ETH zürich

NO. 3/2015

GLOBE

RESOURCES

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THE VALUE OF GROUNDWORK

Lino Guzzella,
President of ETH Zurich

Raw materials shape our lives. Without them there would be no buildings, no drugs, no computers – not even sufficient food. The lifestyle we enjoy today owes much to our success in ensuring that raw materials are available to meet our various needs. In many cases, however, we manage these materials wastefully, which leads to pollution and sometimes scarcity. That's why so many people at ETH are working on new solutions. Their research takes various forms: Some are searching for as yet untapped mineral resources, or revisiting the way we use construction materials. Others are examining how trace elements influence crop yield or developing processes for creating chemical compounds more efficiently. And of course, they also are looking for ways to optimise how we manage, consume, and recycle resources. You can read about them in our special focus section on resources starting on page 14.

How we manage raw materials is also the subject of an exhibition entitled *Boden Schätze Werte (Earth's treasures),* which will be running until 28 February 2016 at focusTerra, ETH's research and information centre for earth sciences. ETH's educational adventure programme, Treffpunkt Science City, will also look at this topic in November.

As you can see, raw materials are a key topic that ETH is tackling in a wide variety of ways. I hope you enjoy digging into this issue!

Lino Guzzella
President of ETH Zurich

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Photos: Swiss Seismological Service; Daniel Winkler, Khalil Anvar

Nicola Spaldin with Brutus, the powerful supercomputer at ETH Zurich.

Körber Prize 2015

HIGH HONOURS

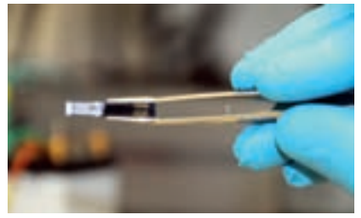
Nicola Spaldin, a professor of material theory at ETH Zurich, has been awarded one of Europe's highest scientific honours: the Körber Prize. Endowed with 750,000 euros, the prize honours outstanding scientists working in Europe. Spaldin is receiving the Körber Prize for developing multiferroic compounds, a new family of crystalline compounds. These could revolutionise the world of computing.

Research on learning

INTELLIGENT BRAINS WORK MORE EFFICIENTLY

Precisely how differences in intelligence are reflected in the human brain is one of the major questions of intelligence research. One hypothesis proposes neural efficiency: the brain of a more intelligent person can perform tasks more efficiently, meaning it does so with less activity. This hypothesis has already been backed up with scientific data. However, ETH researchers have now also found evidence of this effect for the first time in a group of people possessing above-average intelligence for tasks that involve what's known as working memory. Psychologists define working memory as a person's ability to associate memories with new information as well as to adapt to changing objectives by filtering out information that has become irrelevant.

ETH researchers asked over 80 students to solve tasks on a computer and measured the electrical activity of their brains. They found no differences in brain activity between the intelligent and highly intelligent subjects when performing very easy or very difficult tasks. None of the subjects had any trouble whatsoever with the simple tasks, and the difficult tasks were cognitively demanding even for the highly intelligent subjects. However, the researchers were able to observe clear differences between the two groups when performing moderately difficult tasks. All subjects succeeded in solving these tasks, but the highly intelligent subjects required fewer resources to do so.



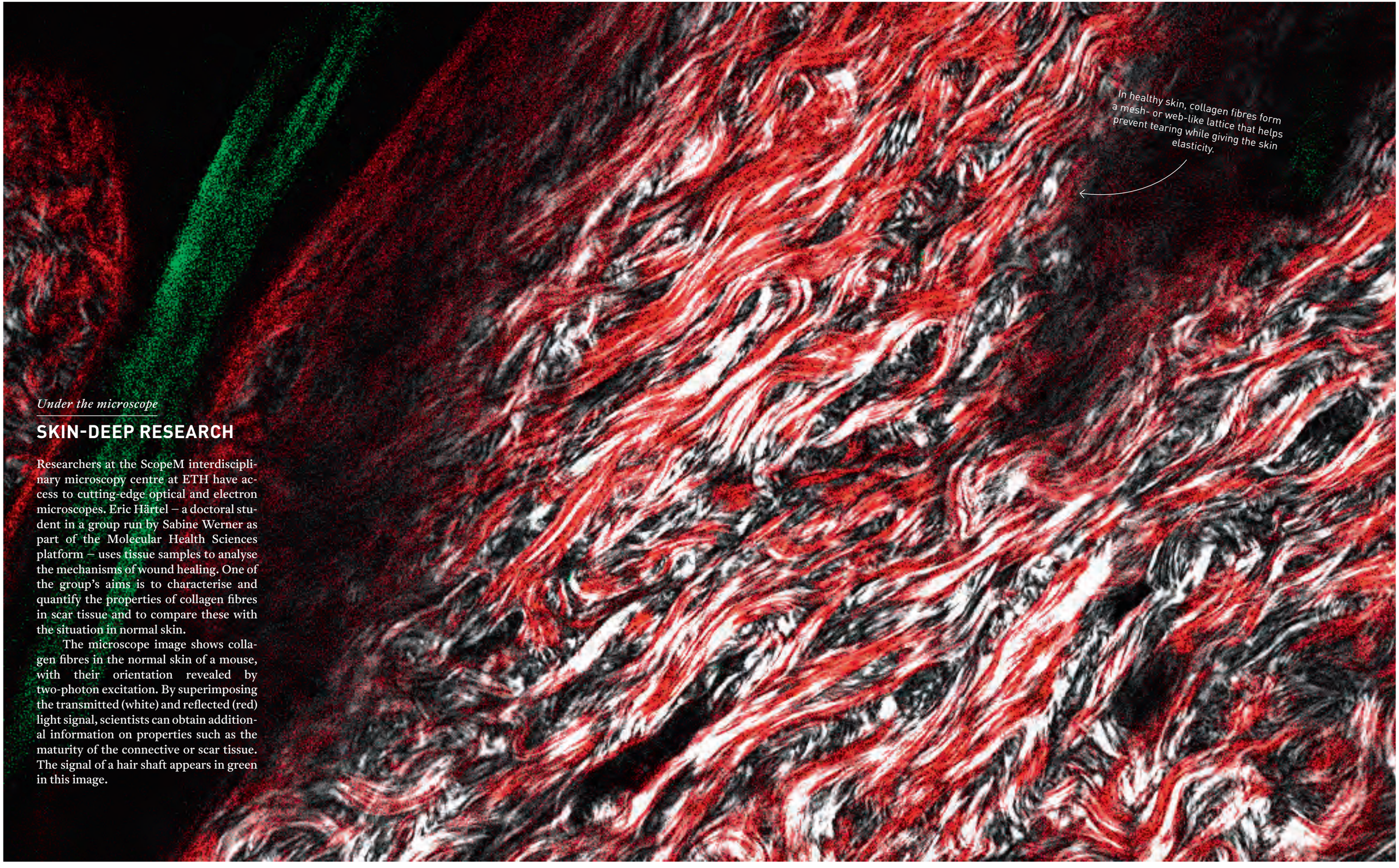
Materials science

NEW CO_2-SENSOR

Materials scientists at ETH Zurich and the Max Planck Institute of Colloids and Interfaces in Potsdam have developed a new type of sensor that can measure carbon dioxide (CO_2). The sensor is made of a new polymer nanoparticle composite that interacts with CO_2 molecules and changes its conductivity depending on the concentration of CO_2 in the environment. This will open the door to developing extremely small devices that consume less energy.

Photos: Körber Foundation/Friedrun Reinhold; Fabio Bergamin

NEW AND NOTED



Under the microscope

SKIN-DEEP RESEARCH

Researchers at the ScopeM interdisciplinary microscopy centre at ETH have access to cutting-edge optical and electron microscopes. Eric Härtel – a doctoral student in a group run by Sabine Werner as part of the Molecular Health Sciences platform – uses tissue samples to analyse the mechanisms of wound healing. One of the group's aims is to characterise and quantify the properties of collagen fibres in scar tissue and to compare these with the situation in normal skin.

The microscope image shows collagen fibres in the normal skin of a mouse, with their orientation revealed by two-photon excitation. By superimposing the transmitted (white) and reflected (red) light signal, scientists can obtain additional information on properties such as the maturity of the connective or scar tissue. The signal of a hair shaft appears in green in this image.

Photo: Eric Härtel/ScopeM

ETH GLOBE 3/2015

New hazard map

Switzerland has earthquakes too

The Swiss Seismological Service (SED) has just published an updated seismic hazard map for Switzerland. It shows that even in Switzerland, the earth can tremble at any time.

The last moderate-strength earthquake in Switzerland happened approximately three years ago: a magnitude 4.2 earthquake occurred at a depth of 30 kilometres in the vicinity of Zug. The shock was felt across wide parts of central and eastern Switzerland. This example shows that even in Switzerland moderate-strength earthquakes can occur at any time, in any place.

And yet many public authorities and insurance companies remain convinced that some areas of Switzerland are immune to earthquakes. This may have something to do with the colours of the old seismic hazard map, compiled in 2004, where certain areas – for instance the low-lying region between Zurich and Bern or South Ticino – are depicted in blue or green. Perhaps people interpreted this to mean that earthquakes would not occur there.

The new seismic hazard map, compiled by the Swiss Seismological Service (SED) on behalf of the Swiss federal government and published in early September 2015, aims to eliminate this misunderstanding. A wealth of new data and modelling techniques were used to analyse seismic hazard. As a result, the SED scientists regard the new hazard assessment model as a significant improvement on the 2004 version. The most striking change for the lay reader is that those reassuring blues and greens have been replaced by shades of yellow, orange, red and purple. The new map conveys a message that SED director Stefan Wiemer condenses into a single sentence: "Earthquakes are a common occurrence in Switzerland, and no region can consider itself entirely safe."

Earthquake hazard in the Canton of Graubünden, and especially the Engadin region, is estimated to be higher than previously assumed, with scientists now rating the statistical probability of seismic events 20 to 30 percent higher than they did ten years ago. This reassessment is based partly on the fact that two of the ten strongest earthquakes recorded in Switzerland over the past 800 years occurred in Graubünden. Moreover, this canton experienced numerous moderate-strength earthquakes with a magnitude of 3 or larger in the past 30 years.

NEW HAZARD MAP
The latest edition of the seismic hazard map shows little change in the regional distribution of earthquake hazard. The hot spots in Switzerland are still Valais, followed by Basel and Graubünden, the St. Gallen Rhine Valley and central Switzerland. The seismic hazard is slightly lower in all other parts of Switzerland.

The map shows the horizontal acceleration at a frequency of 5 Hertz that has a 10% chance of occurring within 50 years.

Graphic/Photo: Swiss Seismological Service (2)

This monitoring station records strong earthquakes.

Ground motion as a decisive factor

The hazard map is merely the most visible part of the new seismic hazard model assembled by the SED researchers. This probabilistic model is based on a synthesis of many different elements that have been combined according to the best available scientific knowledge.

In developing the model, the key questions were: Where are earthquakes expected to occur over the next 50 years? How strong will they be? And what associated surface motion can be expected (in different frequency ranges)? Structural engineers need this kind of information in order to design earthquake-resistant buildings and infrastructures. One of the most important requirements in this respect is the ability to accurately estimate the level of uncertainty in these predictions. "For us as scientists, the fact that the uncertainty of our predictions has decreased is an indication that our intensive research over the past years has been worthwhile," says Wiemer.

The seismic hazard map is a representation of earthquake hazard that is difficult for non-experts to read. It shows the horizontal ground acceleration that can be expected in different areas of the country within a specific period of time. The values on the map refer to acceleration on solid rock. For a more precise estimate of the hazard in specific locations, the local soil conditions must also be taken into account: the softer the subsurface, the higher the expected ground acceleration in that particular location.

To illustrate what these figures mean, the hazard can be expressed in relation to the average human lifespan: someone living in the Swiss Canton of Valais has a 30- to 50-percent chance of experiencing a magnitude 6 earthquake during their lifetime. An example of such an event is the magnitude 6.3 earthquake that struck the Italian town of L'Aquila on 6 April 2009, devastating the town and 40 surrounding villages. The disaster led to the death of more than 300 people and caused material damage valued at 15 billion Swiss francs. In Switzerland, magnitude 5 events are more likely to occur. On average, the seismology experts estimate that such events can be expected once every eight to fifteen years. Depending on the region in which they occur and at what depth, these events might cause severe damage to buildings.

Up to 800 seismic events per year

The SED experts also now predict higher ground acceleration in certain frequency ranges than they did ten years ago. Their new ground motion model includes more recent research data from close-by observations of larger seismic events, where subsequent analysis indicated that, in certain cases, the ground motion was stronger than previously thought. According to the SED, these findings are also relevant, at least partially, to seismic conditions in Switzerland.

This latest version of the seismic hazard map is based on more data than ever before. One of the various reasons for this is that Switzerland today has one of the densest and most advanced networks of seismic monitoring stations in the world. Every year, these sensors record hundreds of seismic events in Switzerland. In the past few years, the SED has enhanced and expanded this network, in particular the Swiss National Strong Motion Network. Between now and 2019 a further 100 monitoring stations will be installed, mainly to collect data on earthquakes with a magnitude of 2.5 or more.

Earthquake-resistant buildings

Who actually uses the seismic hazard map? "In the first instance, it's designed to meet the needs of engineers, public authorities, insurance companies and researchers," explains Michèle Marti, the SED's press officer. But the building codes based on the hazard map are not yet legally binding in all cantons. Furthermore, she says, Switzerland does not yet have obligatory earthquake damage insurance across the whole country, "and this despite the fact that earthquakes are potentially the most damaging natural disaster the country has to face."

In Stefan Wiemer's opinion, people shouldn't wait until the codes become legally binding. "There's no reason why earthquake-resistant construction methods can't be applied voluntarily, even if this is not required by law in all regions. It would still be a worthwhile achievement if all new buildings were constructed to safer standards." This wouldn't even cost homebuilders much more money. It's just that they aren't aware of the problem. "In this respect, we still have our work cut out for us," says Wiemer. — Peter Rüegg

Swiss Seismological Service:
→ www.seismo.ethz.ch/index_EN

Fructose is added to a high number of prepared foods, soft drinks and juices.

Heart muscle cells

VICIOUS FRUCTOSE CIRCLE

Because it has long been viewed as a healthier form of sugar, fructose spread throughout the food market in recent decades. In contrast to glucose, fructose barely increases insulin secretion at all and makes glucose levels in the blood rise only slightly. But there's a downside: the liver converts fructose very efficiently into fat. People who consume too much high-fructose food can in time become overweight and develop high blood pressure, dyslipidaemia with fatty liver and insulin resistance. ETH Professor Wilhelm Krek and his colleague Peter Mirtschink have now identified a further, more troubling side effect of fructose: it is also a key driver of uncontrolled growth of the heart muscle.

When a person has high blood pressure, the heart has to work harder to pump the blood through the circulatory system. This causes the heart to grow. As a result, its cells switch to an alternative energy supply: instead of drawing energy from fatty acids, they rely more on an anaerobic process called glycolysis, or "splitting of sugars". If the heart muscle cells can access fructose in addition to glucose, this can set off a fatal chain reaction. A lack of oxygen in the heart cells cues the appearance of the HIF molecule, a universal molecular switch that flips whenever a pathological growth process is under way. HIF causes the heart muscle cells to produce ketohexokinase-C, the central enzyme in fructose metabolism. It can process fructose very efficiently and also has a reinforcing effect on the glycolysis. This kicks off a vicious circle that can ultimately lead to heart failure.

Heatwaves

WHY EUROPE WAS SWEATING

ETH meteorologists have come up with a new explanation for why heatwaves occur. It has long been known that extremely stable high-pressure systems in the upper troposphere – that is, five to ten kilometres up into the atmosphere – can trigger summer heatwaves by deflecting low-pressure systems. Now ETH researchers have shown that air masses rising up from the lower troposphere can also be a determining factor in the formation and perpetuation of such systems. "Latent heat" plays an important role in this process: clouds form in the ascending air masses, water vapour condenses and releases so-called latent energy. The resultant heating of the parcel of air can push it still higher.

These new findings may also prove useful in other areas of climate research. For example, global warming results in more moisture in the air. This releases more latent heat, which could also lead to a change in the frequency of high-pressure weather systems.

Photo: iStock.com/RapidEye

Unusual wool

YARN FROM SLAUGHTERHOUSE WASTE

ETH researchers have developed a yarn from ordinary gelatine that has excellent properties comparable to those of merino wool fibres. The biological protein fibres offer an environmentally friendly way to recycle slaughterhouse waste. Now the researchers are working on improving the process and making the yarn more water-resistant.

Model flight

RECORD FOR SOLAR AIRCRAFT

Scientists at ETH Zurich are working on a project that is breaking multiple records. Their unmanned aerial vehicle, AtlantikSolar, has flown for an uninterrupted 80 hours. In doing so, AtlantikSolar has completed the longest unmanned flight in its weight class (under 50 kilogrammes) and the second-longest solar-powered autonomous flight worldwide. AtlantikSolar is part of the EU's Icarus research project.

→ www.atlantiksolar.ethz.ch

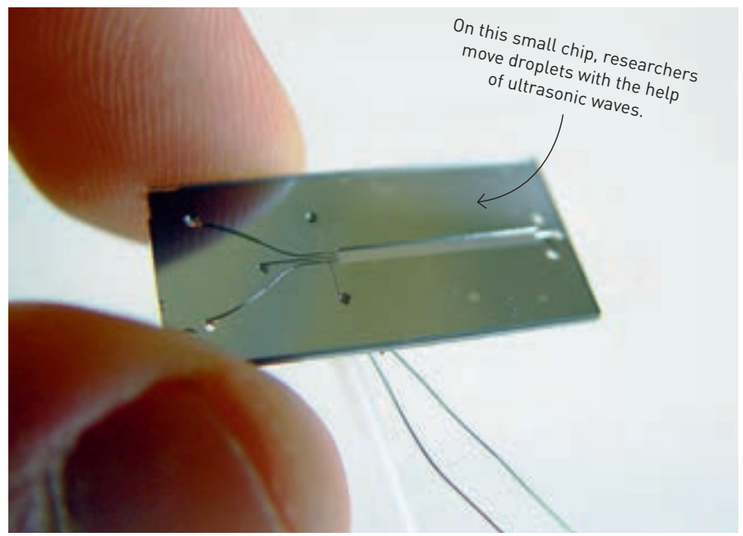
Mini-laboratory

DANCING DROPLETS

When attempting to compress an entire experiment into the size of a chip, one question is crucial: how can minuscule amounts of liquid or individual cells be moved, merged and assessed in a controlled way? Researchers at ETH Zurich have developed a technique that does this with sound waves.

The technique uses an ultrasonic standing wave to move aqueous droplets through a carrier liquid of oil on a silicon-glass chip. When the ultrasonic standing waves are applied, the droplets move to the node of the wave. This means researchers can place two different droplets in both sides of the channel to merge them in a controlled manner. In addition, changing the frequency guides certain droplets – for example, those featuring a light signal – into a branched-off channel for later analysis. The droplets, which have a diameter of 50 to 250 micrometres, cannot mix with the carrier liquid, nor can they evaporate, because they are held together by surface tension.

Scientists can use this highly biocompatible and versatile method for cells as well as for DNA, reagents and chemicals. The ETH researchers expect their technology to become a valuable part of laboratory equipment, allowing for high-throughput experiments with minimal consumption, and have filed a patent application for it.



Photos: Philipp Stössel; Ivo Leibacher

Scarcity and waste

It’s impossible to imagine living our lives without using natural resources. Yet the wasteful way we consume these materials has grave consequences – not because these resources might one day run out, but because of the negative impact our consumption has on the environment. Climate change, air pollution and biodiversity loss all result from our careless use of resources – which is why ETH researchers are looking for ways to limit its environmental impact.

Photos: t.light / iStockphoto; fei-chunying/Getty Images

Treasures from the deep

People are going to ever greater depths to find workable ore deposits. ETH geologist Christoph Heinrich conducts research into how to find these.

TEXT Felix Würsten

Metals

Open pit mining for metal ores can have enormous consequences for the environment. Chuquicamata is the world's biggest open pit copper mine. Located in the Atacama Desert in northern Chile, this mine reaches depths of up to 1,000 metres.

Christoph Heinrich, a professor at ETH's Institute of Geochemistry and Petrology, is keen to emphasise one thing right from the start: "It's simply wrong to talk about final limits to resource availability – at least for metals." Although he acknowledges that raw materials such as copper, gold and zinc are getting harder to extract, he says that we won't be running short of these metals in a physical sense any time soon.

Heinrich's principal concern is not scarcity, but rather the environmental impact of resource extraction. "It makes sense to use metals sparingly and recycle them where possible. But that's not because those metals are running out – the real issue is that metal extraction from rocks costs energy and impacts on the environment. Therefore, you have to find a place where metals have accumulated naturally." Heinrich argues that the limiting factor in long-term resource supply is our ability to locate geological ore deposits. He also stresses the challenges of finding socially responsible ways of extracting resources and of developing environmentally friendly methods of processing ore. Heinrich is convinced that we can resolve these challenges, and so he does not like the term "resource curse" at all. "It's unnecessarily negative," he says. "Mineral resources are a necessity, and they represent a valuable asset for many countries," he insists. "The problem isn't natural resources, it's people's behaviour. The fact is: we need rare elements and specialised materials to solve what is arguably today's biggest environmental problem – achieving sustainable energy conversion without causing catastrophic changes in the earth's climate."

Metals from four kilometres down

Heinrich has reasons for his assertions. Having spent many years studying the geology of metal deposits in his research work, he is still intrigued by the question of why these elements accumulate in certain places when, on average, they are distributed so sparsely in the crust. He investigates the geological process of metal enrichment, because this knowledge is needed to understand their uneven distribution and to search for new ore deposits. The importance of this issue lies in the fact that most of the deposits containing metals in workable quantities close to the earth's surface have already been discovered – and are being mined out rapidly. But a few kilometres down there are still plenty of places where scientists can reasonably expect to find ample quantities of metals in rich deposits. The problem is that these are much harder to find than deposits exposed at the surface.

Heinrich predicts a trend towards ore extraction from underground mines, which he also argues makes sense from an ecological perspective. Large-scale ore extraction in surface mining takes up giant swathes of land and consumes huge amounts of energy. That's because you can't simply dig a vertical hole in the ground: to get to the deeper deposits, you first have to remove tons of unusable rock from around the ore zone. Depending on the shape of the metal-enriched zone, it therefore becomes more economical and energy-efficient to extract the ore underground. From a technical perspective that's already feasible – in fact the deepest mines extend down to four kilometres below the earth's surface.

> "The problem isn't natural resources, it's people's behaviour"
>
> Christoph Heinrich

Finding new deposits that are hidden at great depths will require a better understanding of what creates these zones in the first place, and that's where Heinrich's research comes in. His work revolves around two key approaches. The first one is the geological characterisation of existing deposits – a method that provides insights into the geometry of metal distribution – combined with accurate dating of past geological events, which supplies a precise history of when large-scale ore-forming processes such as magmatism were active. The second focus of Heinrich's research is to examine the physical and chemical processes that cause metals to accumulate.

Heinrich is particularly interested in deposits that form beneath volcanoes, such as those found in the Andes. These volcanoes are situated near subduction zones where an oceanic plate sinks beneath a continental plate. Magmatic bodies form in the crust above the subduction zone, and as the magma rises, it emits hot, highly saline fluids: solutions that also carry abundant metal and sulfur. These fluids transport the metals from the magma to the surrounding rock. But this mobilisation ›

Photo: DC_Colombia/iStockphoto

alone is not sufficient: for a deposit to form, you need a second chemical process that precipitates the metals in the form of ore minerals in a confined rock volume.

Over the past few years Heinrich and his group have been investigating small fluid inclusions in minerals contained in the rocks around ore deposits. These inclusions help researchers identify the conditions in which the minerals were formed and the chemical properties that contributed to their precipitation. Besides investigating these chemical processes, the experts are also taking a closer look at the physical transport of fluids through fractured rocks. Their results show that there are two opposing forces that provide the key to the concentrated accumulation of metals: the hot fluid from the magmatic body, and the cold groundwater that seeps into the rock from the surface. The interface between these two fluid regimes defines the zone where metals are deposited in concentrated form.

To understand these processes quantitatively, Heinrich's group has developed a numerical model that simulates the large-scale circulation of surface water as well as the fluid expulsion from the magma. "At the moment it's still a generic model that we're using to depict the conditions in a generalised form," Heinrich says. "But now we want to tailor the model more closely to real conditions, to enable the modelling of specific situations in the future."

Yet even the rough model they've developed so far confirms that the crucial zone for ore formation is confined to a depth range between two and five kilometres. Experts therefore have good reason to suspect that there are plenty more as-yet undiscovered deposits at these depths. "There's a key question for us as geologists," says Heinrich: "How can we determine if there's a workable deposit underground if there are hardly any traces left on the surface of those long-gone fluid processes?"

A sample case in Eastern Europe

Heinrich plans to apply the scientific work of his team as part of a European "Horizon 2020" project that also includes researchers from Geneva, France, England and Germany. The goal of the project is to obtain a clearer understanding of how deposits formed in Eastern Europe, from Romania to Turkey. "Computer models obviously can't replace the traditional methods of geological and geophysical exploration," Heinrich explains, "but they can provide new insights into ore formation and help us locate deeply buried deposits more efficiently." There are good reasons why the researchers chose Eastern Europe for this project: during the most recent major phase of mountain formation – which is when the Alps were formed – this region was situated on the northern shore of the Tethys Ocean. The plate motions led to the formation of a subduction zone with magmatic activity similar to the Andes. This set the stage for the formation of ore deposits in which important metals such as copper, lead, zinc, gold and silver accumulated, along with many other rare metals.

The science developed by the ETH researchers can also be used to investigate the formation of ore deposits on the ocean floor.

Field research is still important when searching for natural resources – despite numerical models.

Recently discovered metal deposits off the coast of New Zealand are also attributable to their volcanic surroundings, but they owe their current position to a quite different process. The calculations done by Heinrich's team suggest that the metal-rich fluids from the magma are too heavy to rise to the ocean floor, so they tend to accumulate beneath it.

Salty seawater plays an essential role by washing the metal-rich solutions to the ocean floor after submarine magma activity subsides, forming hydrothermal vents (known as black smokers) that are particularly rich in copper and gold. "Thanks to our model we now have a more detailed understanding of the factors that shape these events, which could contribute significantly to the exploration of untapped resources for the future," sums up Heinrich. ○

Fluids and Mineral Resources Group:
→ ww.ethz.ch/mineral-resources

Christoph Heinrich

Christoph Heinrich is Professor of Mineral Resources in the Department of Earth Sciences at ETH Zurich. He specialises in the formation of metal deposits. His group also works on other fluid processes, particularly in the field of deep geothermics. In addition to field research, his group develops methods of modelling transport processes deep inside the earth and techniques for analysing fluid inclusions in minerals.

Photos: Giulia Marthaler; Christoph Heinrich

Making more efficient use of nutrients for plants

Plant nutrients such as zinc and phosphorus are unevenly distributed globally. ETH researchers are investigating how to use them more efficiently.

TEXT Corinne Johannssen-Hodel

Ask Rainer Schulin to name the most important soil resource and he doesn't hesitate. "The problem isn't a scarcity of zinc, phosphorus or nitrogen," says the professor of soil protection, "it's quite simply that there's a shortage of fertile land." All over the world, good soil is increasingly being built on instead of being used for agriculture. What's more, in Switzerland the quality of much agricultural land is decreasing as a result of soil compaction caused by the heavy machinery of industrial agriculture. Farmers often seek to remedy these problems by overfertilising the soil. For example, the feeding of zinc supplements to cattle means excessive quantities of zinc are making their way into the soil through farmyard manure. This is exacerbated by the fact that soils at Swiss latitudes are comparatively young, which means they contain large amounts of primary minerals that release trace elements through weathering. "There's enough zinc in Swiss soils to supply plants with this essential micronutrient for at least two to three decades without a single replenishment," says Schulin.

Things look very different in many tropical areas, where the soil has been leached out over millions of years and few farmers have access to fertilisers. The situation is also problematic in arid and semi-arid areas: here, soils may contain plenty of zinc but this is tightly bound and all but inaccessible to plants. The soils across large parts of Iran and India, for example, ›

Zinc and phosphorus

Plants will thrive only if the soil they are growing in contains sufficient nutrients such as zinc and phosphorus. But that alone is sometimes not enough. The nutrients must be present in a form that roots can absorb.

Photo: Cordelia Molloy/Science Photo Library

are calcareous, so they have a correspondingly high pH. As a result, the majority of the zinc is bound to the solid-phase soil particles and cannot be absorbed by plant roots. “The zinc is there, it’s just in the wrong form,” Schulin explains. And this has some significant consequences – in fact, zinc deficiency is one of the most serious problems in human nutrition on a global scale. It’s a situation that is exacerbated by the fact that much of the world’s population has little or no access to meat. The zinc that occurs in animal products is much more readily available to the human body. Cereal grains, in contrast, are rich in phytic acid, which makes it harder for the body to absorb zinc.

Mobilising zinc

Yet there are some microorganisms that are capable of mobilising zinc in the soil. These soil bacteria play an important role in making nutrients available to plants. For example, some bacteria release acids that decrease the pH of the soil. This, in turn, frees up the zinc, making it available to plants. As part of a joint project with a group led by Emmanuel Frossard and the Research Institute of Organic Agriculture (FiBL), a doctoral student is currently engaged in a large-scale screening process designed to improve scientists’ understanding of soil biology. The study will tackle questions such as how many species of bacteria actually have this property, where they occur in the field, and how high the zinc content is in those places. “It’s crucial to understand how these things interrelate,” says Schulin.

A project completed in Iran has already shown that the addition of clover and other leguminous plants can improve yields and zinc content. That’s because the root nodules of these plants contain bacteria that can bind nitrogen. This enhances the supply of nitrogen, which helps to improve the uptake and storage of zinc. “You have to get the right balance,” says Schulin. “Once zinc is plentiful, then a different nutrient will soon become the limiting factor.”

The link between zinc content and pH is another area Schulin’s team is investigating in collaboration with Frossard’s group on a plot at the Reckenholz location of Agroscope, the Swiss centre of excellence for agricultural research. Since 1949 this location has been the site of experiments with 15 different fertiliser regimes, ranging from mulch and manure to mineral fertilisers. In India, farmyard manure – in other words the mix of dung and urine from a farmer’s own cattle – has proved to be the best means of increasing nutrient availability in the soil. Farmers can produce this themselves, making it much cheaper than mineral fertilisers. “That’s why we believe small-scale farming should always seek to form closed ecological loops,” says Schulin, “because that way we can achieve lasting progress.”

Frossard’s experience tallies with Schulin’s conclusions. “Livestock farming is closely tied to crop production here in Switzerland,” says the professor of plant nutrition. “But in many tropical countries these two interests have traditionally been kept separate.” That deprives plants of the benefits of manure, with important nutrients instead lost to the environment. Changing this approach could be a valuable step forward, especially in countries where crop production is often limited by inadequate levels of nitrogen and phosphorus and farmers struggle to get hold of fertiliser. Farmyard manure could be a promising solution in Madagascar, where animals are herded in from the savannah at night to protect them from thieves. That makes it easier to collect dung for subsequent spreading on the fields.

Frossard’s research group is currently analysing the data gathered in a project that ran for several years in Madagascar. The goal of the research project was to determine the effectiveness of conservation agriculture (CA) on the African island. CA is a form of agriculture that is promoted in sub-Saharan Africa by the Food and Agriculture Organization of the United Nations (FAO).

The key tenets of CA include not ploughing the soil, following a process of crop rotation, and ensuring permanent soil cover. CA’s key objectives are to prevent erosion and increase yields. However, long-term increases in productivity require supporting measures to boost nutrient availability and uptake, and Madagascan farmers have limited quantities of dung at their disposal.

After five years of fieldwork, the researchers’ preliminary findings showed that nitrogen content is indeed increased by the introduction of crop rotation with leguminous plants. In contrast, the conservation agriculture practices had not succeeded in boosting the phosphorus content of the soil. Any phosphorus present comes from dung. “The most important thing about our projects in African countries is that it gives farmers access to the knowledge they need to develop their own systems of cultivation,” says Frossard. Information is a key resource, but it is out of reach of many farmers.

A single use isn’t sustainable

Switzerland has also reaped benefits from Frossard’s research. One of the projects he now runs in his home country began in 2006, when the fear of BSE prompted the government to ban farmers from recycling sewage sludge for agricultural uses. Since then the sludge has been burnt, with the ash ending up at landfill sites. “It doesn’t make sense to use phosphorus only once – and it’s not sustainable either,” Frossard argues. But to prevent soil contamination with heavy metals or other pollutants, the sludge first has to undergo a complex process to remove them. What remains is a phosphate-laden substrate, but laboratory, greenhouse and field experiments have all shown that plants are unable to take up this phosphorus because it is so heavily crystallised. A new approach involves extracting phosphorus from the sludge directly instead of trying to eliminate the toxic substances, and the researchers are therefore now trying out a new method with the support of the Canton of Zurich. “The product has outstanding qualities,” says Frossard, “but it still contains heavy metals such as cadmium.” Further refinement of the process is therefore necessary.

Frossard enjoys this wide-ranging search for key elements, involving as it does both laboratory experiments and fieldwork, and Schulin is equally enthusiastic about the broad scope of his work and the opportunity to collaborate with other disciplines. A master’s student supervised by both Frossard and Schulin recently worked together with the FiBL to investigate why it is that farmers choose conventional or organic methods of agriculture. “Those kinds of sociological studies are equally important in my area of research,” says Schulin, “since they help us understand the big picture.” ○

Chair of Soil Protection:
→ www.soilprot.ethz.ch

Chair of Plant Nutrition:
→ www.plantnutrition.ethz.ch

In India, ETH researchers are studying the availability of zinc in organic farming.

Rainer Schulin has worked as a professor of soil protection at ETH Zurich’s Institute of Terrestrial Ecosystems since 1990. A qualified biologist and forest scientist, Schulin teaches in the departments of Environmental Sciences and Civil, Environmental and Geomatic Engineering. His research focuses on soil degradation caused by heavy metals and compaction due to mechanical stresses by heavy machinery.

Emmanuel Frossard has been professor of plant nutrition at ETH Zurich’s Institute of Agricultural Sciences since 1994. His research focuses on the availability, dynamics and effects of nutrients in soil and plants. He also investigates the recycling of nutrients in farmyard manure, sewage sludge and compost. Frossard is the president of the steering committee of the national research programme “Sustainable Use of Soil as a Resource”.

Photos: Giulia Marthaler (2); Roman Grüter

Resources, politics and fairness

FOEN director Bruno Oberle, environmental engineer Stefanie Hellweg and economist Lucas Bretschger discuss ways to make resource consumption more eco-friendly, both in Switzerland and around the world.

TEXT Roland Baumann and Martina Märki
PHOTO Nicole Bachmann

Professor Hellweg, which resource do you think is the scarcest?
STEFANIE HELLWEG – Strictly speaking, resources are natural raw materials, such as fossil fuels and metals, but also renewable resources such as water. A raw material is said to be scarce when it is no longer available in the quantity or quality needed to satisfy demand.

In my work, I look at resources from an environmental perspective and examine the effects on the environment from, say, extraction activities. If the use of metals increases, over time you will find ores with lower and lower concentrations of the metal you're looking for. This could mean that in future, more energy is required to extract it. Things were different in the past, though, because the technology was becoming more refined and energy was being used more and more efficiently. In global terms water is not a scarce resource, but at the regional level water scarcity can have dire consequences for people and the environment. If you're talking about fossil fuels, we consider the climate change caused by burning them to be a much bigger problem than their availability.

And if you define the term "resource" more broadly?
HELLWEG – Then you could also count the climate or biodiversity as natural resources. Next to global warming, loss of biodiversity is probably the most serious problem we face worldwide.

As an environmental policymaker, Dr Oberle, do you hold the same view?
BRUNO OBERLE – At the Federal Office for the Environment, we define "resources" very broadly, similar to the way the European Union does. This definition does include biodiversity, for example.

However, at the moment Swiss law doesn't include any protective regulations for rare goods. The environmental law in effect right now is really concerned only with the negative consequences of resource use, such as emissions or pollution. An amendment to this law is currently in the Swiss Parliament. If it goes through, it would mark the first time that Switzerland has made scarcity a topic in its own right and a basis for taking action.

If we want to show that these actions are actually effective, we automatically talk about the global situation as well. And that plunges us right into the complicated discussions we're all used to having about the climate. In this respect, the scarcest resource I have is political consensus [laughs].

Why do you want to change Switzerland's environmental protection act?
OBERLE – Because we believe that demanding too much from the systems upon which our economic and social activities are based will jeopardise Switzerland's welfare over the medium and long term. Science is indicating that this is already the case in many areas. As regards biodiversity and the climate, we are already outside a "safe operating space" – in other words, we have exceeded the limits of what the earth can tolerate. ›

"In this respect, the scarcest resource I have is political consensus."

Bruno Oberle

Professor Bretschger, which resources are considered scarce from an economic point of view?
LUCAS BRETSCHGER – In economics, we operate with a very broad definition of "resources", because we're interested in how people manage them. This view includes natural resources, but could encompass things like time or political restrictions. Scarcity is everywhere, in fact; we have less than we'd like of most resources.

So is it a question of allocation?
BRETSCHGER – There are certain mechanisms for allocating scarce resources. One of these is an individual's own decisions, or personal responsibility. Another is the market that determines the price, which itself is an indicator of scarcity.

Is it as simple as saying the most expensive goods are the scarcest?
BRETSCHGER – It's not quite that straightforward, as demonstrated by the "diamond–water paradox", for example. Although water costs virtually nothing while diamonds are very expensive, if you were dying of thirst, you would gladly trade a diamond for some water. In certain situations, the usual relationships are reversed. This means we have to take a good's value or price into consideration in all possible circumstances.

If resources have no price, practically speaking, such as air or water, does that lead to wastefulness?
BRETSCHGER – This is the core of environmental economics. If the price of a good doesn't reflect the entire social cost, then it is too low and will lead to waste. Basically, there is no such thing as a good that is completely free. There's competition for everything, even the air we breathe. Of course I can pollute without having to pay the cost myself, but someone else is going to suffer as a result. And let's not forget the long-term consequences for our climate. This is why we have to come up with different allocation mechanisms – ones that are not provided by the market.

What are they?
BRETSCHGER – For example the state, which supports allocation through regulation. There's also international trade, which balances out the uneven distribution of rights of use among countries. In our research, we look at how we can manage natural resources sustainably. This means using natural systems in a way that doesn't give future generations a quality of life that's worse than our own. Other resources come into play here: inputs created by people, such as knowledge and human capital, better institutions, etc.
HELLWEG – Our research aims to quantify effects on the environment, such as the loss of biodiversity or the years that get taken off people's lives when something harms their health. The idea is to take costs that currently have no price – what we call external costs – and make them transparent. By doing so, we want to help those who make decisions about which resources should receive more protection. You could even go a step further and translate the costs into a monetary currency, but that's not so easy.

How effective is price as a regulation mechanism?
BRETSCHGER – We're often able to adjust only relatively poorly to prices over short time frames. Let me explain using crude oil as an example: the price of oil can indicate many things, but it can't change the fact that the heating systems in our homes are designed to last for 10 to 30 years. At today's rate of renovation, it would take a whole century to completely equip Switzerland's buildings with an alternative. This means the influence of price is greatest over the long term. The same holds true for transportation systems, which are similarly designed with long service lives in mind. And here's an interesting thought: if China skipped over the petrol-powered phase and went directly to electric mobility, the impact would be massive – and would extend to the European automotive sector, too.

Besides prices, there are also laws and regulations.
OBERLE – Wherever a system doesn't regulate itself – in other words, where there's some kind of market failure – that's where sensible laws should be put in place. But laws can also be used to help a certain development along. For example, the Chinese could ban petrol-powered cars, a measure that would require strict government implementation – something the Chinese have that we don't. However, we could also try to do more in future. Theoretically you could define an upper limit for certain resources, based initially on scientific findings, and then let the price mechanism do its work. That's what was done with the CO_2 pool.

And what about appealing to people to take voluntary action?
HELLWEG – That can be successful if people understand what it's about and how to adjust their actions accordingly. I'm sceptical as to whether or not such appeals can work on their own. Changing consumption behaviour is particularly difficult. You usually need additional support measures, such as legal requirements, taxes or subsidies for new technologies.
BRETSCHGER – Individual responsibility plays a major role in every system, but it doesn't go far enough for urgent environmental problems.

What really drives people – and we see this in climate talks – is a consideration of fairness. The price is in fact the mechanism that correctly signals scarcity, but how rights to use the environment are allocated is key to achieving political acceptance. If some people have good intentions and do something for the environment, but others don't, then those who do will eventually find the situation unfair and will stop. This is counterproductive.
OBERLE – Day-to-day politics are complex; it's not simply a question of whether voluntary action is the way forward.

In the initial phase, we often work with people who volunteer to effect change. You have to protect these pioneers so that they're not immediately clobbered by reality. Once there are enough of them to provide a foundation, you can try offering incentives to get more people on board. And if we then have, for example, a two-litre car or an electric car, or engineers know how to build a truly energy-efficient house, then you can say: right, as of now, this technology is standard and mandatory. Political action takes time – for major changes, about 30 years.

Is it true that when the economy is doing poorly, such as in recessions, it means tough times for environmental policies?
BRETSCHGER – If you look at it that way, then it's always a tough time for environmental policy. In bad times, people say, oh, we can't afford that right now, and in good economic times, they say, oh, we don't want to do anything to jeopardise things when they're going so well. In other words, environmental policy should ignore these economic cycles; we have to think on a much larger time scale.

Is it still possible today to take political action with such long-term perspectives?
BRETSCHGER – One can find examples throughout Switzerland's history of people realising intergenerational projects – the Gotthard Tunnel, for instance. Nowadays, there's less and less enthusiasm for such long-term projects, and less pioneering spirit. People often overestimate the difficulties and costs that would result from such a transformation.

In the long run, switching to environmentally friendly technologies would also provide opportunities for growth and advantages in international competition.

Background

Key political processes related to resources and environmental damage are currently running on both the national and international levels:

…on changes to the Swiss environmental protection act

The current amendments to the Swiss environmental protection act (EPA) are an indirect counterproposal to the "green economy" popular initiative, the goal of which is to have Switzerland further develop and modernise its environmental policy. The changes create new legal bases for the conservation and efficient use of natural resources. The Swiss Federal Council is attempting on the one hand to reduce the environmental impact caused by its citizens' consumption; this measure should also take into account any impact caused abroad.

On the other, the Council is aiming to strengthen the security of supply and efficiency of Switzerland's economy. If the amendments pass, they should create conditions that help make consumption more sustainable, close loops in materials use and provide information on resource efficiency. The effect of these measures is to be reinforced by promoting voluntary initiatives in close cooperation with business, science and society.

…on the UN Climate Change Conference

Towards the end of 2015, countries will send delegates to Paris to discuss a new global climate protection agreement. The goal of the conference is to find a successor to the expiring Kyoto Protocol, which was the first to set internationally binding target values for greenhouse gas emissions. As was agreed at the Durban conference in 2011, the post-Kyoto deal was to be prepared by 2015 and adopted at the 21st UN Climate Change Conference in Paris. The agreement is scheduled to take effect in 2020.

"What really motivates people in discussions about the climate is fairness."

Lucas Bretschger

> “The largest part of the footprint created by Swiss consumption lies outside Switzerland.”
>
> Stefanie Hellweg

Switzerland is not a country rich in raw materials; we have to import most of what we need. What implications does that have for the environment?
HELLWEG – The biggest part of the footprint created by Swiss consumption lies outside Switzerland. We can show this with the help of a lifecycle analysis.

What does this mean specifically?
HELLWEG – Let’s take food imports as an example. When you look at the land used to produce the total amount of food consumed in Switzerland, the area of that land located abroad is roughly the same as here in Switzerland. While it is possible to see effects on biodiversity in Switzerland, the negative consequences in other countries are much worse; for example, when you look at species loss.

Water consumption presents a similar picture. We have plenty of water in Switzerland, but when we import fruit from Spain, then we contribute to water scarcity there. Regarding CO_2 emissions and the effects on climate change, the relationship is more balanced, but even so nearly half of CO_2 emissions attributable to Swiss consumption are produced abroad by the many products we import. This is also a problem of the political instruments at hand – especially if they’re somewhat older than, say, the Kyoto Protocol. Here the thinking is still very much bound by national borders, with hardly any incentives to reduce indirect emissions.
OBERLE – The Kyoto Protocol ties emissions to the locations where they are produced. An alternative approach would be to attribute emissions to countries based on their consumption. The thing is, we ought then to have the opportunity to say at the border: this or that product isn’t allowed in because it would put too much of a strain on our CO_2 account. However, that clashes with international treaties and of course with the interests of exporting countries. In this context, what concerns me much more is that we have to consider how completely dependent we are on the world – not just as regards oil and gas, but also food.

In light of this international interdependence, what can Switzerland do?
BRETSCHGER – As I see it, there’s no need for a complicated switch from the current production-based perspective to a consumption-based one. After all, adding environmental taxes into the product price means they are still very much borne by consumers, which is advisable from an economic point of view.

But in my opinion, it would be better if we here in Switzerland developed new low-emissions technologies and drove them forward. Then we would really be achieving something on a global scale. We should also play a more active part in international negotiations: we may not be the most influential country, but we can build bridges and liaise among the various players, contribute good ideas and perhaps soften the hard line taken by the major blocs. Ultimately, if we still want to achieve the two-degree target, the upcoming climate negotiations in Paris will have to produce substantial results.

What sort of global effect would it have if Switzerland were to develop new technologies?
OBERLE – We export technologies and standards as well. Take cement, for example: cement production is a major source of CO_2. Lafarge-Holcim is the largest cement manufacturer in India. The company operates to the same standard in every country as a matter of principle, so if Holcim came up with a good technology, then this would also be an enormous help in India.
HELLWEG – Another example would be technologies for waste incineration and for recovering metals from slag. This is an area where Switzerland is a world leader, and international interest in these technologies is quite high.
OBERLE – If the new environmental protection act goes through, we will have the opportunity to roll out this kind of new technology throughout Switzerland. This would let us create at least a limited market . ○

A world of construction without cement

Building with less cement is the ambitious goal of Guillaume Habert, professor of sustainable construction at ETH Zurich. But there are many hurdles to overcome.

TEXT Corinne Johannssen-Hodel

It was a brilliant idea: why not renovate the Gothic Cathedral of Notre Dame in the centre of Lausanne using stone extracted from a nearby demolition site, after the buildings there had been razed to the ground? After all, the church was originally built of local stone that today lies buried under the city. “The redevelopment made this resource accessible again, at least for a short while,” says Guillaume Habert, professor of sustainable construction at ETH Zurich. A doctoral candidate demonstrated the local scarcity of resources under the joint supervision of Habert and the originator of the idea, a professor of architecture at the Geneva Institute of Technology, Architecture and Landscape (hepia). But sadly this was as far as it went, as Habert explains: “We just didn’t have enough time to realise the project.” By the time all the details had been worked out, the stone had already been crushed by excavators and the fragments were too small to be useful. But Habert hasn’t given up hope: “At least these ›

Foto: Andre Seale /Alamy

Guillaume Habert

Guillaume Habert has been an associate professor at ETH Zurich since 2012 and holds the Chair of Sustainable Construction. After obtaining a PhD in geology from the University of Toulouse, he worked as an engineer in the construction industry before continuing his academic career. The main focus of his current research lies on the sustainable use of construction materials at all stages of a building's lifecycle.

efforts served as a wake-up call; perhaps next time we will succeed, be it in Lausanne or another city."

Habert is a fervent advocate of using local resources – especially in urban environments, where construction materials are in high demand. One frequently encountered problem is the availability of resources. Most cities are built on rock formations that could provide more than enough stone for construction, but nobody wants a quarry in their back yard. So stone is instead sourced from quarries situated far from centres of demand. This means it must be transported over long distances, at high cost, and with no regard for environmental balance. In Habert's view, the main issue for the construction industry is not the shortage of resources but how they are distributed.

One of the local resources of most interest to urban development is recycled concrete, since the raw materials from which it is made – gravel, sand and cement – can be partially recovered and reused when an old building is demolished. The first step in the process involves crushing the recuperated concrete. This rough fraction contains gravel and sand that can be extracted and used to produce new concrete. The dust that remains consists mainly of cement, which had hardened in contact with water during the original manufacturing process. "Cement recycling is a more complex process – but it's crucial," insists Habert. This is because the manufacturing process for cement generates large quantities of carbon dioxide (CO_2), partly as a result of heating the two main ingredients – limestone and clay – to a temperature of 1,500 °C, and partly due to decarbonation of limestone. The latter step liberates no less than half a tonne of CO_2 per tonne of cement. When the raw material is recycled in a cement factory, it has to be reheated to a high temperature so it can regain its original form, but at least this process doesn't release any additional CO_2 – provided climate-neutral energy sources do the heating.

Different building materials compared at the Grounded Materials summer school

Less cement, lower CO_2 emissions

Cement is the ideal binder for concrete. When mixed with water, it binds together gravel and sand. As part of the "Energy Turnaround" national research programme (NFP 70), Habert leads the joint "low energy concrete" project. Other ETH scientists and research groups from EPFL and Empa are also participating in this joint project. Its aim is to develop a product that contains less cement than traditional concrete but still has the same properties. Concrete manufacturers are already using waste from industries such as coal and steel to replace part of the cement in concrete. These waste products have ideal properties and cannot be reused or recycled by the industry that produced them. Nowadays, they replace 30 percent or more of the cement in commercial concrete products.

The researchers want to double the waste content without reducing the mechanical strength of the final product, which must still withstand a force of 30 megapascals. "This would allow buildings to have the same dimensions as today but with a significantly better CO_2 balance," says Habert. The team's current work consists of characterising the new concrete with a lower cement content and optimising it still further.

One of the challenges with which the researchers are repeatedly confronted is how to manage the interaction between the low-cement concrete and other materials, including the steel reinforcement bars (rebars) that are cast into the concrete during construction. If the concrete contains too little pure cement, the steel rusts much too quickly. "Such reinforced concrete structures would be less durable, but that's obviously not the result we're looking for," emphasises Habert.

That's why the scientists are not just optimising the new concrete but also developing alternatives to steel reinforcement. They are working together to find rust-free alternatives such as carbon-fibre-reinforced polymers or synthetic fibres. "My role in this research is to evaluate the environmental impact of these materials," says Habert. He analyses the CO_2 balance of the various technologies and identifies possible ways of optimising this balance.

Photos: Giulia Marthaler; Sasha Cisar

One novel solution can be found on the Hönggerberg campus: the House of Natural Resources, inaugurated this summer in a project led by Andrea Frangi. It serves both as an office building and as a research laboratory for sustainable construction. The concrete slabs used in its construction are reinforced with timber instead of the usual steel. "Concrete and timber make an ideal combination," says Habert, "because there is absolutely no risk of corrosion."

Radical approach

Another approach Habert is pursuing is a much more radical departure: concrete made with clay rather than cement. Clay is a far more eco-friendly building material because it is not heated to a high temperature and hence doesn't trigger any chemical reactions. But this also has its downside: clay-based concrete has a mechanical strength of only 3 megapascals, which is roughly ten times lower than that of conventional cement-based concrete. "Consequently, this type of concrete cannot be used in the same applications," says Habert. One possible solution would be to restrict the use of cement-free concrete to non-loadbearing walls. This alone could significantly reduce the amount of cement used in construction.

Along with optimising the material per se, another of Habert's research group's priorities is to improve the way it is processed at the construction site. After the novel concrete has been poured into the formwork, cracks often appear as it sets. To solve this problem, the researchers are investigating ways of chemically modifying the surface properties of the clay. Their aim is to produce a cement-free concrete that remains workable for three hours – like traditional products. The experimental cement-free concrete sets in 30 minutes, which leaves far too little time for it to be transported and processed. Special porous formwork that allows water to penetrate might also help.

Nonetheless, Habert is well aware that new building materials will only be accepted by the market if they can be used without upsetting conventional construction industry practices. "Very few people are willing to pay more for eco-friendly construction," says Habert.

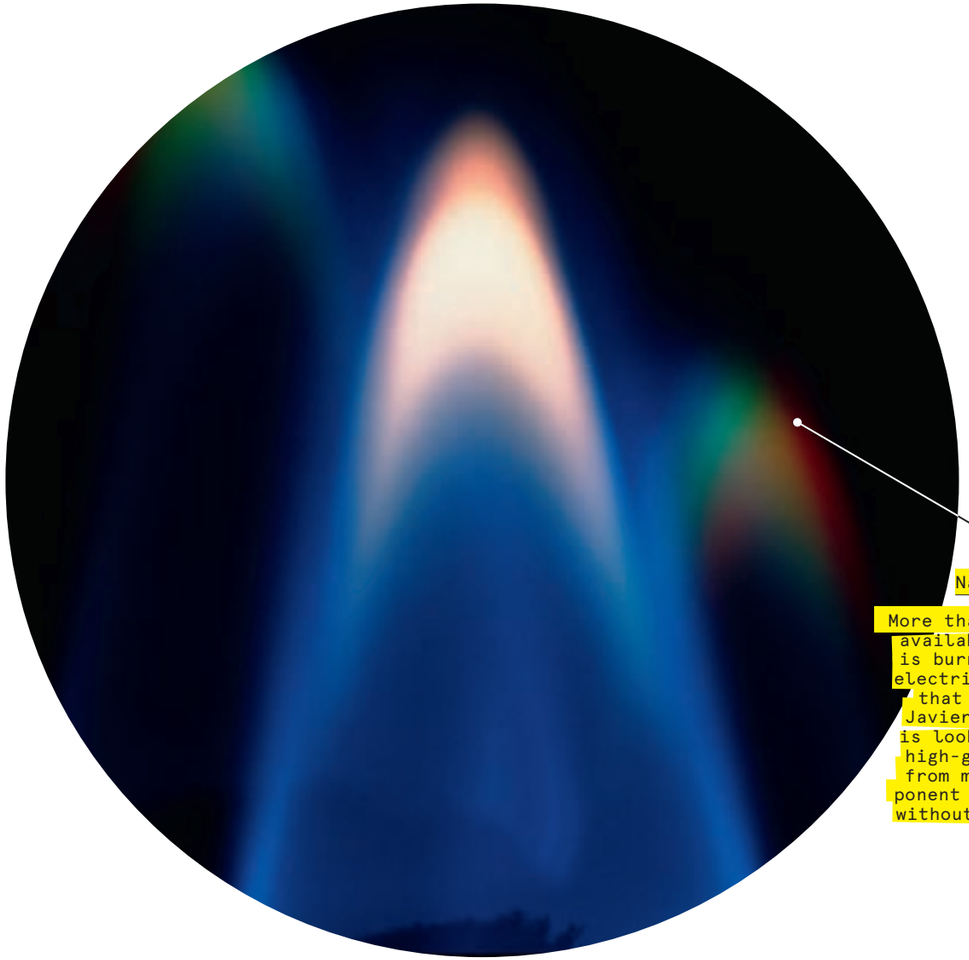
Next generation

With a view to transmitting his knowledge to his students, Habert organised a summer school this June on the theme of "Grounded Materials" in cooperation with the Grenoble National School of Architecture (Ensag) and the ETH Department of Environmental Systems Science Transdisciplinarity Lab (TdLab). The ETH students looked into the question of how to promote the use of eco-friendly, locally sourced materials by the construction industry in and around Zurich. Students from the Departments of Architecture, Materials, Environmental Systems Science, and Civil, Environmental and Geomatic Engineering spent two weeks identifying the barriers to more widespread use of local building materials. On the basis of these findings, they developed strategies for making such materials attractive to stakeholders. These strategies focused less on technical characteristics, such as the mechanical strength of concrete or CO_2 emissions, and more on aspects drawn from the fields of sociology, economic science and communication.

> "Wherever there's an interface between the environment and human society, things get exciting."
>
> Guillaume Habert

Habert is very happy that he has been able to raise the younger generation's awareness of these issues. "As a geologist, my reflex is to see resources as something physical, found in a specific place in a fixed quantity," he explains. "But wherever there's an interface between the natural environment and human society, things begin to get more exciting." What use can be made of the resource? Where is it situated and where is it needed? Who knows how to use it? How much does it cost? After this year's summer school, Habert's students also know that these are important questions. ○

Chair of Sustainable Construction:
→ www.ibi.ethz.ch/sc/index_EN



Natural gas

More than 90 percent of available natural gas is burned to generate electricity, a process that releases CO_2. Javier Pérez-Ramírez is looking to produce high-grade chemicals from methane, a component of natural gas, without producing CO_2.

Fuelling sustainable chemistry

A group of researchers led by Javier Pérez-Ramírez is developing catalysts that could help make plastic manufacturing greener and less dependent on oil.

TEXT Martina Märki

In the Middle Ages, alchemists strove to transform base metals into gold – a goal that still eludes us to this day. Yet much of modern chemistry actually does something similar, producing a plethora of refined products from a limited number of the cheapest available materials. According to estimates, 90 percent of the chemical reactions this involves rely on the use of catalysts.

Catalysts are substances that initiate or speed up chemical reactions. “They play a key role in our efforts to optimise the use of available resources,” says Javier Pérez-Ramírez, a professor of catalysis engineering. He and his team are busy developing new catalytic technologies to foster “greener” chemistry that will make manufacturing more eco-friendly and lead to more sustainable products. “The goal is to make efficient use of raw materials while consuming less energy and creating less waste.”

Photos: Alfred Paseika/Science Photo Library/Keystone

Turning a waste product into biodegradable plastic

Pérez-Ramírez points to the plastic cups of water on the table: “That’s a perfect example.” Most plastics are made from crude oil. At the same time, plastic waste is a huge environmental issue because many plastics are not biodegradable. One alternative that already exists is an eco-friendly, biodegradable plastic made from polylactic acid (PLA). Working with a number of other ETH researchers, Pérez-Ramírez’s group has succeeded in developing a new method of producing lactic acid. As well as being more efficient and cost effective, their process is also less polluting than conventional manufacturing techniques, reducing CO_2 emissions by up to 30 percent.

The new method for making PLA uses glycerol, a waste by-product of first-generation biofuel production. Glycerol previously had a very low reuse value, but PLA production now offers an environmentally friendly application. One of the keys to minimising the environmental impact is the catalyst used in the reaction, which the researchers have optimised by various different means. This is based on a zeolite, a microporous mineral with a structure that has proved to be ideal for certain chemical reactions. “With the new methods we’ve developed, we can do things like investigating how the pores of a catalytic material are connected,” says Pérez-Ramírez, adding: “The combination of precisely tailored, rational design and a little help from nanotechnology has enabled us to raise the bar of catalyst quality.”

A new use for natural gas

His team is also creating catalysts to facilitate new applications for natural-gas components such as methane. “Natural gas is currently used to supply energy, but it could also potentially be a useful raw material for chemistry, like oil is now,” argues Pérez-Ramírez: “Perhaps in the future we won’t just be producing plastics from methane, but also vitamins or even pharmaceutical products.”

In recent years fracking has opened up access to large reservoirs of gas, so methane is now available in abundance. One major challenge, however, is that methane is chemically very stable, which makes it difficult to transform into useful chemicals. Currently, the most common method of using methane is to convert it into synthetic gas by means of steam reforming. “That uses a lot of energy and produces CO_2, neither of which is a sensible goal,” says Pérez-Ramírez. Other attempts to produce chemical products from methane have generally been thwarted by the expensive and time-consuming nature of the catalytic methods involved, or due to their poor selectivity – in other words, the targeted product represents only a small fraction of the reaction end products.

Pérez-Ramírez and his group have come up with a new approach, creating a catalyst that offers very high efficiency. They use hydrogen chloride and hydrogen bromide to convert methane. Both of these are chemical waste products that this new process can recycle. However, halogen chemistry is complicated by the fact that the compounds are highly toxic and very corrosive. “Only a handful of laboratories worldwide can work with halogens in the same way we do,” says Pérez-Ramírez. The conversion process yields products that can be used to create useful raw materials for chemistry. To develop the catalytic process, the group has worked with different phosphates and metal oxides; their catalyst presents a selectivity of over 90 percent. The researchers are now hoping to establish a spin-off company to commercialise their groundbreaking technique. ○

Advanced Catalysis Engineering Group:
→ www.perez-ramirez.ethz.ch

Turning a waste product into biodegradable plastic:
→ www.ethz.ch/news-bioplastic

Bioplastic can be produced in an even more eco-friendly way.

Javier Pérez-Ramírez

Javier Pérez-Ramírez has been a professor of catalysis engineering at ETH Zurich’s Institute for Chemical and Bioengineering since 2010. He studied chemical engineering at the University of Alicante and earned his PhD at TU Delft in the Netherlands in 2002. After spending a few years working in industry, he returned to academia in 2005 as research professor at ICIQ in Tarragona, Spain.

Photos: Bo Cheng; Giulia Marthaler

ETH Alumni

INSIGHTS INTO SYNTHETIC BIOLOGY

The alumni associations of ETH Zurich and the Massachusetts Institute of Technology (MIT), in partnership with swissnex Boston, brought together two of the world's leading researchers in synthetic biology. The networking event was held at the Koch Institute for Cancer Research at MIT in Cambridge, MA.

ETH Professor Yaakov Kobi Benenson and MIT Professor Ron Weiss presented the latest results of their research. Both scientists are looking into using cellular and molecular mechanisms to perform increasingly sophisticated computational tasks. "Programming" cells to follow human-defined algorithms shows great promise for therapeutic applications ranging from targeted cancer treatment to in vitro tissue growth.

Following the presentation, there was plenty of time for lively discussions between the scientists and ETH as well as MIT alumni.

ETH Synthetic Biology Group:
→ www.bsse.ethz.ch/synbio

Successful spin-off

KOUBACHI ACQUIRED

ETH spin-off Koubachi owes its success to sensors and apps that make it easier to look after plants. Now the young company, founded in 2009, has been acquired by Sweden's Husqvarna Group.

Game technology

NEW CENTRE

The Department of Computer Science is setting up a Game Technology Center. This new centre will be a place for scientists from various disciplines to work with each other and with industry on new technologies for developing computer games. ETH President Lino Guzzella explains the decision: "Game technology is of interest not only for start-ups and the creative industries, but also for science and teaching. In future, we want to pool ETH's strengths and pay more attention to this technology."

A computer game developed by master's students at ETH Zurich.

Photos: Christine Luiggi/swissnex Boston; Game Technology Center

Zurich Information Security and Privacy Center

Working together to improve information security

Thanks to a donation by Zürcher Kantonalbank, ETH Zurich is expanding its Zurich Information Security and Privacy Center (ZISC). This expansion will also strengthen ZISC's collaboration with business and industry.

The more our lives are driven by information technologies, the more we need to focus on security. Business, finance, communication, energy supply, transportation and entertainment are increasingly reliant on networked information systems. And whether you're handling electronic payment transactions, managing power plants, or simply sending personal data by email, nothing is immune from attack. "Wikileaks and Edward Snowden are just two examples of how vulnerable we are," says Srdjan Capkun, a professor at the Institute of Information Security and Director of the Zurich Information Security and Privacy Center (ZISC).

Expertise in the field of information security is already in huge demand – and there's no sign of that demand letting up. At the same time, there is an acute shortage of security experts in the world. "But now we have an opportunity to recruit and train up even more outstandingly talented people," enthuses Capkun. Zürcher Kantonalbank has donated five million Swiss francs to the ETH Zurich Foundation specifically for this purpose. The money will be invested incrementally over the next ten years.

Open Lab with partners

ZISC currently employs four professors and some ten doctoral students and researchers. The aim now is to facilitate a significant increase in the number of researchers and young talent in the field of information security. The donation will also allow ZISC to build on its partnerships with business and industry. Information security is a complex topic that requires more than just a purely academic or technological approach, says Capkun: "You can have the best security system in the world, but it's useless if customers and users refuse to accept it and work with it." That's precisely why there is such value in direct communication with specialists on the front line who know users' needs.

A key feature of the new ZISC is the planned ETH-ZISC Open Lab, an open platform enabling students, researchers and IT experts at ZISC's participating partners and companies (see box) to exchange ideas and opinions. The Open Lab is due to be up and running by late 2015. It will host some 20 people who will be able to meet not only virtually but also physically. Capkun is hopeful this approach will pay dividends: "We've learned that the best ideas always stem from direct contact between people." The ability to deal directly with others fosters creativity and mutual trust, he argues, noting that trust is one of the key prerequisites for collaboration – especially in the field of information security research.

Basic research and practical applications

Participants in ZISC hope that closer contact between researchers and industry representatives will lead to even more efficient identification of business and industry needs in future, and will accelerate the transfer of research results into everyday applications. The plan is to pursue both basic and applied research, with projects being carried out on the basis of "open innovation", making them visible to everyone.

It's not just today's applications that the ZISC researchers have in their sights; they're also working intensively to develop ground-breaking new systems for the future. For example, Capkun would like to see more accurate and more secure alternatives to today's satellite-based GPS. Meanwhile, ZISC Professor Adrian Perrig and his research group are busy working on a completely new internet system that they hope will not only be more resilient to interruptions and glitches than today's internet, but will also leave the control of data decryption to each individual country. "Perhaps the internet of the future will come from Zurich," says Capkun enthusiastically. At any rate, his primary goal is clear: "We want to become one of the world's most prestigious institutions in the field of information security." — Martina Märki

Zurich Information Security and Privacy Center:
→ www.zisc.ethz.ch

Looking forward to a productive collaboration: (from left to right) Emo Welzl, Deputy Head of the Department of Computer Science; Daniel Heinzmann, Head of IT Strategy, Architecture and Security at Zürcher Kantonalbank; and ZISC Director Srdjan Capkun at the signing of the agreement.

Photo: Peter Rüegg

ZISC PARTNERSHIPS

Since it was founded in 2003, ZISC has worked closely with the business world to jointly develop solutions for practical problems. ZISC offers research projects and education of the highest quality for business experts. Current and past partners include Armasuisse, Credit Suisse, Google, IBM, Kaba, NEC, and Sun Microsystems. Zürcher Kantonalbank will become a founding partner of the new ETH-ZISC Open Lab.

Careers

SWISS ENGINEERING

In May of this year, Beat Dobmann was elected the new president of the Swiss Engineering professional association. The 54-year-old earned his degree in mechanical engineering from ETH and did a second course of studies in business administration at the University of St. Gallen. He is especially interested in setting up networks among SMEs and Swiss universities.

FLEXIBLE PACKAGING

Suk-Woo Ha (47) took over as CEO of Cellpack Packaging in May 2015. The company has production locations in France, Germany and Switzerland. Ha, who holds an engineering degree from ETH and an executive MBA from the University of St. Gallen, was most recently a member of the executive board of IVF Hartmann Holding AG.

Photo: Cellpack

AGRICULTURE

He is just 36, studied agricultural engineering at ETH Zurich with a specialisation in livestock farming, and previously served as director of the association of Swiss vegetable growers (Verband Schweizer Gemüseproduzenten). Now Pascal Toffel has been named director of the Grangeneuve Agricultural Institute (Landwirtschaftliches Institut Grangeneuve, LIG).

The departure from the current sheds heralds the start of the new building project.

Building permit issued

CONSTRUCTION BEGINS AT STRICKHOF

Construction can start in Eschikon Lindau: the municipality of Lindau, near Zurich, has granted a permit for the construction of the new and replacement buildings planned for the Agrovet-Strickhof Education and Training Centre. This allows the Strickhof cantonal competence centre for agriculture and the food industry, the University of Zurich and ETH Zurich in Eschikon Lindau to build a jointly operated education and research centre focusing on the agricultural and veterinary sciences. The opening of Agrovet-Strickhof is scheduled for spring 2017.

ETH app

UPDATE BRINGS NEW FUNCTIONS

Read ETH News on your phone, find buildings and people you're looking for, or compare what's on the menu in the various cafeterias… You can do all this and more using the official ETH app. The latest update adds a few important features to the app's existing functions. Users can now select their preferred news sources, comment on articles, share news and events via Facebook, Twitter, or email, and enter selected events into their own calendars.

Eni Award

AWARD-WINNING GEOPHYSICIST

Johan Robertsson is a professor of geophysics at ETH Zurich and a specialist in seismic wave propagation. For his work on a new method of acquiring seismic data, he has now been honoured with the "New Frontiers of Hydrocarbons" Eni Award, the world's most prestigious prize in the energy sector.

Apprenticeships

63 COMPLETED

In 2015, 63 newly qualified apprentices – 26 women and 37 men – successfully completed their apprenticeships at ETH Zurich. Half of them earned a federal vocational baccalaureate. The apprentices each received a torch engraved with their name and profession as a gift from Lukas Vonesch, head of human resources. These were made by trainees in electronics and polymechanics (metalwork) in the Department of Physics workshop. ETH Zurich is currently training more than 170 apprentices in 13 commercial and technical fields.

Vocational training at ETH Zurich
→ www.ethz.ch/vocational-training

Photos: Alessandro Della Bella; Giulia Marthaler

Column

A virtuous circle

As the Rector of ETH, I am invited to a least one event a day, and sometimes even two or three in the same evening. Obviously I can't go to all of them, but the ones I do attend are tremendously enriching. Whenever I do go along to an event, I like to take the time to talk to the hosts and guests. As well as giving me insights into new aspects of ETH, these conversations give me the satisfaction of seeing just how much admiration, goodwill, and even affection people have for our institution.

Then there are events where I'm the host! It was a huge pleasure for me this May to invite the patrons of the Excellence Scholarship and Opportunity Programme to "Meet the talent". As the name implies, our guests were able to meet the students who are benefiting so much from this programme, chat with them in person, and learn more about the projects these talented young people are pursuing. It was an exciting evening that was thoroughly enjoyed by all.

Being from England myself, I'm very familiar with this form of sponsorship. Ever since I left university, I've maintained close ties to my alma mater. Even while we were still doing our bachelor's degrees, we were so thrilled to have the opportunity to study at Cambridge University, and our experience there has proved to be a huge boost to our lives. Obviously studying at Cambridge requires some financial investments, which is why many Cambridge graduates are so determined to give something back. Just like our predecessors helped us, we want to give future generations the same, or even better, opportunities – ultimately creating a virtuous circle.

But just because something works in England doesn't mean it will automatically work in Switzerland. Students who pass their Swiss university entrance exam can study at any university in the country – and the lion's share of their education costs are covered by the state. That could be one reason why they are less demanding when it comes to asking what they're getting from their university. Could it also mean that students feel less "connected" to their university? Or are Swiss people simply more reserved in this respect?

When I talk to students, alumni and alumnae, it often takes a while before they express their pride in ETH. But eventually they mention that doing a course at ETH is worth its weight in gold. Education has a long half-life. But people are also looking for additional options for life-long learning. I can see real potential in continuing education as a means of helping ETH alumni and alumnae to benefit more from their alma mater in the future. And perhaps that might even help reinforce a virtuous circle in Zurich, too.

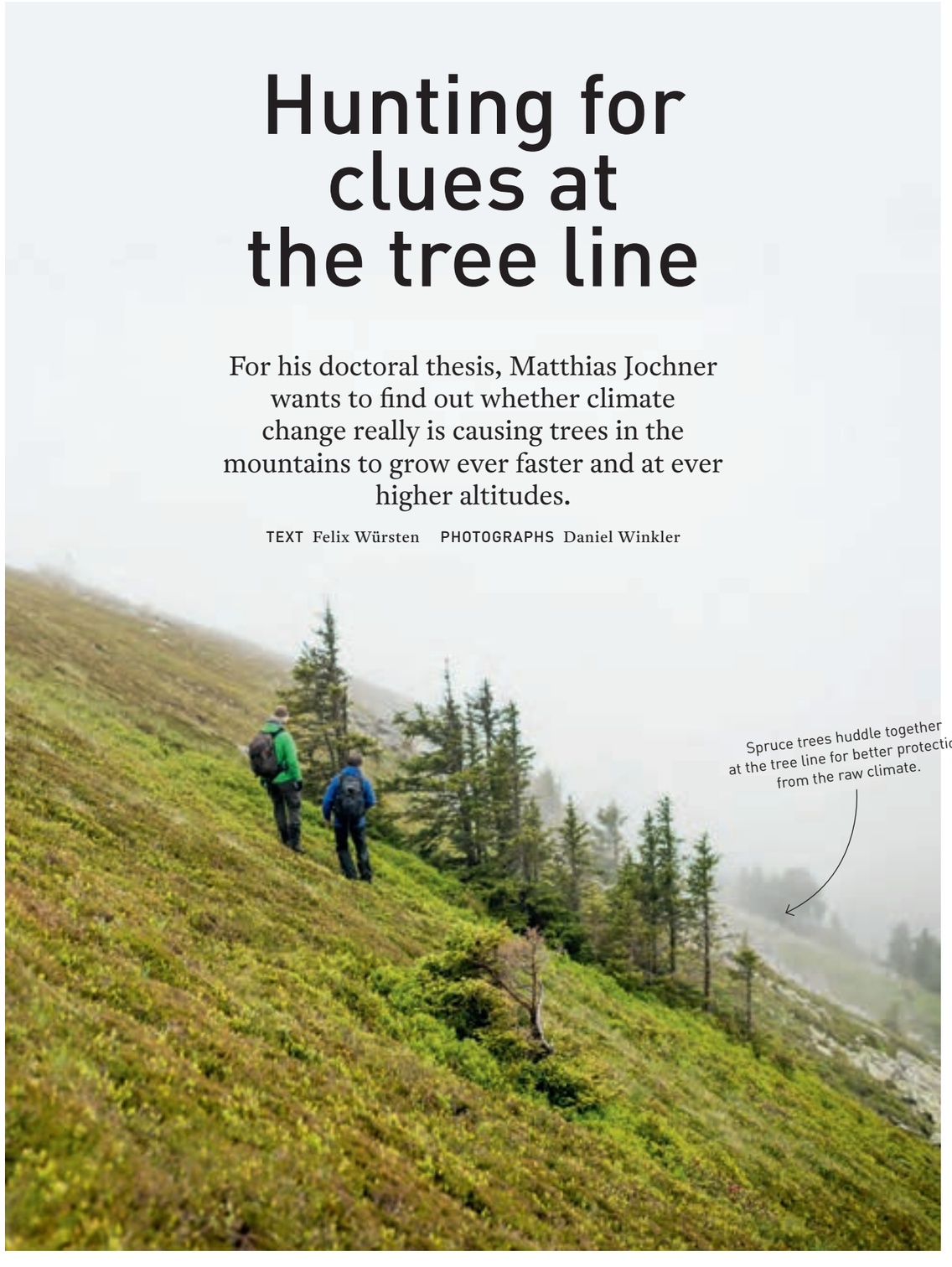
Sarah Springman has been Rector of ETH Zurich since 2015 and a full ETH Professor of Geotechnical Engineering since 1997.

Illustration: Thomas Fryscak; photo: Giulia Marthaler

Hunting for clues at the tree line

For his doctoral thesis, Matthias Jochner wants to find out whether climate change really is causing trees in the mountains to grow ever faster and at ever higher altitudes.

TEXT Felix Würsten PHOTOGRAPHS Daniel Winkler



The weather could be better. A front carries more rain over the Ällgäu alp, just a few minutes' drive beyond Habkern, near Interlaken. Mist and fog shroud the mighty Hohgant, the crown of the Emmental Alps. But Matthias Jochner and Christof Bigler don't let the nasty conditions put them off. "Last year I often had to head out on field trips in weather like this," Jochner shrugs.

The work this ETH doctoral student in Harald Bugmann's Forest Ecology group is doing takes him to the upper edge of the forest. "I want to find out what effect climate change is having on tree growth and the location of the tree line in the mountains," he explains. Here on the south face of the Hohgant is one of his three study areas. The other two are below the Gorner Ridge in Zermatt and above Bosco/Gurin in the Maggia Valley. Together, these sites provide a nuanced look at how mountain forests throughout the Alps might develop.

It's no coincidence that Jochner is studying trees in precisely these three places. To get an answer to his question, he needs to consider areas where human impact has been at its slightest – but that's no easy undertaking in the Alps, an area of significant human activity. "In many places, the forest now stretches higher into the mountains because the Alpine pastures above the tree line aren't being worked as hard as they once were," explains Bigler, senior scientist in the Forest Ecology group, "and these factors mask the effect of climate change." Here on the Hohgant is one of the few places on the northern side of the Alps where tree growth has been able to take its natural course.

Each tree studied is meticulously measured.

The samples taken from the trees are five millimetres thick.

A measurement every hour

Today, Jochner wants to work together with his supervisor Bigler to collect more samples. After spending around 55 days in the field last year, he is now into the final third of his fieldwork. After half an hour Jochner consults his GPS device, then says: "It's right around the corner here." Last year he installed a temperature sensor two metres above ground level on a tree set a short way back from the path; this device measures the air temperature every hour. Meanwhile a second device, attached to a cord to make it easier to find, measures the ground temperature.

To find out whether there have been any changes to tree growth at this altitude in the last few decades, Jochner takes five-millimetre-wide core samples from selected trees. Later, back in the lab, he will analyse the tree rings and then compare the results to the relevant temperature data. "Up here, of course, there's no official weather station," he explains. "That's why we're measuring the local temperature with our own devices over a two-year period, so we can deter- ›

mine how to recalculate the long-term measurement series from the Interlaken station for this site," Jochner says. Unfortunately, the measuring devices do not automatically send their readings to Zurich. Instead Jochner visits them regularly, using his laptop to extract the new data from them. Today, though, he has left his computer in the car: "I'll come back tomorrow, when the weather's better."

Theory and practice

As Jochner and Bigler continue, the rain dies away. "The second spot I'm studying is over there," Jochner says, pointing to the next crest, which is now visible between the misty clouds. A third spot is right on the other side, and just as remote from the hiking path. The higher the two climb, the more the forest thins out. And the trees change shape, too. At the highest reaches, there are several groups of smaller spruce, huddled together like shrubs as if seeking safety in numbers.

According to the textbooks, the tree line is a clearly defined feature: namely, the altitude above which no more trees measuring at least two metres can be found. In reality, the tree line is more of a transition zone. Ascending the crest, Jochner and Bigler have now drawn level with the last few trees. Only one solitary, mighty specimen still looks down on them from a sunny, sheltered patch behind a rocky outcrop facing south. Is that the tree line up there? Or is it in fact further down, back in a hollow where a few spruce are trying to survive amidst the barren scree?

"You can tell just by looking at them that the trees up here aren't doing so well," says Jochner. He has selected the first of the spruce that he will take a sample from today, and he jots down various specifics on a data sheet: tree height, trunk diameter at breast height, slope gradient, slope aspect and the tree's exact position. On flat land, none of these measurements would be difficult to take; here, out on a steep, damp hillside with numb fingers and wet equipment, it's much more of a challenge. "When you've spent the whole day hiking a few metres up and down and standing awkwardly on slopes, you definitely notice it in your legs that evening," Bigler states.

High-tech in the field: the drone with the digital camera in action.

Where's the middle?

Jochner takes two cores from each tree: one at breast height and the other at the foot of the tree. The upper core will enable him to later reconstruct the tree's growth, while the lower sample will tell him when the tree germinated. This, too, sounds more straightforward than it really is, because to even get at the trunk Jochner has to fight through a dense thicket of branches.

Collecting the samples proves easier at the second stand of trees, as the selected trunk is easier to get at. Jochner applies the borer with some pressure, then gives it a few turns to reach the middle of the trunk. He carefully inserts the spoon-like extractor into the hollow borer. One final twist in the other direction and the sample is ready to be extracted. Out comes a thin core of wood showing a delicate pattern of rings. Bigler counts the brown rings to get an initial rough estimate of the tree's age. "At least 50 years old," he is happy to confirm.

But all the effort was for nothing: "We missed the pith of the tree by quite a way, so we'll have to take another core," Bigler declares. Because the trees are standing on the slope, they don't grow evenly. That's what makes it hard to hit the centre of the tree on the first attempt. Back in the preparatory discussion in the office, the work Jochner and Bigler would be doing here seemed simple enough. But in the field it soon becomes clear that all the little hindrances add up and make it a tough assignment. Jochner takes cores from a total of 64 trees at each of the three sites along the tree line on the Hohgant, half of them spruce and the other half mountain pines. In addition, he samples another 20 trees lower down to complete the picture. That's over 500 core samples altogether – on the Hohgant alone. They are joined by equal numbers from Ticino and from Valais.

Counting and measuring tree rings involves a lot of painstaking work.

Once the samples have been prepared, the rings are clearly visible to the naked eye.

Shortly before the two scientists get back into the car, Jochner quickly demonstrates how forest ecology, too, is increasingly turning to high-tech tools. From the boot of the car he fetches a small drone to which he has attached a simple digital camera. Controlled by software on Jochner's laptop, the drone follows a pre-defined flight path and takes pictures at regular intervals. Jochner will later use these to help him produce a digital elevation model. "The 3D model is precise enough to let us automatically calculate the height of each tree," Jochner explains. "Having measured lots of trees here by hand, I can now check how accurate the tree heights calculated by the model really are." If the approach proves to be worthwhile, it would make it much easier in future to determine how quickly the trees grow up here.

Distinctive growth rings

Back in the tree-ring lab at ETH, Jochner has a lot of painstaking work ahead of him. He must take the core samples that he packed into drinking straws for safety in the field and carefully glue them to wooden core mounts, then take these to the workshop for sanding and polishing. Once that is done, he can analyse the pieces of wood from the mountains under the microscope to count the tree rings and measure how wide each ring is. "The width of the rings tells us how strongly the tree grew in that year," he explains. "Comparing the rings from all the trees lets us spot characteristic patterns." For example, one year that left a distinctive trace is 1948, a year in which the cold weather caused all trees to grow more slowly than normal. Jochner's trained eye can also quickly pick out frosty 1954 from the extensive cell damage it caused, or the early winter of 1972 with its narrow band of very pale summer wood.

It's still too soon to draw any substantive conclusions from Jochner's work. How strongly a tree grows in a given year depends not only on the climate but also on the age of the tree. Only once he has corrected the ring thicknesses to reflect the age curve will Jochner know for sure whether there is truth in the suggestion that trees near the tree line will grow more quickly than they do today if the climate warms as expected. ○

TREE-RING LABORATORY

The ETH tree-ring laboratory was established in 2006 and is part of the Chair of Forest Ecology. Its focus is primarily on dendroecological studies. Researchers use tree rings to study forest dynamics and investigate the effects of climate change and natural disturbances on trees, forests and landscapes. Tree rings also allow for the dating of wood samples taken from sources such as deadwood or old buildings.

→ www.fe.ethz.ch/lab/index_EN

CONNECTED

1 *Expo Milano*

SCIENCE ON YOUR PLATE

Guests invited to the opening ceremony for Zurich Week in the Swiss Pavilion at Expo Milano received a welcome from Michelle Grant, executive director of the World Food System Center at ETH Zurich. ETH Zurich President Lino Guzzella also spoke to guests at the event. As the guests enjoyed the various dishes served, ETH Zurich researchers provided them with interesting background information about the food's value chain in keeping with the theme of "Science on Your Plate".

2 *Rössler Prize*

GROUNDBREAKING NANO-OPTICS

This year's Rössler Prize has been awarded to David J. Norris (left). The materials engineering professor in the Department of Mechanical and Process Engineering specialises in the manufacture and testing of optical materials not found in nature. His goal is to find structures that interact with light in new and unusual ways. At the award ceremony, Norris provided prize sponsor Max Rössler (centre) and Detlef Günther (right), vice president for research and corporate relations at ETH Zurich, with a look at his laboratory experiments. Endowed with 200,000 Swiss francs, the prize has been awarded to promising researchers at ETH Zurich since 2009.

A video entitled "Water – The Source of Life" about ETH research into water and food security.

1 *Expo Milano*

2 *Rössler Prize*

3 *Doris Leuthard*

4 *AIV*

5 *"venture"*

Photos: ETH Zurich (2); Peter Rüegg; Singapore-ETH Centre

Photos: Sebastian Etter; AIV Alumni (2); Venture/Cédric Dürig

3 *Doris Leuthard*

FEDERAL COUNCILLOR VISITS SINGAPORE

Swiss Federal Councillor Doris Leuthard visited the Future Cities Laboratory at the Singapore-ETH Centre, where she talked to the Centre's researchers about her vision for the environment, transportation, energy and communication from the Swiss point of view. Her presentation also revealed several parallels between Switzerland and Singapore.

4 *Academic Engineers Association*

RICH VARIETY AT ANNIVERSARY EVENT

This year marks the 125th anniversary of the Academic Engineers Association (AIV). At the anniversary celebration, short speeches on current topics were given by Vice President of AIV Alumni Martin Gähwiler, AIV President Matthias Bühler, ETH Rector Sarah Springman and Professors Hans-Rudolf Schalcher and Ulrich Weidmann (l-r). Things took a more playful turn during the afternoon – for example, two alumni enjoyed building a few Jenga towers.

5 *"venture"*

BEST BUSINESS IDEA

Judges at the "venture" start-up competition selected the Pregnostics team, led by Sabrina Badir (second from left), as the team with the best business idea. These rising stars have developed a system that can determine the risk of premature birth more reliably than conventional ultrasounds. Six companies from ETH Zurich were included among this year's finalists.

Agenda

EVENTS

25 October–22 November 2015
Autumn series on resources on earth
The upcoming instalment of Treffpunkt Science City will investigate questions such as: What raw materials are there and how can we make sensible use of them? Will wars be fought over water and sand? How do we treat animals and plants? Will humans consume so much that the earth actually dies? In addition, there is a new offer aimed at 13- to 17-year-olds. For example, young people can program a raw materials app of their own.
→ www.treffpunkt.ethz.ch

26, 27, 29 October 2015, 8.15 p.m.
Wolfgang Pauli Lectures
This year's lecture series focuses on mathematics. Professor Ingrid Daubechies of Duke University in North Carolina, USA will use her three lectures to show what maths has to do with art history, evolution and data compression.
ETH Main Building, Audimax
→ www.pauli-lectures.ethz.ch

21 November 2015
ETH Day
ETH Day is when ETH Zurich recognises outstanding performance, honours individuals for their exceptional achievements and thanks all those who have rendered services to the university.
ETH Main Building
→ www.ethz.ch/eth-day

Would you have realised that this picture was by Andy Warhol? The Collection of Prints and Drawings is showing some of his surprising works.

Collection of Prints and Drawings

ANDY WARHOL AT ETH

4 November 2015–17 January 2016 ETH Zurich's Collection of Prints and Drawings has selected some 80 examples from a treasure trove of drawings that caused a sensation when they were discovered in Andy Warhol's archives in 2011. The Collection is now showing these works to the general public in a special exhibition entitled "Andy Warhol – The LIFE Years 1949–1959". There will be a private view on 3 November at 6 p.m.
→ www.gs.ethz.ch/english.html

ETH Klimarunde 2015

VISION ZERO

4 November 2015, 3–7.30 p.m. Every climate target is associated with a CO_2 budget. This year's ETH Klimarunde sees experts discussing the scientific findings that underpin these budgets. Under the heading of "Vision Zero: The path to a carbon-neutral society", the Center for Climate Systems Modelling and the Energy Science Center are organising table talks, lectures and a panel discussion. Questions for policymakers and society will also be discussed: What is the current status of the political debate? What can be expected as the result of the next UN climate conference? What role can and should Switzerland play?
ETH Main Building, Audimax
Register by 1 November 2015 (the event takes place in German):
→ www.c2sm.ethz.ch/events/klimarunde2015

Image: The Andy Warhol Foundation for the Visual Arts Inc.

100th anniversary

EINSTEIN SYMPOSIUM

12–14 November 2015 Entitled "100 years of general relativity – From simple physical concepts to a new notion of space, time and gravitation", the symposium is celebrating the 100th anniversary of Albert Einstein's four papers on general relativity. Einstein submitted these four pioneering publications to the Prussian Academy of Sciences in November 1915.

In the lectures, which are open to the public, internationally renowned speakers will trace Einstein's historic path. They will also look at technological progress in the here and now that would have been impossible without Einstein's theory. Admission to the conference is free, and the conference languages are German and English.
ETH Main Building, Audimax
→ http://einstein.phys.ethz.ch

EXHIBITION

29 October–11 November 2015
50 years of spatial planning
This anniversary exhibition illuminates the long and often rocky road to spatial planning in Switzerland. It examines the motivation of the field's pioneers, its sociopolitical causes, the country's spatial

development, the institutionalisation of spatial planning, and how the field came to be a course of study at ETH Zurich. The exhibition is open to the public during ETH Zurich's opening hours, and guided tours are also available.
Private view: 28 October 2015

ETH Main Building, main hall
→ www.raumplanung.ethz.ch

CONCERT

14, 18, 21 November 2015, 8:00 p.m.
Academic Chamber Orchestra Zurich
At its autumn 2015 concert, the *Akademisches Kammerorchester* Zürich will play works by Johannes Brahms and Wolfgang Amadeus Mozart.
Conductor: Johannes Schlaefli
Victoria Hall, Geneva (14 November)
Lausanne Cathedral (18 November)
Grossmünster church, Zurich (21 November)
→ www.ako.ethz.ch

Book tip

10 PORTRAITS OF SUCCESSFUL SPIN-OFFS

Many scientists dream of starting a second career as an entrepreneur and translating their research findings into marketable products. *The Success Formula for Start-ups:* venture graduates go to the top profiles ten Swiss spin-offs that have successfully made this transition. Six of them are from ETH Zurich: Covagen (now Johnson & Johnson), HeiQ, OLMeRO, Optotune, Glycart and Sensirion. All the spin-offs participated in the "venture" ideas competition, so it's no coincidence that Thomas Knecht – who worked with ETH Zurich in 1997 to establish the contest – published the book and is interviewed in it as well. In the foreword, Swiss Federal Councillor Doris Leuthard underscores how many jobs the spin-offs create.

ISBN: 978-3-03810-112-3
Publisher: NZZ Publishing
Price: CHF 40.00

Photos: ETH-Bibliothek, image archive; Colourbox.de; NZZ Publishing

PROFILE

Arno Candel

Arno Candel grew up in the municipality of Untersiggenthal in the Swiss Canton of Aargau. He studied at the Department of Physics at ETH Zurich under professors such as Ralph Eichler and Matthias Troyer, developing simulations for particle physics as part of his doctoral dissertation. As a Staff Scientist at Stanford University's SLAC National Accelerator Laboratory, he had access to the world's largest supercomputers. He has also collaborated with CERN on the development of next-generation particle accelerators. Candel currently serves as Chief Architect at H2O, an open-source big data analytics start-up.

A Swiss big data pioneer in Silicon Valley

While studying for his doctorate at ETH Zurich, Arno Candel learned that there's a solution to every problem. He currently serves as Chief Architect of H2O, a big data software platform.

TEXT Samuel Schlaefli PHOTOGRAPH Khalil Anvar

Silicon Valley is the epicentre of technological innovation, a place of bold dreams and stratospheric careers fuelled by investors who are famously willing to take risks. The birthplace of Google, Facebook, Twitter and LinkedIn, it is a breeding ground for thousands of start-ups each year; some of them change the world, while many others simply disappear. And it's right here, in San Jose, where one man is revolutionising how we analyse the vast quantities of data we create every single day. Meet Arno Candel, an ETH alumnus, big data expert, Untersiggenthal native – and a beacon of hope for Swiss aspirations in Silicon Valley.

Candel, the "big data all-star"

I meet up with Candel on a sunny Saturday afternoon near his apartment in Santana Row, a small pedestrian zone in San Jose. This is an area of smart restaurants and expensive boutiques, and the boulevard is lined with date palms and patches of bright purple petunias. We take a seat on the terrace of the Left Bank Brasserie, a bistro with Parisian flair. Candel orders a Niçoise salad and a glass of Chardonnay. He tells me he likes coming here, though by the time he leaves work it's often as late as 10 p.m. before he starts dinner here with his wife, while their son sleeps beside them in his stroller.

Candel has certainly had an eventful year. He became a father last September, shortly after *Fortune* magazine had chosen him as one of its top 20 Big Data All-Stars, then in April this year he was promoted to Chief Architect at H2O. "What I'm developing here has the potential to change the world," he says, praising the attraction and excitement of Silicon Valley in a Swiss German Aargau dialect with a few American words thrown in for good measure. He is jointly responsible for developing one of the fastest and most flexible big data analysis platforms for H2O, which is the name of both the company – founded just four years ago – and the software it produces. Analysts argue that data is the new oil, but the only way to transform mountains of unstructured data – including emails, statistics, tweets and images – into valuable information is by using intelligent analysis software. To illustrate his point, Candel gives an example of a customer from the pharmaceutical industry who worked with H2O to accelerate their speed-to-market – not just with limited data samples, but with all of the available data. This produced a significantly more accurate forecast, which – according to the customer – led to seven million dollars of additional revenue. H2O may not have been around for very long, but the company already has some big-name users: PayPal uses its system to detect insurance fraud, while Cisco uses it to rank potential buyers. Meanwhile some hospitals are using the algorithms to calculate which rooms to allocate to patients to keep infection risks as low as possible.

Networking with pizza and presentations

Candel pulls his smartphone out of his jeans and shows me pictures of the H2O headquarters in Mountain View, near the Google campus. They reveal a long and completely open-plan space, just a third of which is occupied by employees' desks. The rest is left clear ›

"What I'm developing here has the potential to change the world."

"It would be tough to get used to the greyness of Baden after this!"

for presentations and meetings. Every two or three days H2O sends out invitations to people who share an interest in the company's activities. Up to a hundred guests feast on pizza while H2O employees and guest speakers provide insights into their work. "It's a great way of getting in touch with potential customers," says Candel.

H2O's owners are hoping to go public in two or three years. That may seem odd, since anyone can download the software for free and the company only earns money by providing support and services, but things move fast in Silicon Valley! When he joined H2O 18 months ago, Candel was one of just eight employees – today the company employs 38 people. Candel programs virtually around the clock, improving the system and adding new features. Yet he still finds time to attend exhibitions and conferences and give presentations. He hasn't taken a vacation in the last 18 months. Even at the weekend he typically spends a few hours working. Since he made the switch from research to industry four years ago, his hobbies, which include golf, photography and the violin, have taken a back seat. But that doesn't bother Candel: he has no doubt that any sacrifices he has made are easily justified by the opportunities H2O offers.

A keen learner from a musical family

The son of a Turkish mother and a Dutch father, Candel was raised in the Swiss municipality of Untersiggenthal near Baden. For many years his parents played the violin and flute in an orchestra that is now known as the Sinfonia Baden; their son played violin in the Siggenthal Youth Orchestra. Candel describes a happy childhood in the countryside. Learning came naturally to him right from the start, and he attained excellent grades throughout high school. "I always wanted to be up there among the best," he explains.

Candel decided to follow in the footsteps of his father – still his role model – by focusing on scientific and technical subjects. His father spent his entire career working for the Swiss electrical engineering company BBC, now known as ABB. Soon after he arrived at ETH to study physics, Candel discovered an interest in computers. Ralph Eichler, Candel's professor and later the president of ETH, offered him the chance to run supercomputer simulations at the Paul Scherrer Institute (PSI) while working on his master's thesis. "That was my debut in the world of big data," Candel recalls. He subsequently wrote his doctoral thesis on the computer-aided simulation of electron sources for x-ray free-electron lasers, again in collaboration with the PSI and Ralph Eichler. He says that these experiences gave him a lifelong confidence that "there is no such thing as an unsolvable problem."

The move to Stanford

Shortly before completing his dissertation in 2005, Candel gave a lecture in St. Petersburg. He caught the eye of a researcher from Stanford University in California, who invited the young physicist to tailor his simulations for SLAC's particle accelerator. Candel made a good impression and was hired as a staff scientist. In 2011 – by which time he had qualified for a green card – he switched to the private sector, initially to another big data company, Skytree, and then to H2O.

Having finished his glass of wine and salad, Candel orders a double espresso. Before we leave I ask him: can he still imagine making a life for himself in Switzerland? He glances at the passers-by – a series of faces from all over the world – and then nods ruefully towards the blue sky above him: "It would be tough to get used to the greyness of Baden or Zurich after this!" He explains that he would also miss the amenities that Silicon Valley offers ambitious, constantly busy people like him. He uses an app to do his shopping, which arrives at his door two hours after placing the order. And he can eat in San Jose around the clock, thanks to a combination of apps and home delivery services. But the decision on whether Candel and his family will stay in Silicon Valley also comes down to basic economics. He wants his son to have the same kind of childhood he once enjoyed, with a house, garden, nature and good schools. But that's far from easy in an area where kindergarten places cost up to 3,000 dollars a month, buying a home is a multi-million-dollar investment, and people accept a mortgage rate of four percent or simply pay for the whole thing in cash. That's why Candel has set himself a time limit: "I'll give myself another five years. If I make it, then I'll be able to guarantee my family a good life here. If not, we'll look for somewhere else where the cost of living is lower." ○

COMPANY PROFILE

H2O is a software platform for big data analysis and machine learning. Founded in 2011 in Silicon Valley by two experts in big data, it enables companies to extract key information from large data sets and use the results to make forecasts. Unlike existing big data software products, H2O is open source and can be adapted and scaled to match any system requirements.

5 QUESTIONS

Nicole Wenderoth is glad that today's undergraduates want to work in the laboratory. *"My university studies were shockingly unscientific."*

Nicole Wenderoth is a professor of neural control of movement and head of the Institute of Human Movement Sciences and Sport.
→ www.ncm.hest.ethz.ch

1 *How would you define "critical thinking"? And how do you apply it in your daily work?*

The essence of critical thinking has been around for a long time. It can be traced back to the ancient Romans, and it crops up in every collection of quotes from Kant as "Have the courage to use your own reason!" It's why I am always wary when people start a sentence with "Everyone knows that..." because some things that supposedly everyone knows ultimately turn out to be wrong! For me it all comes down to whether a statement is supported by empirical data – and whether I'm confident that that data has been collected and interpreted in a reliable way.

2 *Does the current system of publishing harm academic research?*

It doesn't harm academic research per se, but it might have a negative impact on young, talented scientists who are doing promising work. Today's publishing system has altered the whole academic landscape. High-impact publications have taken on enormous importance. However, successful publishing depends not only on the scientific quality of a publication, but also on the social network of the group leader. That's why it's so important to interpret quality indicators such as impact factors in the appropriate context.

3 *What were your first impressions of ETH Zurich?*

The first time I visited ETH was when I applied to be a professor here. I quickly realised that this is an incredibly inspiring environment to work in. That's largely because my colleagues in the department are extremely open and accessible, and because we have a very good relationship with the Institute for Biomedical Engineering, the ETH mathematicians, and the Neuroscience Center Zurich.

4 *Are large-scale international projects a good idea?*

I think that collecting large sets of data and making them publicly accessible offers huge opportunities. We know from brain research that you can use the available data from a range of disciplines to investigate new approaches to diagnosis and personalised treatment. Unfortunately Switzerland is focusing heavily on genetics, and that approach is too narrow for neurological and psychiatric diseases.

5 *Which of your teachers influenced you most?*

From today's perspective my university studies were shockingly unscientific. For most students, the fact that our knowledge actually comes from somewhere and that it is mostly based on experiments reported in academic publications was a well kept secret until they had to write their master's thesis – and then it was quite a shock! Personally I was quite lucky. In my second term at university I started a part-time job at the German Sport University Cologne, working for Uwe Hoffmann. Everything I learned in that laboratory – including how to carry out analyses and, in particular, how to interpret experimental data – had an impact on my subsequent career. That's why I'm so pleased when undergraduates take the initiative to approach me and ask if they can work as laboratory assistants.

— Interview by
Corinne Johannssen-Hodel

Photo: Valerio Zerbi

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