundation, Six and his team analysed the value chains of teff in Ethiopia and cocoa in Ghana. Teff is the most important food staple in Ethiopia, while cocoa is Ghana's key export commodity. The team of researchers looked for factors that could enhance the resilience of the teff and cocoa value chains. They conducted several hundred interviews and focus group discussions with farmers, seed manufacturers, transport companies, agricultural service providers, lenders, government authorities, insurers, NGOs, distributors and consumers – because shocks affect not just farmers, but all the stakeholders in the value chain. A lack of communication between these stakeholders is one of the causes of inadequate resilience to factors such as droughts and fluctuations in global cocoa prices.

On the basis of their analysis, Six and his team drew up action plans together with the stakeholders. Responsibility for the interactions with the stakeholders was shared by the Transdisciplinarity Lab (TdLab). At TdLab, natural scientists and social scientists from the Department of Environmental Systems Science work hand in hand to develop solutions for sustainable development in close cooperation with the relevant stakeholders. "The objective of our research is not only to achieve a better understanding of sustainable development, but also to make a real difference on the ground," explains co-director Pius Krütli. "But we can only do that by involving local stakeholders in the research process at a very early stage."

To this end, the team used techniques such as the rich picture method. This method requires stakeholders to record the everyday challenges they face as well as potential solutions, in order to gain a clear overview of both the problem and the available scope for action. It is a promising tool, especially in cases where illiteracy rates are high and education levels low. The AERTCvc team also deployed the design thinking method, encouraging workshop participants to come up with creative solutions in a structured process. While that worked well in Ghana, it was less successful in Ethiopia, where many of the stakeholders spoke only Amharic. Six and Krütli had to work together with interpreters, which made the process more complex. "It's all part of the intercultural learning process," says Krütli.

Do organic methods promise greater resilience?

The experience the AERTCvc team have gained is proving to be a useful resource for researchers on the OrRes project (funded through the Mercator Research Program of the World Food System Center and the ETH Zurich Foundation), which aims to discover whether the value chains of organic products are more resilient to weather extremes than those of conventional ones. To answer this question, William Thompson, a doctoral student, is analysing the value chain linking small-scale cocoa producers in Ghana with chocolate manufacturers in Switzerland. Last year, Thompson carried out drought resistance assessments together with more than 500 cocoa farmers from two different regions of Ghana. The assessments were based on data from the period 2015–2016, when Ghana was stricken by severe drought. In addition to conducting interviews, focus group discussions and workshops, he measured soil conditions, available shade for the cocoa plants, biodiversity and planting density at 70 different farms. Thompson is currently evaluating the data, but says it is still too early to draw any conclusions with regard to resilience. He does, however, point to a dramatic drop in the number of pollinators in Ghana. In 2018, this led to the unprecedented deployment of thousands of workers to pollinate the cocoa plants by hand. The decline in the number of pollinators is most probably due to the use of pesticides that are banned in organic agriculture. Still, Six considers it questionable whether organic production methods can make the system as a whole more resilient, since organic and fair trade labels rarely provide farmers with the significantly higher incomes they need to ensure a sustainable, resilient livelihood.

Cocoa

Owing to the dramatic drop in the number of pollinators, thousands of workers had to be deployed in Ghana in 2018 to pollinate cocoa plants by hand.

Less waste and more productive soil

Six's latest project – his most complex and ambitious to date – is entitled RUNRES. In collaboration with the TdLab and supported by the Swiss Agency for Development and Cooperation (SDC), a transdisciplinary team is working across four African countries to analyse the flow of valuable nutrients between rural areas and cities, the goal being to reduce the accumulation of nutrients in cities and instead use them in agriculture. Thus, the analysis will serve as a basis for constructing a circular economy based on nutrient recycling. "Organic waste – like kitchen scraps, for example – account for around 70 percent of all refuse in African cities," explains Six. "At the moment, this waste ends up in unofficial garbage dumps or in rivers, and is a breeding ground for disease." Organic waste of this kind could be returned to rural areas as compost or animal feed. The same goes for human excrement: urine and faeces can be used to make biological fertiliser. That would keep cities cleaner and help enhance the productivity of agricultural land.

Six is currently coordinating this multi-year project from Nairobi, where he is spending his sabbatical, and he will continue in this role once he returns to Zurich. The four research locations – Rwanda, Ethiopia, Democratic Republic of the Congo and South Africa – are represented by professors, postdoctoral students, local project coordinators and a variety of different stakeholders. Six is delighted: "With SDC and our local research partners and stakeholders on board, we have partners who will help put our research into practice on a wide scale. That's a unique opportunity." ○

Further information:
→ https://resilientfoodsystems.ethz.ch

Image: iStockphoto

Artist's impression of the HiLo unit at the NEST research building

HiLo under construction

GEARED TO SAVE ENERGY

The curved concrete roof is spectacular – but there's even more to get excited about inside. With features including sensors, thermoregulating floors and ceilings, and an adaptive solar façade, this building is designed to produce more energy than it consumes. Thanks to a digitally optimised lightweight design, it requires fewer construction materials, which also means less grey energy. Construction began in July on the latest project at the NEST research building. Headed up by ETH professors Philippe Block and Arno Schlüter, the project also involves numerous industry partners.

Close to home

"GLOBE" CONNECTS

In March, the ETH magazine *Globe* asked readers what they like about the magazine and where they see room for improvement. Over 1,500 readers took the opportunity to send in their feedback. The majority of the respondents (74 percent) read every issue of *Globe*. Many readers commented on how they value *Globe* as a means of keeping in touch with ETH. Research proved to be a particularly popular topic, with 92 percent of readers expressing interest in articles on that subject. In second place, with 54 percent, were articles on business matters and spin-offs, followed by topics related to teaching and alumni, both at 41 percent. Most popular are the articles covering research findings, and the in-depth Report articles. Readers also appreciate receiving a printed copy of the magazine, with only a few respondents expressing a preference for a purely digital format. High marks went to the design and readability of the magazine, though some argued there is room for improvement in the choice of topics. The respondents also requested more information on corporate relations and spin-offs. Some said that the reporting should take a more critical stance, including in regard to ETH itself. There was also criticism of the fact that *Globe* is delivered in a plastic wrapping. The editorial team is now examining how best to respond to the feedback. One thing has already been decided: *Globe* will no longer be sent in a plastic wrapping in Switzerland from the beginning of 2020.

Cybathlon 2020

GET YOUR TICKETS

The SWISS Arena in Kloten near Zurich will be opening its gates for Cybathlon 2020 on 2 and 3 May. This is a unique competition in which people with physical disabilities compete against each other to complete everyday tasks using state-of-the-art robotic assistive technologies. Tickets are already available:

→ www.cybathlon.ch/tickets

Image: Block Research Group; Nicola Pitaro

Reforming the doctorate

Doctorate – what's next?

The ETH doctorate has been the subject of widespread debate over recent months. What stage has ETH reached in the reform process? And where do we go from here?

Symposium workshop on the supervision of doctoral students

Following the dismissal of an ETH professor who was accused of serious professional misconduct – including in the supervision of doctoral students – the ETH doctorate has faced months of scrutiny in the German-language media. At ETH, however, these discussions began much earlier and delved far deeper, as evidenced by the steps already taken in the reform process.

Supervision of doctoral students: a field ripe for research

A good three years have passed since ETH Rector Sarah Springman asked chemistry professor Antonio Togni if he would consider taking on the position of Vice Rector for Doctoral Studies – and he spontaneously agreed. As a long-time supervisor of many doctoral students, he was keen to delve deeper into the question of how doctoral students are best supervised in today's world. "I suggested to the Rector that we organise a symposium where professors, doctoral students and administrative staff could discuss the topic with international experts and colleagues from other Swiss universities," he recalls, "and the Rector gave the go-ahead."

Symposium debate

While familiarising himself with his new role, Togni also got to grips with the literature on doctoral supervision and started organising the symposium. Everything finally came together in late January this year. During the two days of presentations and workshops, 350 members of ETH and 40 external guests took an in-depth look at key issues related to the supervision of doctoral students. The results of the symposium included over 200 flipchart sheets and brief summaries prepared by the facilitators, containing key findings from the discussions.

Benno Volk and Marion Lehner from the Educational Development and Technology administrative department at ETH Zurich subjected the flipchart sheets to a qualitative content analysis. They sorted through all the information and then categorised and clustered it. "We succeeded in identifying three factors that make for successful supervision: cultural, psychological and administrative/procedural factors," says Lehner. Lehner and Volk will publish their analysis this autumn.

Meanwhile, Vice Rector Togni and his team have been evaluating the summaries and using their findings to derive key measures for the ongoing development of the doctorate. They were in the middle of preparing an ETH-wide consultation on these measures in early March when the Executive Board approached the ETH Board to request the dismissal of a professor.

Unfolding events draw media attention

ETH President Joël Mesot, who had only been in office for two months, quickly realised that the time had come to talk to the media and explain the university's decision. At the same time, he presented a series of measures to the public. As well as modifying certain structures and processes, these included, in particular, improvements to the university's practices relating to management and supervision.

ETH Rector Sarah Springman announced the main thrust of what ETH was looking to change in the field of doctoral supervision. This was based on the preparatory work carried out by her Vice Rector for Doctoral Studies. One of the key points was the introduction of a system of dual supervision for doctoral students throughout ETH, in order to bring to an end doctoral students' structural dependency on a single person. In addition, Springman announced induction courses for doctoral students and lecturers as well as the establishment of a central contact point to help tackle disagreements between doctoral students and their supervisors. At that time, it was not yet clear exactly how these measures would be formulated. This was to be decided in a broader consultation process scheduled to begin two weeks after the announcement.

> "The symposium clearly demonstrated that there is no such thing as a blueprint for the doctorate that we can simply adapt to our needs."
>
> Sarah Springman

Broad consultation on ideas

A total of 53 specific proposals for the ongoing development of the doctorate were submitted to the academic departments and university groups. Two thirds of these received a positive response from a majority of those consulted, including new suggestions such as induction courses for doctoral students, an introductory programme for new professors, and the incorporation of an "admissions colloquium" held after one year prior to a definitive admissions decision. There was also majority support for the proposal of appointing a second supervisor in the future, at the latest upon submission of the research plan. However, there was also feedback suggesting that the rights and roles of the various supervisors needed to be clarified.

In addition, four ideas received a less positive response overall, including the suggestion that the doctoral supervisor should no longer be a member of the examination committee. These measures will not be pursued any further.

An ongoing project

The next steps include revising the Ordinance on Doctoral Studies and adapting regulations at the academic department level. The new contact point for doctoral students and lecturers has already been established, and the first courses have been scheduled.

Springman is confident that this package of measures will deliver significant improvements. At the same time, she acknowledges that this is merely another step in the process, not a complete solution. "The symposium clearly demonstrated that there is no such thing as a blueprint for the doctorate that we can simply adapt to our needs." And she adds that, however the rules are formulated, "ultimately doctoral students and supervisors need to engage with each other, understand each other's needs and communicate openly with each other." Improved structures are a very effective way to promote these positive interactions.
— Roland Baumann

Philanthropy

FILLED WITH THE ETH SPIRIT

By Donald Tillman

What sort of people use their own private funds to support ETH Zurich? Here are a few facts to start with. Our youngest benefactor is a 26-year-old woman; our oldest is a man born in 1911. Many of our sponsors have studied or worked at ETH themselves, while others have family members who did. Some have no personal ties to ETH, but an affinity with a certain field of research. They live not only in Zurich and all parts of Switzerland, but also in Pretoria, Lima or the United States. They include civil engineers, writers and administrative employees as well as ex-parliamentarians and former ETH professors.
What does this diverse group of people have in common? And what ties them to ETH Zurich? It is the spirit that an ETH lecturer and sponsor of long standing sums up in the phrase "striving for excellence". A spirit that makes big things possible, that translates visionary ideas into reality, that uplifts and inspires. It is a spirt that gives us reason to hope – at a time when the challenges humankind faces look quite daunting.

→ www.ethz-foundation.ch/en

Image: Giulia Marthaler

Image: Eline Keller-Soerensen

ETH Alumni

NEW AFFILIATE ORGANISATIONS

ETH alumni activities are expanding with the addition of new regions and a new specialist group. The creation of two new affiliate organisations offers ETH alumni more networking opportunities than ever. The Northwest Pacific Chapter – recently established in the Vancouver region – welcomes alumni from both ETH and EPFL who are resident in southwestern Canada or the northwestern US.

Another new addition is the architecture specialist group, which caters to architects, landscape architects, planners and all alumni interested in the built environment.

QS ranking

THE WORLD'S SIXTH BEST UNIVERSITY

This year ETH Zurich came sixth in the QS World University Rankings – better than ever before. Rising one place since last year, ETH has continued the upward trend of previous years. The top spots in QS rankings were previously shared between American and British universities. Once again, first place went to Massachusetts Institute of Technology (MIT). ETH Zurich's sixth place puts it one place ahead of the University of Cambridge, making it the second-best university in Europe after the University of Oxford.

Rössler Prize

BRILLIANT COLOURS IN NANO FORMAT

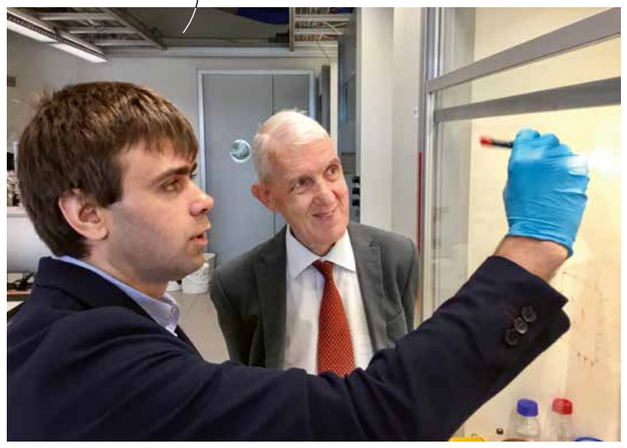
Brilliant blues, luminous greens and deep reds light up the test tubes in Maksym Kovalenko's lab. In recognition of his research on bright nanoparticles, Kovalenko received this year's Rössler Prize at the ETH Foundation's annual "Thanks Giving" event.

The colours in the test tubes are produced by tiny, glowing nanocrystals known as quantum dots. A few years ago, Kovalenko discovered that these quantum dots could also be manufactured from special semiconductor materials known as metal halide perovskites.

One potential application of these materials is to manufacture displays that not only offer better brightness and colour resolution than current models, but are also less expensive and, importantly, more energy efficient. These novel materials also hold interest for basic research: Kovalenko's group was able to show that these particles emit single photons in rapid succession, making them a potentially interesting choice for applications in the field of quantum information processing.

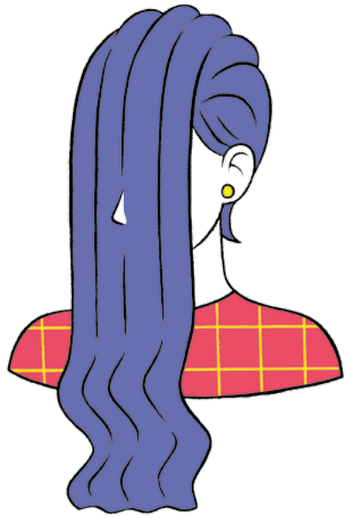
The Rössler Prize is now in its tenth year. In 2008, Max Rössler made an endowment of ten million Swiss francs to the ETH Zurich Foundation. He uses the interest earned on the capital to fund an annual prize for ETH professors who are "rising stars" in their particular area of research. The prize money of 200,000 Swiss francs makes it ETH Zurich's most generous research award.

"Our quantum dots shine more brightly and in the purest colours. They're also simpler to manufacture."



Maksym Kovalenko with prize sponsor Max Rössler

Image: ETH Foundation / Nicola Pitaro



Column

Breaking the grip of self-doubt

The tenure track period – starting from an individual's appointment as an assistant professor and ending with the offer of a permanent contract – is typically a very stressful time. Life on the tenure track is all about "proving yourself" and "becoming a leading light in your field of research". The tenure track period culminates in a meticulous review of everything the individual has achieved in terms of research results, publications, citations, teaching evaluations and so on. Yet what is regarded as "sufficient" is not clearly spelled out, but rather decided on a case-by-case basis by the academic department and tenure committee.

This is a period with no clear "learning objective", yet with a major examination at the end – and that's the perfect recipe for self-doubt. I spent my tenure track years at Carnegie Mellon University. Each month, we met for an informal tenure track female faculty lunch at the College of Engineering. That's where I first heard of impostor syndrome. This is the feeling that you aren't as good as other people think – and the belief that people will soon realise that you don't deserve the recognition you receive. Both men and women can experience this feeling, but I believe this topic takes on particular significance when it comes to promoting women in academia.

So why bring up impostor syndrome in this column? Firstly, I often meet women who doubt their own abilities and knowledge and question their worth. And, secondly, I remember my own tenure track period and what a huge help it was when I discovered this voice of self-doubt had a name. I fervently hope that any young women (and men, too!) who are experiencing a phase in which they must prove their merit will read this column. And the next time they start to doubt themselves, I hope they will be able to recognise the symptoms of impostor syndrome. I believe that spotting these signs is the first step on the path to beating self-doubt and boosting your self-confidence.

That's why, in my role as a mentor, I often talk to my mentees about impostor syndrome. Perhaps this column will encourage other mentors to do the same!

Gabriela Hug is a Professor at the Institute for Power Systems and High Voltage Technology. In her column, she discusses how to overcome the stereotypical roles and behaviours that create barriers for both men and women.

Illustration: Benedikt Rugar; Image: Giulia Marthaler

REPORT

Waiting for oxygen

In raised bogs in Sweden, ETH researchers are investigating chemical interactions between peat soil and bacteria. The researchers aim to cast new light on the mechanisms that determine methane emissions from northern peatlands – a key piece of the puzzle in efforts to understand natural sources of this greenhouse gas.

TEXT Peter Rüegg IMAGES Peter Rüegg and Michael Sander

One minute the sun was shining, the next minute fierce gusts of wind were blowing torrential rain almost horizontally across the bog. “Someone please get the computer under cover! I’m not sure it’s waterproof,” Michael Sander calls across to his colleagues. His doctoral student Nikola Obradovic grabs the computer and tries to squeeze it into the materials tent while it continues to collect data. Unfortunately, the sudden movement detaches a fibre-optic cable linked to an oxygen sensor, interrupting the collection process. “Well, now we’re just going to have to wait,” says Obradovic with frustration. “We’ll have to recalibrate the sensor before we can do anything else.” Not the easiest of tasks in a downpour, but the researchers pull on their rain ponchos and waterproof clothing and patiently set to work. Later that day, a combination of hail and thunderstorms finally forces them to give up. Fieldwork rarely goes exactly to plan.

Unknown mechanisms

Since 2014, ETH Zurich researchers Michael Sander and Martin Schroth have been making field trips to Värmland, Sweden with members of the Environmental Chemistry Group led by ETH Professor Kristopher McNeill. This region, not far from Filipstad, is their chosen spot for performing biochemical experiments in raised bogs. This field season, the ETH researchers’ primary goal is to find out why the soils in these bogs often release significantly less methane than expected. The ETH team is working on the assumption that bog soils must be influenced by control mechanisms that suppress ›

the emission of this gas. "But these mechanisms are largely unknown," says Sander.

Understanding these mechanisms is vital, especially since northern peatlands play such an important role in the global carbon cycle. Although they only cover some three percent of the world's land area, they store around a third of the total soil carbon.

Raised bogs and other types of wetland are an important natural source of methane – a potent greenhouse gas that is about 25 times more efficient in trapping heat in the atmosphere than carbon dioxide (CO_2). Scientists are concerned that global warming could cause bogs to release more methane into the atmosphere, because higher temperatures stimulate biological activity in the peat soils, which may increase methane production.

Together with CO_2, methane is the ultimate end product of the decomposition of peat organic matter under the anaerobic conditions that prevail in water-saturated bog soils. Methane is only formed, however, when peat microorganisms lack certain compounds to which they can transfer the electrons released during respiration of the organic matter. In humans, this "electron acceptor" is oxygen: cellular respiration of organic substrates in our cells is coupled to the transfer of electrons to the oxygen we breathe in.

The track to the test site is far from a relaxing stroll: one wrong step and Nikola Obradovic will be up to her knees in the bog.

Push-pull test: Meret Aeppli and Prachi Joshi retrieve injected water from the bog soil and measure the remaining oxygen concentration.

Peat battery suppresses methane formation

Microorganisms – unlike humans – can even respire when oxygen is unavailable under anoxic conditions in the peat, by making use of other electron acceptors. The microorganisms prefer to use certain inorganic compounds: nitrate, sulphate and iron ($Fe3+$). Yet, as these compounds are in very short supply in raised bogs, one would tend to expect microorganisms to make use of the least favourable electron acceptor, CO_2, and thereby produce methane.

"The finding that many raised bogs release less methane than expected suggests that bog soils might contain a hitherto unidentified electron acceptor that microbes use instead of CO_2. We believe this electron acceptor is likely to be the peat material itself," says Sander. If so, the microorganisms would transfer electrons from their respiration directly to solid peat material. "That would mean that peatland soils act like 'batteries' which are charged by the microorganisms, and that this charging process suppresses methane formation," he adds. But wouldn't the battery eventually be fully charged, bringing the process to a halt, and so to methane being formed again? Not necessarily, because the "charged" peat soil periodically comes into contact with air – for example when the water level drops in the peat soil – and can then transfer the stored electrons to the oxygen in the air. This discharging would regenerate the peat battery, allowing it to again suppress the formation of methane when the water level rises and water replaces the air; and so the cycle restarts. "It seems that the peat battery can be charged and discharged periodically," Sander says. "Without this battery effect, methane emissions from peatlands would be far higher."

Focused on the task in hand: measurements taken by project investigator Martin Schroth confirm his hypothesis.

Only fishing requires more patience

"We're hoping these field trials will confirm our hypothesis of methane suppression," says Martin Schroth. Back again after yesterday's downpour, he has turned a plastic bucket upside down to sit on and is now completely focused on the metal tubes stuck in the bog soil in front of him.

The researchers are performing what are known as "push-pull tests", which require almost as much patience as catching fish. Schroth empties a syringe full of bog water, which he has enriched with atmospheric oxygen, into the peat soil through transparent plastic tubing connected to the metal tubes. "Time – oxygen – time – oxygen...," he begins to recite. The project manager starts to take readings and the doctoral student enters them in a ring binder. Bob Marley's "Buffalo Soldier" accompanies their work from a little red wireless speaker. Twenty metres away, postdoctoral researcher Prachi Joshi and former doctoral student Meret Aeppli are seated on pallets performing the same experiments, the only difference being their choice of music – in this case some tunes by Mumford & Sons.

Push-pull tests provide evidence

To test their battery hypothesis, the ETH scientists first inject oxygen-saturated water into the bog soil 30 centimetres below the surface – a depth at which no oxygen was present when the experiments began. They then wait for an hour and a half before retrieving the injected water from the bog soil and quantifying the remaining oxygen. If the peat transfers some of the stored electrons to the injected oxygen, then the oxygen concentration should now be lower. "We actually do most of our research in the lab. But now we've decided to come out into the field to test our hypotheses under real conditions. It's pretty exciting!" says Sander. It's also challenging, especially in raised bogs. These can give way ›

at the slightest tread, and it's easy to sink in up to the knee simply by putting your foot in the wrong place. To minimise that risk, the researchers always follow the same path to their test site next to a pond in the Lungsmossen peat bog. Sander has marked out the route with birch branches so that nobody sinks in and causes damage.

"We're actually walking across milk, because like milk, peat soils are about 95 percent water," quips bog expert Klaus-Holger Knorr, who is here on a visit from the University of Münster. He and Sander are now embarking on a new task: they are about to use a special peat drill to take some samples from the bog soil below their test site.

The researchers screw together several iron rods before adding the final piece to the end of the pole: a sword-like sampler that can collect and retain samples at any peat depth. Next, they push the drill rod several metres into the ground, rotate it around its own axis and pull it up again with all their might. Knorr immediately takes a look at the peat material contained in the sampler. In addition to the remains of various mosses – the main component of peat – he also finds remnants of cotton grass, sedges, and some well-preserved wood.

"The soil is saturated with water and therefore lacks oxygen, which means dead plant material degrades only very slowly. And because degradation is so slow, the remnants of the bog vegetation are still clearly recognisable," he explains.

Sander and Knorr finally hit the bottom at a depth of over 6 metres. The material in the sampler looks like lake sediment. "We've reached the bottom of the bog, an impermeable layer of clay," says Knorr. The bog systems here in Sweden are fully intact, he says, noting that this is confirmed by the soil

Silvan Arn and Klaus-Holger Knorr use a corer to collect soil samples from deep below the peat surface.

The core sample features plant material that has barely decayed over hundreds of years.

profile. He estimates that the material they have brought to the surface is at least 3,500 years old. "It's much harder to examine processes in bogs in Central Europe because most bogs there have been disturbed in some way or even drained by humans," says the Münster-based professor.

He has another reason for taking such a keen interest in biogeochemical processes in bog soils: when damaged peatlands are restored, they often release more methane than natural raised bogs such as those here in Sweden. "So if you want to estimate how much methane will be produced through bog restoration, you need to know which processes cause methane to form," says Knorr, who is inspecting the ETH scientists' test sites this year with an eye to collaborating with Sander and Schroth next summer.

Promising preliminary results

It's late evening, but there's no sign of darkness setting in. Silvan Arn, a Master's student in the group run by Sander and Schroth, is still hard at work. He's standing in front of a refrigerator on the porch of the house that the research group inhabits during their field trips. Three plastic columns are hanging in the refrigerator, all of them connected to tubes. Alongside the field trials, Arn is conducting experiments under more controllable conditions. He began by filling the plastic columns with peat soil from the raised bog while avoiding any contact of the soil with oxygen. The subsequent experiment involves pumping oxygen-saturated bog water through the columns and continuously measuring the oxygen concentration in the water at the column outlet. The graphs now displayed on the laptop screen look exactly as the researchers imagined they would: oxygen is being consumed, which indicates that the peat battery is being discharged. So the measurements support their hypothesis.

Work in the makeshift lab: project investigator Michael Sander examines changes in the oxygen content of bog water over time.

Martin Schroth is pleased with the field data too. "The first data looks promising," he says, sitting on the sofa with the computer on his lap. He and Aeppli are examining the data and initial plots from the push-pull tests. These, too, show the oxygen concentration decreasing. The researchers still have a week's fieldwork ahead of them, including taking their daily trek along the swampy, treacherous path into the bog and testing their patience while fishing for oxygen and electrons.

Back in Zurich, routine work awaits the researchers. They will continue some of the experiments back in the lab using peat soil collected from the bog. A few months from now, they will have finished analysing the data, drawn their conclusions and submitted their results for publication – and very possibly face a new set of questions. Soon they will also start planning the next bog field trip. Sander and Schroth have received funding from the Swiss National Science Foundation that will allow them to travel to Sweden on at least two more occasions. This is crucial if they are to piece together the various pieces of the puzzle that the environmental chemists have collected over the years, so they can finally form a complete picture. ○

Find out more:
→ envchem.ethz.ch/research

By the way: *Globe* editor Peter Rüegg traveled to Sweden by train to write this issue's Report.

CONNECTED

1 *Hyperloop Competition*

FROM 0 TO 252

Everyone was jubilant. At the final of the Hyperloop Pod Competition in Los Angeles, Swissloop's capsule, or "pod", accelerated to a speed of 252km/h. The Swissloop team, comprising students from ETH Zurich and other Swiss universities, took second place. Several hundred teams had entered the competition, and 21 were invited by SpaceX to Los Angeles. Only four made it to the final.

2 *WCSJ 2019*

INQUISITIVE JOURNALISTS

In July, ETH Zurich attended the World Conference of Science Journalists and presented research projects from the fields of climate change, health and robotics. The conference was organised by EPFL and took place at the Swiss Tech Convention Centre. Attended by some 1,200 journalists from all over the world, it included workshops, panel discussions and networking events. The conference offered ETH an opportunity to interact with experts in these fields and acquaint them with its latest scientific findings and innovations.

3 *W.A. de Vigier Prize*

AWARDS FOR START-UPS

To mark its 30th anniversary, the W.A. de Vigier Foundation has honoured twice as many start-ups with prizes this year than usual. Six of the ten prizes went to ETH Zurich start-ups. Bernhard Winter, CEO and co-founder of Scewo, was not the only one delighted to receive an award. Other winners included PXL Vision, Vatorex, PharmaBiome, Piomic Medical and Sleepiz – all ETH Zurich start-ups.

4 *Alumni party in Sydney*

ANNIVERSARY PARTY DOWN UNDER

The ETH Alumni Association is celebrating its anniversary not only in Zurich, but elsewhere around the world. Even the Sydney chapter has joined in the festivities. Swiss Consul General Bernadette Hunkeler Brown hosted an evening event at the consulate, capturing it in a snapshot.

5 *Spaceport America Cup 2019*

AIMING HIGH

ETH students spent almost a year developing and building a rocket. At the Spaceport America Cup 2019 in New Mexico, they competed against 50 other teams of students – and their hard work and dedication paid off. Nicknamed *HEIDI*, their rocket reached an altitude of three kilometres, securing them second place in the world's biggest rocket-building competition for students.

1 *Hyperloop Competition*

Elon Musk talking with the Swissloop team.

2 *WCSJ 2019*

3 *W.A. de Vigier Prize*

4 *Alumni party in Sydney*

5 *Spaceport America Cup 2019*

Images: Swissloop (2); Nicole Kasielke

Images: Andrea Wullimann; Bernadette Hunkeler Brown; Aris

Agenda

TOURS

15 October 2019, 6.15 – 7.15 p.m.

Robotic fabrication in architecture

During this tour you will get to know the HIB building, which features a robotically constructed roof, and the Robotic Fabrication Laboratory, the only one of its kind worldwide.

ETH Zurich, Hönggerberg campus, HIB building

19 November 2019, 6.15 – 7.15 p.m.

How brain cells "think"

State-of-the-art microelectronics grant us unimagined insights into the electric signalling behaviour of nerve cells and neural networks. For one thing, it is possible to track how signals are generated in space and time in high resolution. For another, scientists can examine in detail interactions and signal processing in neural networks. The tour provides glimpses into the broad spectrum of potential applications, e.g. in the treatment of brain diseases and in pharmaceutical research.

ETH Zurich, Mattenstrasse 26, Basel, BSA building

You'll find information on these and other tours here
→ www.tours.ethz.ch

View of Bachalpsee and the Schreckhorn (left)

Treffpunkt Science City

NEWS FROM THE BLUE PLANET

27 October – 24 November 2019

Water is the basis of all life, and two thirds of the Earth's surface is covered with this precious liquid. With more than 1,500 lakes and rivers as well as numerous glaciers, Switzerland can boast large supplies of freshwater. But what is the quality of the water in our streams and rivers? Why are glaciers disappearing? Are there heatwaves in the ocean too? And how do you build a house that produces zero wastewater? Water, a liquid of inestimable value, is the focus topic at Treffpunkt Science City this autumn.

Programme and registration:
→ www.ethz.ch/treffpunkt-en

Alumni Travel

A PLACE OF LONGING

14 – 23 March 2020

Many people long to visit Sicily, not least because it is the setting for the internationally renowned crime novels of local author Andrea Camilleri and his protagonist, Inspector Montalbano. The TV series based on the novels was filmed in Ragusa, and it is there that tourists can follow in the famous detective's footsteps. Or they can attend a film night to compare the film set with the reality around them. The island also offers a rich variety of artworks, culinary experiences and captivating (volcanic) landscapes.

Information and registration:
→ www.alumni.ethz.ch/events

Images: © ITA/Arch-Tec-Lab AG, Andrea Diglas; Shutterstock

DISCOVER

26 – 30 September 2019

The InCube Challenge

InCube combines aspects of young entrepreneurship, innovation funding and location promotion, and lends them an international touch. Teams of five students spend four days in glass cubes at urban hot spots – like Europaallee in Zurich, for instance. The challenge for them is to come up with an innovative concept to resolve a particular problem. They are allowed to consult with experts and elicit direct feedback from the public at large.
→ incubechallenge.com/event

1 October 2019, 6.15 – 7.15 p.m.

Building for research and teaching

It is not uncommon for cities, sometimes even whole countries, to be measured in terms of their universities and their campus buildings. The architectural history of ETH Zurich campus, for example, is a revealing chronicle of both education policy and urban planning. Changing requirements and different architectural trends have shaped both the internal and external appearance of ETH and continue to do so down to the present day.

ETH Zurich, Hönggerberg campus, HIL building

Until 17 November 2019

Deep Inside – Out

In her works, Lara Almarcegui explores urban spaces, delves into the relationship between the design, decay and regeneration of our built environment, and focuses on the question of who owns natural resources.

ETH Zurich, ETH Main Building, Graphische Sammlung
→ gs.ethz.ch/en/current

Lara Almarcegui, Untitled [Pulse 5], 2012, Graphische Sammlung ETH Zurich

Seismic fountain

It's an artwork-cum-prototype – with a fountain that responds to seismic waves. The Earth's core provides the impulse. The Swiss Seismological Service at ETH delivers real-time signals of seismic waves, which are measured at the earthquake surveillance station not far from the Dolder Grand Hotel in Zurich.

Near Enge wharf, Zurich

Book choice

THEODOR & OTTO FROEBEL

Horticulture in Zurich in the 19th century

As late as the 1830s, horticulture and botany were still much-neglected disciplines in Switzerland. But their popularity grew with the rise of the middle classes and the advent of the first landscape gardeners, among them Theodor Froebel (1810–1893). Together with his son Otto Froebel (1844–1906), he built up a flourishing business in Zurich that was considered the most renowned landscape and commercial gardening enterprise in the entire country. This new publication follows the work of these two garden designers and businessmen. The book sheds light on the public spaces they created in Zurich, their contribution to shaping Zurich's current urban fabric following the construction of the quays, and the myriad private gardens they designed. It also describes how they built up their business and the range of plants they used.

Author: Claudia Moll
gta Verlag, 2019
ISBN 978-3-85676-386-2

Images: Thi My Lien Nguyen; © Lara Almarcegui; Michael Roggon/Metallatelier GmbH; gta Verlag

The problem-solver

Julia Wysling combines a flair for numbers with social engagement to help society progress. The mathematician and former VSETH president simulates and optimises pedestrian flows.

TEXT Corina Oertli IMAGE Annick Ramp

Even as an infant, Julia Wysling counted streetlights from her pram. At least that's the story her father – a journalist who still can't quite understand his daughter's flair for numbers – likes to tell. Wysling was always better with numbers than words. "I began attending high school after year six rather than year eight; that way I didn't have to pass a French exam." The logical and rational are what have always truly fascinated her. "It's more about right and wrong," she says, "with less scope for discussion."

So Wysling, who is now 28, decided more than ten years ago to attend a high school specialising in maths and science. It was a very conscious decision on her part. "I had a teacher who was convinced that women had no place in the world of science and who used to mark me down because of that." But that only made her more determined: "I wanted to prove him wrong." If he knew the career Wysling has made for herself, he'd have to admit she was right.

After leaving school, Wysling enrolled as a maths student at ETH Zurich. But her true desire was to combine numbers with something more socially oriented. The student advisory service recommended psychology. "But I found that a bit far-fetched." So, in the end, it was just plain maths. And why did she choose ETH? "That wasn't a rational decision – which is not at all typical for me." Wysling's mother had studied pharmacy at ETH and often raved about what a great time she'd had. Although Wysling initially toyed with the idea of studying abroad, when she saw how ETH scored in international university rankings, it was a clear-cut case. "Why wander far from home, when the good things are just around the corner?"

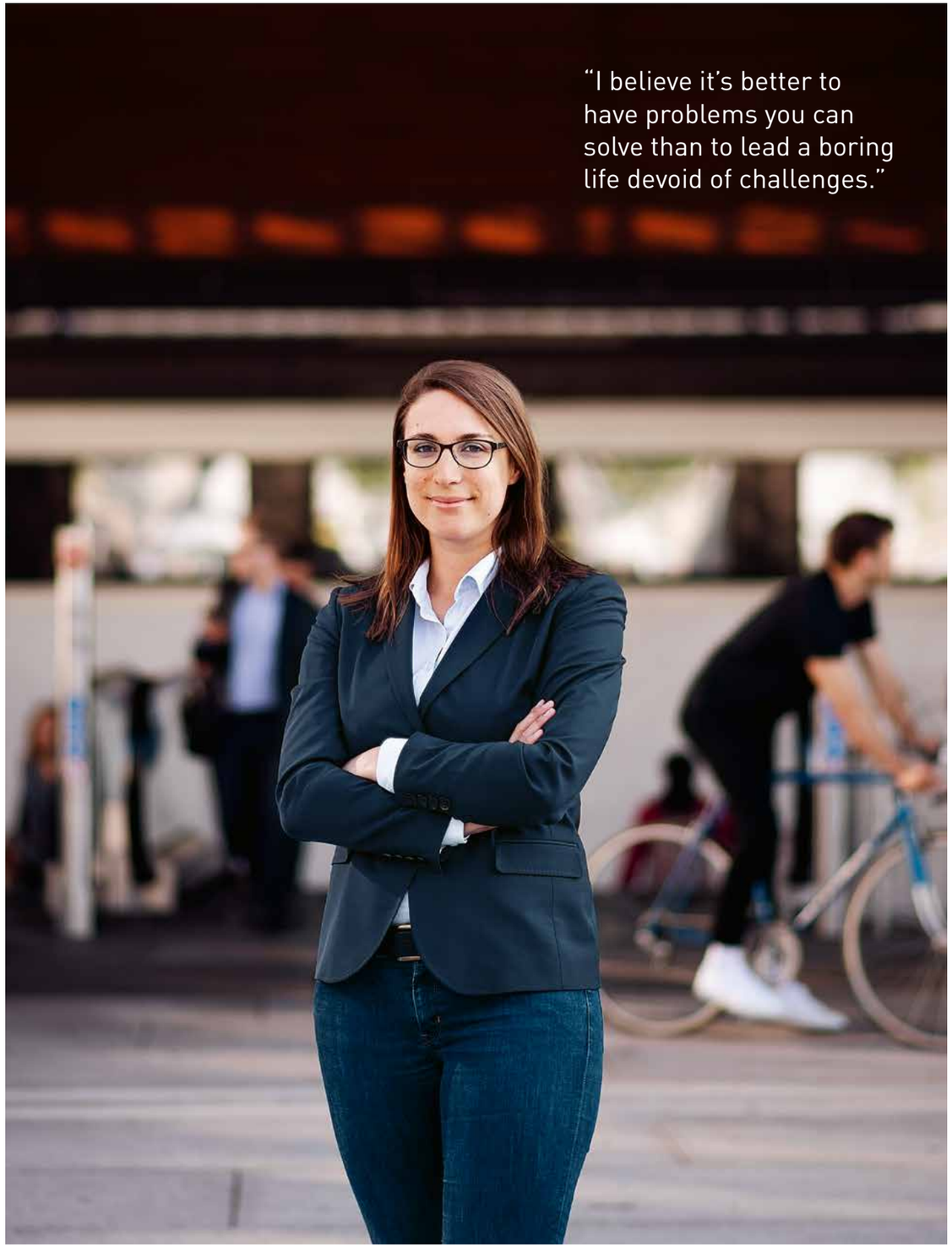
Never a dull moment

Zurich-born Wysling has never regretted her decision – even though she would probably make a different choice today. "I think structural engineering or computer science would have suited me as well." But she felt right at home in the company of mathematicians. Although the majority of students were men and she was sometimes the only woman in small lectures, she never felt out of place. "Mathematicians are very sociable."

In this environment, Wysling was also able to fulfil her desire to do something for society. Even during her Bachelor's course, she did volunteer work on the board of the VMP, the association of maths and physics students, helping organise events. After one year, she was president of the association and organising events for VSETH, the Association of Students at ETH – all on top of her own studies and part-time job as an assistant in the maths library. "My studies did suffer a bit sometimes." But it also granted her flexibility and a lot of freedom. "You just have to tackle every day as it comes." As a counterweight to all the studying, working and volunteering, Wysling did a lot of sport. "I stumbled upon triathlon as a student." But it was only ever a pastime. "For me the only competitive element was improving my own performance." ›

JULIA WYSLING

Julia Wysling (28) studied maths at ETH Zurich. After two years of volunteer work for the association of maths and physics students, she interrupted her Bachelor's course for one year to take on the role of president of the Association of Students at ETH (VSETH). Today, Wysling works as a project manager for simulating and optimising pedestrian flows. She is politically active and also takes part in triathlons and half-marathons as a counterweight to her day-to-day work.



"In my job I can apply mathematics in real life and, at the same time, add value for society."

In 2013, however, she was no longer able to reconcile her studies with her volunteer work: after being elected VSTEH president, she took a year off from her Bachelor's degree. It was a year in which she learnt an amazing amount – about interacting with people, communicating, coordinating, managing and problem-solving. It was no easy task representing 15,000 people in diverse fields of study and from different backgrounds, but Wysling mastered it by thinking and arguing rationally. As she says today: "I believe it's better to have problems you can solve than to lead a boring life devoid of challenges."

Dabbling in politics

During her time as VSETH president, a highly political position, her high-school experiences stood her in good stead. "The kids in my class all had a keen interest in politics. If you wanted to be part of the conversation, you had get interested too." Her pronounced flair for politics led her to run for the Zurich city council as a candidate for the Social Democratic party. It doesn't bother her that she wasn't elected. "I simply wanted to take a look at how politics really works." Her conclusion: "People often don't argue rationally. That was a bit of a shock for me."

After a year off to run VSETH, Wysling turned her focus to her studies again. The ETH alumna doesn't consider that year to be wasted time. "I experienced so much and learned a lot for my future life." The same was true of her three-semester stint on the Femtec career-building programme – a programme designed to encourage female engineering and science students, preparing them to enter the working world and take on management roles.

After completing her Master's, Wysling had no intention of pursuing a career in research. "I just wasn't interested enough in maths for that," she admits. She wanted to do something to help people, something with a social component. Then by chance, the young graduate saw a job announcement on the canteen bulletin board published by Analysis Simulation Engineering (ASE) AG, a company based in Zurich. This advert just happened to lead her to the perfect job.

Adding value for society

For two years now, Wysling has been project manager for modelling and simulations at ASE. She performs computer simulations of pedestrian flows, such as in shopping centres, stadiums and train stations. "It's a bit like that video game *The Sims*. I programme an environment, introduce variations and then evaluate the data." At the moment, she is focusing mainly on train stations. As many Swiss train stations are reaching their capacity limits, new solutions are needed; to obtain them, rail companies, the police and the relevant authorities turn to companies like ASE. That's when Wysling begins analysing: with or without bench seating, one set of stairs or two, widen or lengthen the platform?

Wysling uses the data and figures that she gathers to compile reports containing recommendations for her clients. But they are not always able to implement them. "You constantly have to strike a balance between different demands. I try to optimise the environment in terms of safety, functionality, comfort and convenience." Wysling is happy with her job. "I can apply mathematics in real life and, at the same time, add value for society."

Although her life has become a lot quieter since she graduated, Wysling still pursues many different activities. She organises events for ETH Zurich's alumni association and trains for half-marathons and triathlons. At the moment, however, she has plans that will take her in a much different direction: she and her partner are going to live in Paris for a while. He will take up a two-year postdoctoral position in the French capital, while she will continue to work for ASE – thanks to teleworking. And what will happen when the two years are up? Wysling doesn't know yet. Eventually, she would definitely like to return to Zurich; in the meantime, her goal is to learn to speak French. ○

5 QUESTIONS

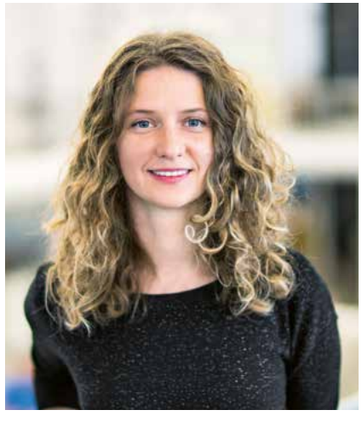
Mariana Popescu developed KnitCrete, a process that turns knitted textiles into concrete structures. This innovation won her a place on the *MIT Review* list of Innovators under 35.

What do you find especially fascinating about your area of research?
What I find most exciting is bringing together diverse areas of expertise that normally have nothing to do with each other, such as architecture, structural engineering, robotics, computer science and systems engineering. A very diverse work environment broadens your perspective and fosters interdisciplinary learning.

After finishing your Master's degree, you worked at a start-up company, among other things. What prompted you to embark on a doctoral programme at ETH Zurich?
I graduated from a group at Delft University of Technology that is breaking new ground in architecture. The start-up was taking a new approach, bringing together architects and engineers for embedded systems. Unfortunately, it wasn't successful. Being a curious person by nature, I wanted to be able to explore a problem in depth and come up with unconventional solutions. The exciting, forward-looking work at ETH in the Block Research Group and NCCR Digital Fabrication really appealed to me and I decided to come here.

Who would you like to swap jobs with?
Intuitively I'd say a pilot – in order to see the world from a different perspective. However, I recently read Melinda Gates's book on what the Gates Foundation is doing to fight global inequity, and to empower women. Gates draws a sobering picture of what constitutes reality for so many around the world; she is compelled to constantly develop and update her ideas. That impresses me deeply. I'd love to swap jobs with Melinda Gates to see the world with fresh eyes, while keeping my feet planted firmly on the ground.

What have you failed at?
Like everyone else, I've had my share of failures, but fortunately none of particular significance. I'd list not learning French at school as one; learning languages is incredibly important in my view. And being a native speaker of Romanian, which is a Latin language, would have made it even easier to learn French.



Mariana Popescu is a doctoral researcher at the Block Research Group, part of the NCCR Digital Fabrication.
→ www.block.arch.ethz.ch

"A diverse work environment broadens your perspective on your own field."

How do you maintain a good work-life balance?
Research in general, and particularly for a doctoral degree, is a very intense occupation. The passion for the work and a certain measure of obsessiveness are strong drivers. This makes my work extremely rewarding. I identify so strongly with my research that the distinction between work and life becomes blurred. – Interview Karin Köchle

Image: Matthias Rippmann