ETH zürich

NO.1/2015

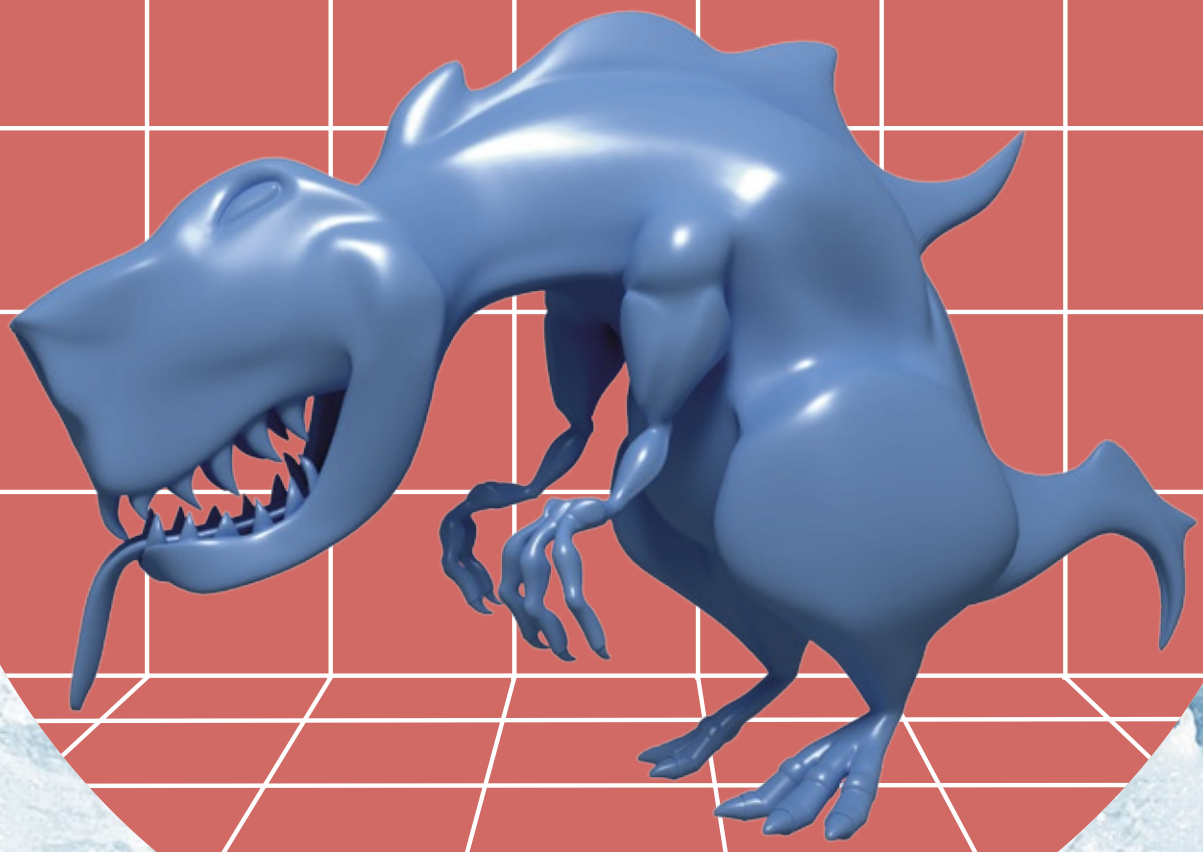
GLOBE

DIGITAL FABRICATION

TOTALLY REAL

Monsters, noses, and construction made to order

PAGE 14



New centre of research fit for practice

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Full steam ahead: the railway laboratory

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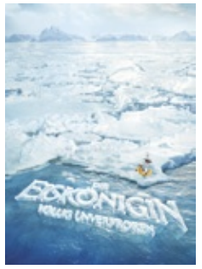
Engineering on the brain, business in the blood

PAGE 46

NEW DIMENSIONS

Ever since the film *Avatar* hit our screens, the term "3D effects" has become familiar to virtually every cinemagoer. More and more of these effects are based on techniques that stem from Zurich. Disney Research Zurich and other labs at ETH Zurich are constantly developing new algorithms that enable artists in Hollywood to make increasingly bigger and grander films. But the manufacturing sector is also taking on new dimensions. Digital manufacturing is now expected to revolutionise the construction industry, too. Automated yet individual – what the face of construction could look like in future. Cue the new Master of Advanced Studies ETH in architecture and digital manufacturing. And while it might sound like the plot to a science fiction film when researchers talk about organs from a 3D printer, it is actually not so far-fetched. The future begins today: this is precisely how scientists already produce cartilage, nose and ear grafts in the Cartilage Engineering and Regeneration group's laboratory in the Department of Health Sciences and Technology. Read more about this in Focus from page 14.

About the cover image: From Disney's Frozen *to helping 3D-printed objects get on their feet, ETH Zurich is leading the way in 3D computing.*



Globe's new look is certainly a reality, too. Dynamic, visually striking and with plenty of concise additional information, the magazine offers you a wealth of opportunities to delve into the world of ETH Zurich and its alumni. We hope you enjoy everything the new *Globe* has to offer.

The editorial team

Cover and Editorial: Romain Prévost, Interactive Geometry Lab, ETH Zurich; ©Disney

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"I've never felt like I was stuck in an ivory tower."

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Picture credits: Oliver Bartenschlager; Peter Rüegg; Daniel Winkler

NEW AND NOTED

The technology they developed makes hybrid buses more efficient.

Energy-efficient mobility

WATT D'OR

ETH Zurich's Institute for Dynamic Systems and Control and Carrosserie Hess won the Watt d'Or, Switzerland's energy award, in the "Energy-Efficient Mobility" category at the beginning of January. The research partners were awarded the prize for the Advanced Hybrid Electric Autobus Design technology they developed, which can be used to configure diesel-electric hybrid buses to ensure optimum energy and operating efficiency.

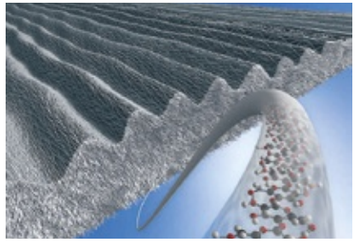
Battery technology

NEW KIND OF GLASS BOOSTS CAPACITY

As energy experts keep telling us, we will need much more clean power in future to replace fossil energy sources and reduce CO_2 emissions, with electric vehicles expected to take over from petrol-powered cars on our roads, for example. However, we need better batteries if we want electric vehicles to travel long distances or mobile phone batteries to last as long as possible. Storage is also a key factor in the transition to renewable energy sources in order to save excess power from wind and solar power stations and compensate for fluctuations in power usage. Researchers are therefore on the lookout for new materials that provide a higher energy density and more charging capacity for the same volume and weight than today's lithium-ion batteries.

In a research project spanning several years, a team of scientists at ETH Zurich headed by Semih Afyon from the Electrochemical Materials Institute have now developed a material that could double battery power: vanadate borate glass coated in reduced graphite oxide, which the researchers use as the cathode material. A battery fitted with one such electrode provided an energy density of around 1,000 watt hours per kilogram and achieved a discharge capacity of much more than 300 milliamp hours per gram. This would be enough to power a mobile phone for one and a half to two times longer that today's lithium-ion batteries .

Electrochemical Materials:
→ www.electrochem.mat.ethz.ch



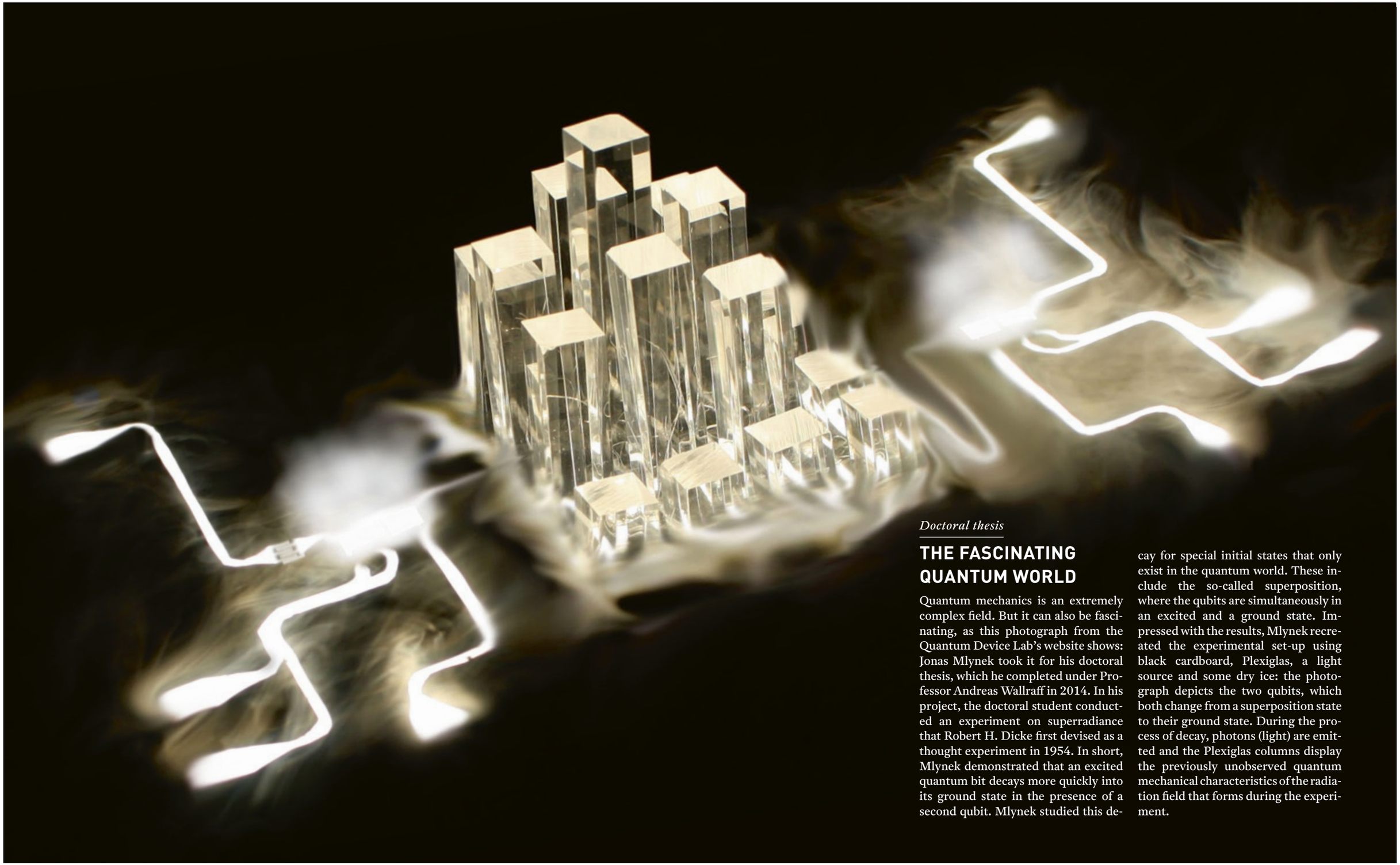
Implants

BETTER COMPATIBILITY

Researchers from ETH Zurich have come up with a way to improve the compatibility of implants. The scientists had already discovered that cells interact better with structured surfaces than with smooth ones and they have now succeeded in producing bacterial cellulose with a structured surface. The material has been hailed as a particularly promising innovation for the production of better implants.

Picture credits: BFE; Ben John Newton

NEW AND NOTED



Doctoral thesis

THE FASCINATING QUANTUM WORLD

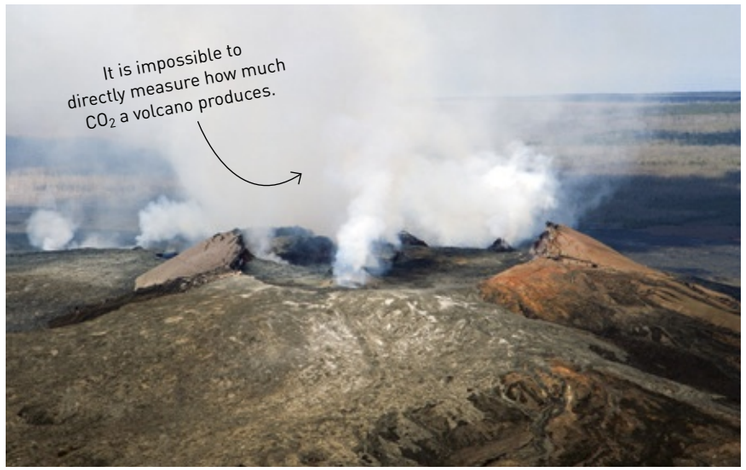
Quantum mechanics is an extremely complex field. But it can also be fascinating, as this photograph from the Quantum Device Lab's website shows: Jonas Mlynek took it for his doctoral thesis, which he completed under Professor Andreas Wallraff in 2014. In his project, the doctoral student conducted an experiment on superradiance that Robert H. Dicke first devised as a thought experiment in 1954. In short, Mlynek demonstrated that an excited quantum bit decays more quickly into its ground state in the presence of a second qubit. Mlynek studied this decay for special initial states that only exist in the quantum world. These include the so-called superposition, where the qubits are simultaneously in an excited and a ground state. Impressed with the results, Mlynek recreated the experimental set-up using black cardboard, Plexiglas, a light source and some dry ice: the photograph depicts the two qubits, which both change from a superposition state to their ground state. During the process of decay, photons (light) are emitted and the Plexiglas columns display the previously unobserved quantum mechanical characteristics of the radiation field that forms during the experiment.

Picture credits: Jonas Mlynek, Quantum Device Lab

Earth Sciences

Uncharted territory

A large amount of carbon rises to the earth's surface from deep underground – and then sinks back down into the depths. Geologist Max Schmidt has been studying exactly how this cycle works in his Solid Media High Pressure Laboratory.



Kilauea on the Big Island of Hawaii is one of the most active volcanoes on earth.

It towers above us as mighty limestone mountains in the Alps, typifies Dover's picturesque rocky coastline and forms the backbone of brightly coloured coral reefs: carbonate rock, which has been increasingly deposited on the earth's surface for millions of years. Although this rock shapes our current image of the earth, it was completely absent in the early days of the planet. This is because the earth's atmosphere at the time did not contain any free oxygen, which meant that carbon could not bind with calcium and oxygen to form carbonates on the earth's surface. This only changed when the composition of the atmosphere was fundamentally transformed around two billion years ago.

Volcanic gases that are difficult to measure

As impressive as these formations are, the majority of the earth's carbon isn't actually found in this rock at the surface, but deep down inside the earth. The earth's mantle, which extends to a depth of 2,900 kilometres, contains three to ten times more carbon than the earth's crust, which forms the uppermost ten to 50 kilometres of the planet. Max Schmidt, a professor of petrology in the Department of Earth Sciences at ETH Zurich, is looking to find out how much carbon is actually present in the earth's mantle, with the aid of elaborate experiments. The experiments involve exposing small rock samples to high pressure and temperature in his lab and examining how the carbon is distributed through the various minerals or molten masses in the sample. The different molten masses absorb different quantities of carbon, depending on the chemical and physical conditions. From this information, scientists can reconstruct the form and amount in which the element is present in the different areas of the earth's mantle. For example, carbon is stable in its elementary form deep inside the earth's mantle, where it forms diamond under the prevailing conditions. In the top layer of the earth's mantle, however, the carbon is oxidised, transforming the diamonds present into carbon dioxide (CO_2) or carbonates.

The interaction between the earth's surface and its mantle is particularly interesting from a geological perspective. In the subduction zones along the plate boundaries, large quantities of carbonates are transported deep inside the earth from the surface. In return, volcanoes emit carbon into the atmosphere as gaseous CO_2. Although the deep carbon cycle is very important geologically, it is still largely uncharted territory. "Based on the movements of the plates and our knowledge of the carbon stored in them, we can calculate how much carbon reaches the earth's mantle from its surface", explains Schmidt. "How much CO_2 rises back up from the earth's mantle, however, is difficult to gauge. This is because, compared to the natural CO_2 concentration in the atmosphere, the emission from volcanoes is so low that reliably determining the amount of gas is virtually impossible using remote sensing methods."

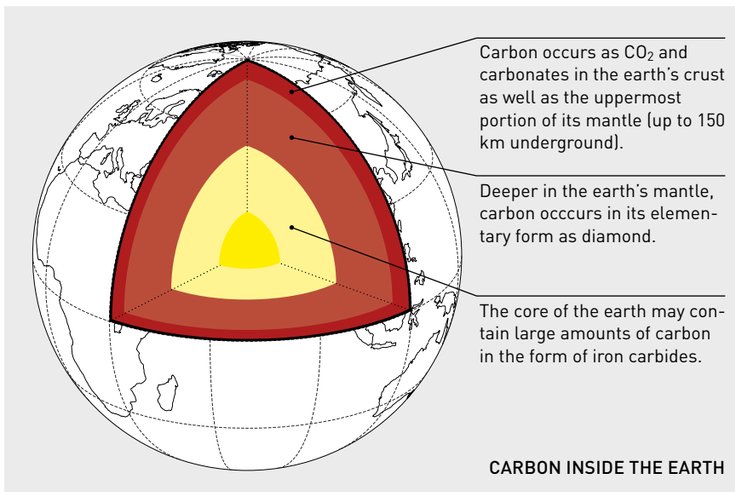
Nonetheless, Schmidt's experiments now provide an indication of the total amount of CO_2 that volcanoes could emit. This is because analysis of the experiments reveals how much carbon remains in the earth's mantle as the magma rises and how much dissolves – thus eventually reaching the surface in volcanic rock as CO_2-rich gas. "If we have an idea of how much carbon is circulated deep inside the earth, we can better understand how the chemical composition of the earth's atmosphere developed over time", notes the ETH Zurich researcher. One thing is certain: over geologically relevant timescales, considerably more carbon reaches the earth's surface than is transported into the depths. This is also why the amount of carbonates on the continents has been progressively increasing over millions of years.

Question mark hangs over the earth's core

However, Schmidt is also interested in another question: how much carbon is actually found in the innermost part of the earth, its core? Unlike the earth's mantle, the core consists of metallic iron and nickel, rather than silicate rock. "We know that carbon dissolves better in metal phases than in silicate melts", says Schmidt. "So it might be a good thing that the earth's core contains much larger quantities of carbon than the mantle."

The question of where carbon is found and in what quantities is also relevant, therefore, because the answer could provide a clue as to how the earth developed over the first few hundred million years. Experts are hotly debating this very question: how did today's earth form from its initial state, when there was just a mixture of liquid silicates and metals, rather than a separate core and mantle? Schmidt wants to help answer this question in a new project, which involves simulating the initial conditions on Earth in his lab. Together with his team, he is keen to find out how carbon is distributed through a planet that consists of silicate and metal melts, with an atmosphere that is as dense as Venus's. Based on these experiments the team will be able to reconstruct the initial situation on Earth 4.5 billion years ago, and determine the as yet unknown carbon content of the earth's core.

But Schmidt is convinced of one thing: "As important as the deep carbon cycle is geologically for the development of the earth over hundreds of millions of years – for humanity, it is the carbon cycle close to the surface that is crucial, even though this is much smaller in terms of quantity." Ultimately, it is not the interplay with the earth's mantle, but the interaction between the biosphere, the seas and the atmosphere that shapes our life on Earth. For instance, this interaction is also responsible for how humankind's greenhouse gas emissions will affect the future climate. — Felix Würsten



CARBON INSIDE THE EARTH

ETH Zurich wants to research what exactly makes sport so good for you.

Health research

HEALTH AND EXERCISE AT AN ADVANCED AGE

Physical activity is one of the main factors that influence our health. Regular exercise helps prevent cardiovascular disease and diabetes, and reduces the risk of certain types of cancer. As very little is known about the mechanisms behind this effect, however, ETH Zurich is setting up a new chair called Physical Activity and Health, to examine the issue in more depth.

The Wilhelm Schulthess Foundation is supporting the project with a donation of CHF 10 million in seed funding spread out over a period of ten years. The new chair will strengthen the existing close collaboration between Schulthess Clinic, which is also supported by the foundation, and the Department of Health Sciences and Technology at ETH Zurich. The two institutions already collaborate closely in the medical engineering and biomechanics sector.

ETH Zurich is also involved in the new large-scale EU project EIT Health, which focuses on health and aging. More than 140 European companies and research institutions are scheduled to collaborate on this project from mid-2015. With a budget of EUR 2 billion spread out over the next seven years, it is one of the world's largest public research initiatives in the health sector. The initiative's main research focuses are chronic conditions as well as cardiovascular and neurological diseases.

Department of Health Sciences and Technology:
→ www.hest.ethz.ch/en

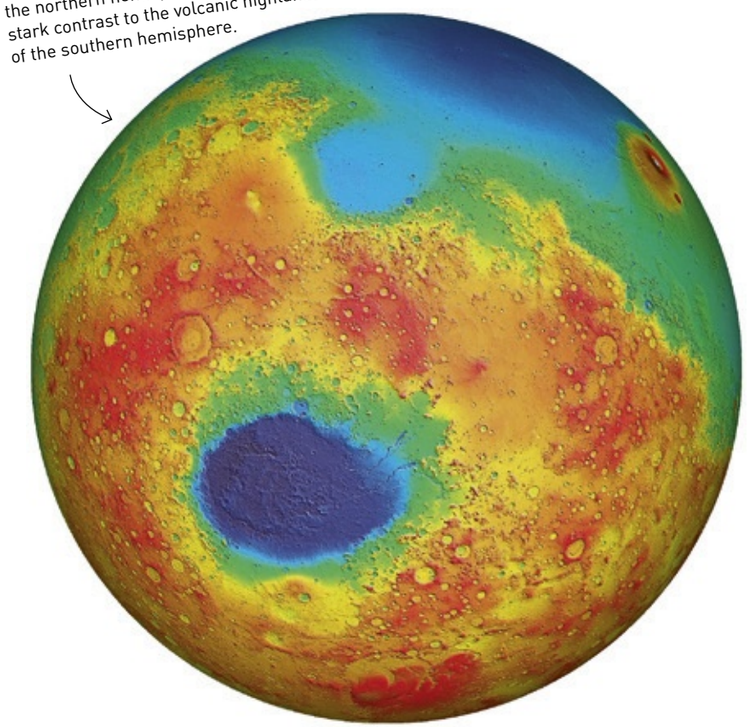
Genetic research

FAULTY DNA DUPLICATED

Genetic material often exhibits a small change in the early days of cancer. The DNA in a somatic cell mutates at a point so that the cell no longer multiplies in a controlled way and begins to grow uncontrolledly. In many cases, such genetic mutations have molecular precursors: chemical changes to individual DNA building blocks, known as DNA adducts. These are triggered by the consumption of tobacco or foods containing ingredients that react with the DNA building blocks to form DNA adducts. Previously, it was only possible to determine whether and in which quantity particular gene samples contained adducts, but not the point in the genetic code where a component was converted into an adduct.

Now, for the first time, researchers from ETH Zurich's Laboratory of Food and Nutrition Toxicology have succeeded in duplicating gene samples that contain DNA adducts so that evidence of these adducts is preserved in the copies. As a result, it seems possible to expand the study of DNA samples to include adducts. This would enable scientists to study the molecular mechanisms involved in the development of cancer in more detail.

Picture credits: Plambeck/laif



The two halves of Mars: the lowlands of the northern hemisphere (blue) are a stark contrast to the volcanic highlands of the southern hemisphere.

Planetary research

THE TWO FACES OF MARS

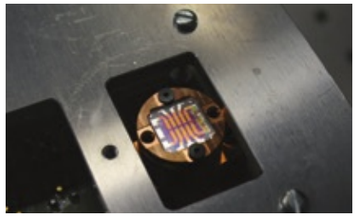
No other planet in our solar system has two halves quite as different as Mars. Flat, non-volcanic lowlands dominate the northern hemisphere, vast highlands peppered with countless volcanoes the southern hemisphere. Experts are still hotly debating the origins of this so-called Martian dichotomy. A team of geophysicists from ETH Zurich headed by Giovanni Leone has now come up with a new explanation based on a computer model: a large celestial body crashed into Mars' south pole in the early days of the solar system. This impact generated so much energy that a magma ocean formed over the southern hemisphere. Eventually, the molten rock solidified to form the mountainous highlands of Mars' southern hemisphere we observe today.

The researchers managed to create the most realistic conditions by starting their simulation with a celestial body that mainly consisted of iron, had a radius of at least 1,600 kilometres and at least a tenth of Mars' mass, and slammed into the planet at a speed of five kilometres per second. Not only did the impact body increase Mars' mass, it also triggered strong volcanic activities that would continue for the next three billion years. Only then did Mars settle down. According to the model, there was subsequently no volcanic activity or magnetic field on the Red Planet – which tallies well with the observations and measurements so far.

Nanocrystal solar cells

UNDERSTANDING THE ELECTRON FLOW BETTER

The next generation of solar cells could be based on crystals that are barely a few nanometres in size. This is because semiconductors made of nanocrystals have excellent optical properties. However, their electrical conductivity is very limited, which also restricts the efficiency of such solar cells. Researchers from ETH Zurich have now described the electron flow in these solar cells in a universal model for the first time, thus paving the way for improving their efficiency.



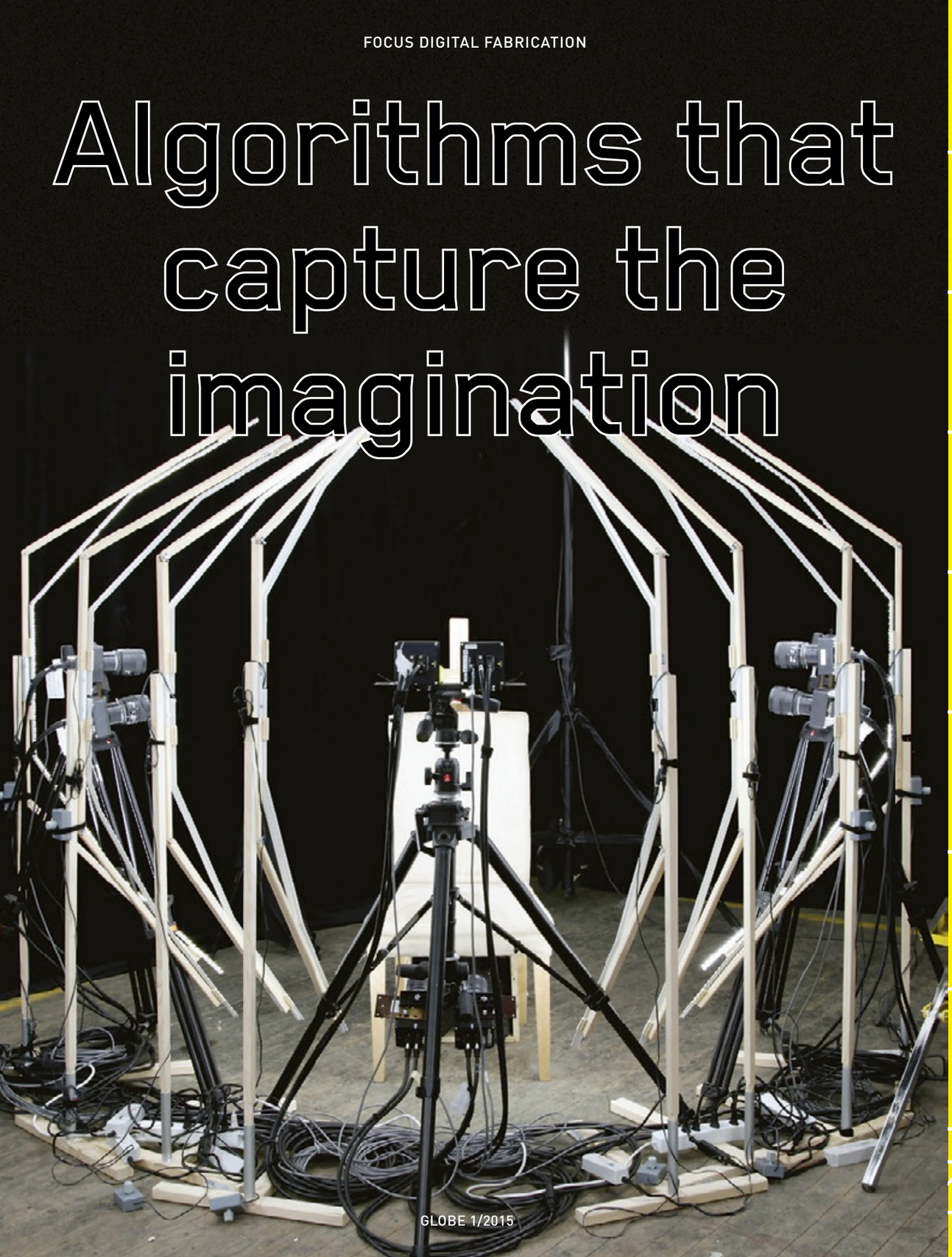
MRI readings

STUDY CANCELLED

In October 2014 researchers from ETH Zurich announced that they had managed to detect a single hydrogen atom using an MRI machine. Now, however, the scientists have cancelled the study after discovering a flaw in the detection method used. A reanalysis of the data revealed that, in some instances, the readings could also be attributed to something other than the explanation put forward in the study.

Picture credits: MOLA Science Team; Deniz Bozyigit

Algorithms that capture the imagination



CAPTURING FACES
The Medusa Performance Capture system created by Disney Research Zurich films actors while they speak. A special software uses the recordings to produce high-resolution 3D faces which can be given to figures in animated films.

Picture credits: Disney/Disney Research (2)

REAL
It consists of transparent crystals and normally has bubbles of air trapped inside. Depending on the number of bubbles, the ice breaks the light in different ways and thereby changes its colour.

VIRTUAL
It is very complex to depict ice in an animated film. The expansion of light in ice is a highly physical process. A central parameter for the mathematical description is the scattering coefficient, which indicates how the radiant power of the light decreases when penetrating ice.

Computer graphics experts feel at home both in mathematics and computer science. Their technologies are useful not only for artistic applications, but also to architects – and even medical patients.

TEXT Roland Baumann

There is a good chance that you have seen the film *Frozen*: it is the most successful animated film of all time, winning countless awards and grossing 1.2 billion dollars globally. The story is based on "The Snow Queen", a fairy tale by Hans Christian Andersen, and takes place in a setting reminiscent of Norway. But the ice in the film comes from Switzerland. Of course, an artist draws the ice in an animated film. But behind the glitter and sparkle lie complex mathematical formulas, and these algorithms come from Zurich: from Disney Research Zurich (DRZ), to be precise. "The volumetric diffusion of light is a highly physical process", says DRZ Director Markus Gross, and explains another secret behind the Swiss ice: "Our researchers measured the scattering coefficients required to depict the ice, working with their measuring equipment under the supervision of Wojciech Jarosz up in the Swiss mountains near Davos."

Disney Research Zurich is the flagship operation when it comes to computer graphics at the Zurich design site. Markus Gross is not only the founding director of DRZ, but also the reason why Disney came to Zurich in 2008. The 50-year-old has been a professor at ETH Zurich and director of the Computer Graphics Laboratory (CGL) since 1994. As a pioneer in the area of computer graphics, he earned himself an international reputation both in the world of academia and in the entertainment industry, which allowed him to convince Disney to establish a Zurich presence. Some 100 people work at DRZ today and 40 at the CGL. The researchers look into all new forms of animation and storytelling, and all the technologies that they require.

The two laboratories, which are only a 15-minute walk away from one another, have different missions here: "At ETH Zurich, we conduct basic research and work on new technologies that are inspired by trends", explains Gross. "At Disney, we conduct corporate research, driven by the changes in the various business areas and the need to ensure that Disney is prepared for them." But it goes without saying that the operations are mutually beneficial.

Gross is particularly interested in areas where disruptions occur – making conventional approaches obsolete. One example of this is the area of big visual data: today's cameras produce such huge quantities of data that conventional methods of video editing no longer work. "At DRZ, a group working under Alexander Sorkine-Hornung is dealing with revolu- ›

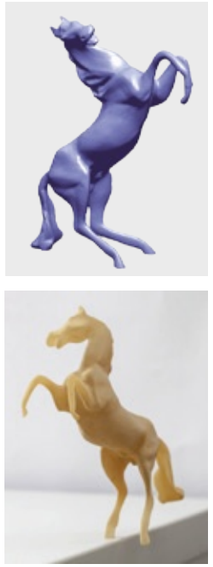
A MAJOR SUCCESS
Frozen is the most successful animated film of all time. It won countless awards and grossed 1.2 billion dollars globally. The ice in the film comes from Switzerland – or from Disney Research Zurich, to be precise.

Picture credits: Kathryn Hansen / NASA, CC by 2.0 (cutout); ©Disney (2)

tionising production in the entire live-action area", says Gross. Shooting and post-production are to merge to form a whole, for instance by adding special effects already on set.

The rapid development of automatic design and digital fabrication is also creating disruptions: "Computers today are able to optimise a design in an interactive manner, which an engineer is unable to do manually", says Gross. And entirely new products can be manufactured with 3D printers, customised and tailored to the individual user. We can have ourselves scanned and printed out as small 3D figures, for example. The results from standard commercially available scanners already look very realistic, with one exception – the hair. Thabo Beeler, who heads up the Capture and Effects Team at DRZ, knows this problem all too well: "Today's scanners cannot identify hairstyles correctly, for which reason they reproduce the hair very roughly or print a generic hairstyle." Together with Derek Bradley, he presented a new kind of technology last year at SIGGRAPH, the world's most important conference on computer graphics, which solves precisely this problem. It is inspired by the process that a sculptor goes through. With the new algorithm, not only can individual hairstyles be reproduced, facial hair can also be rendered realistically.

But the scientists are interested in more. "We are developing methods that have as much general validity as possible", says Gross. "When we build a new scanner, for example to give individual faces to the Storm Troopers from the next Star Wars movie, we aim to make the underlying technologies as generic as possible so that we can apply them as broadly as possible." ETH Zurich, Disney and the University Hospital of Zurich are thus currently working on building the medical version of a scanner within the framework of a CTI project. The photorealistic 3D images of the face and neck can help to improve communication between medical staff and patients during maxillofacial surgery. The researchers at the CGL are currently working on expanding the functionality by integrating medical data, with an eye to commercialising the scanner.



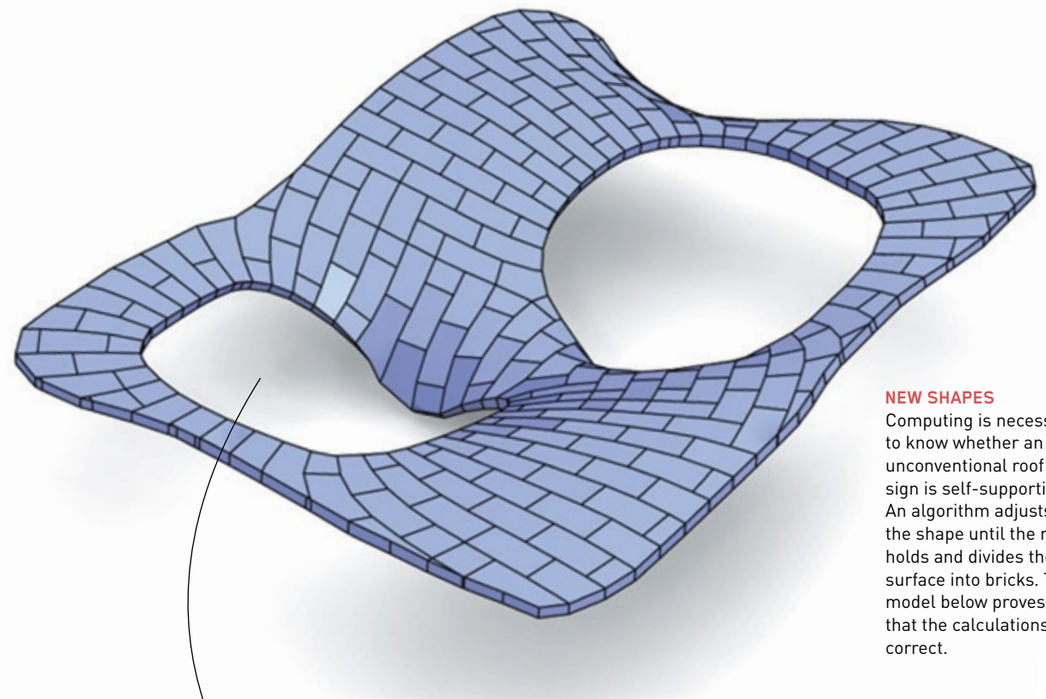
WILL THE FIGURE STAND UP OR NOT?
An algorithm from the Interactive Geometry Lab does more than just determine the centre of gravity of a figure. It also computes whether cavities are necessary in a 3D printout or whether the shape of the figure needs to be adjusted, so that a horse, for example, can find its balance and stay standing up.

In addition to Gross's two laboratories, another lab at ETH is also causing a stir: the Interactive Geometry Lab, which is in the same neighbourhood as the CGL. It is directed by Olga Sorkine-Hornung, who is already an international expert in the area of geometric modeling and optimisation at the age of 34. She came to ETH Zurich in 2011, where she and her team develop algorithms that can help artists to create and animate 3D figures. Her group presented an algorithm at last year's SIGGRAPH that not only provides a further example of the individualisation trend mentioned above, but also perfectly illustrates what is involved in geometric optimisation.

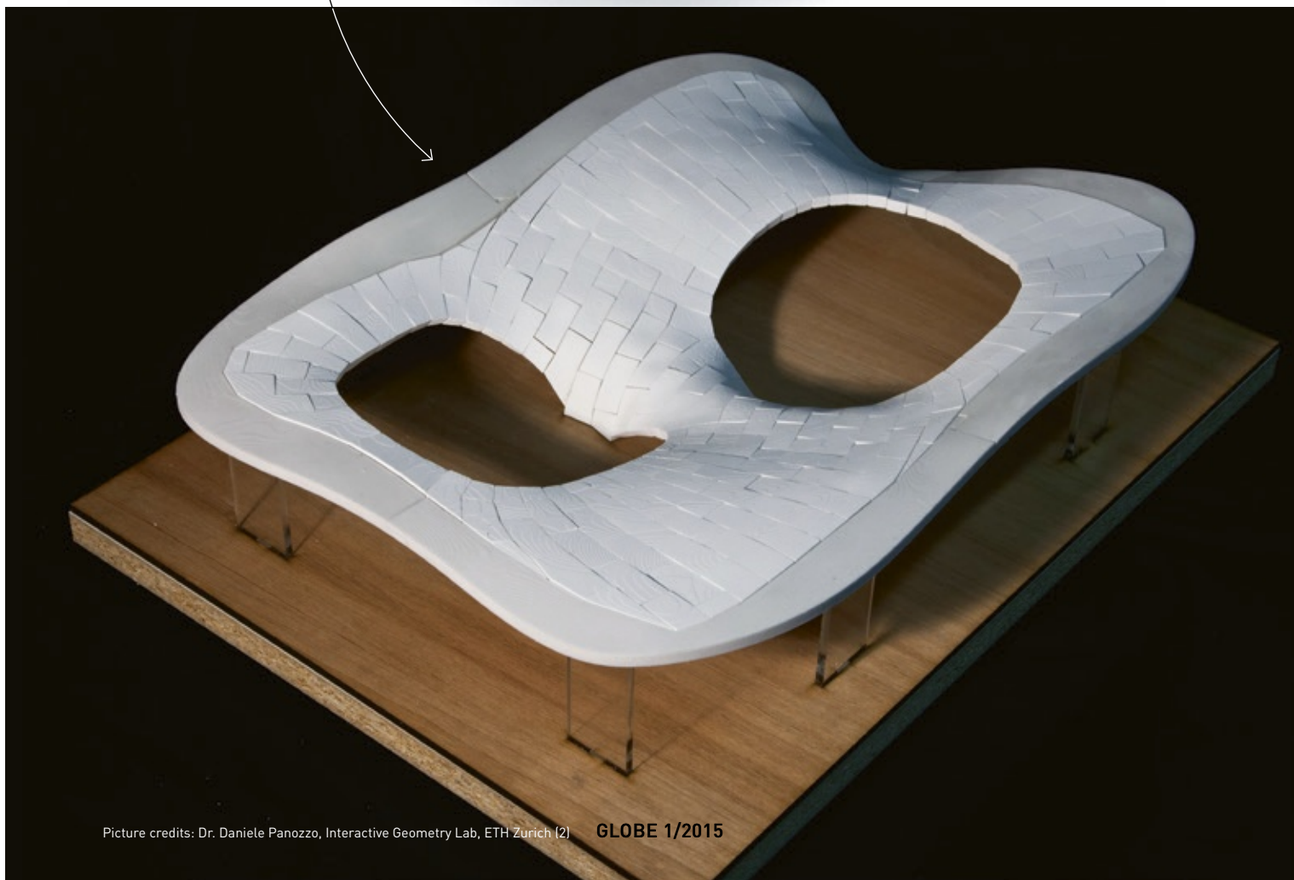
If we want to make a 3D print of a figure in a certain position – a hissing dragon, for example – it is impossible to figure out whether it will stand because we do not know where the centre of gravity is, unlike with a clear geometrical shape such as a cube or a ball. The algorithm Sorkine's team developed calculates not only the centre of gravity of the figure drawn, but also determines the cavities that need to be created during the 3D printing process in order to shift the figure's centre of gravity so that it stands. If it cannot find a stable position for the figure using cavities, the algorithm will change the shape automatically so that that the figure is given a stable position. And all these calculations take place in real time.

"We have developed a whole range of mathematical tools like this, and they really give us a lot of options", says Sorkine. This allows the researchers to be active in areas they have to familiarise themselves with first. One example is the world of architecture, as Sorkine and her postdoc Daniele Panozzo have been working on a project with Philippe Block for several years. The professor for architecture and structure at ETH Zurich is interested in finding entirely new, individual shapes that can be implemented with unreinforced masonry. However, there is no single recipe for this, and the same goes here as with the small 3D figures: an architect cannot assess whether the roof he is drafting will be self-supporting based on the drawings alone. This needs to be computed. And this is where Sorkine's lab comes in: ›

Picture credits: Romain Prévost, Interactive Geometry Lab, ETH Zurich (2)



NEW SHAPES
Computing is necessary to know whether an unconventional roof design is self-supporting. An algorithm adjusts the shape until the roof holds and divides the surface into bricks. The model below proves that the calculations are correct.



Picture credits: Dr. Daniele Panozzo, Interactive Geometry Lab, ETH Zurich (2)

"The idea is that architects draw surfaces that they think could have self-supporting properties, and our algorithm does the rest", explains the computer graphics expert. The algorithm deforms the draft until it is self-supporting and tessellates the surface into individual bricks at the same time. The physical requirement can be explained rather easily here: the forces must add up to zero at every point on the surface. This means that the gravity coming down from the top and the compression forces within the surface need to be in equilibrium. This principle may sound simple on the face of it, yet optimising it mathematically is anything but trivial: "Taking a surface and deforming it in such a way that it fulfils this principle is a bit like magic", says Sorkine.

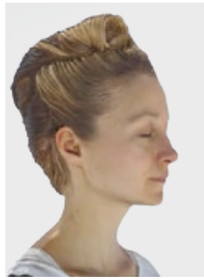
And once this had been achieved, the learning process began, specifically with regards to the actual implementation: how would the principle work on an actual structure? To establish this, the researchers initially built a support made of foam for their model, placed the "bricks" on it and then removed the support. A support structure like this would be far too expensive in reality. But as parts of the surface area are self-supporting, the researchers developed an algorithm that finds these parts and computes the points at which a temporary support is needed. This would allow for step-by-step construction using a crane that is occasionally moved along to the next section. However, what has not yet been solved is the question of how the individually shaped bricks can be made at an acceptable level of effort and realistic costs.

"This project is a nice example of how mathematics and practical challenges can go hand in hand", says Sorkine. "It's mathemically very interesting to arrange the bricks in a roof in such a way that parts of the structure are self-supporting – and this application brings in the next questions and solutions in practice." However, the project also shows what it means to collaborate on an interdisciplinary basis. For instance, it took a certain amount of time until the computer graphics researchers knew what problems they can address and where the architects need to find a solution. What is more, they also had to find a common language: "The architects work with surfaces and geometry as we do, but they have different names for everything", says Sorkine. But it was worth the effort. "Before ETH I never really had the experience of working in such an interdisciplinary manner", she adds with enthusiasm.

"The nicest moments are the ones where you have a complex problem, and you find structure in it that you can describe very simply", says Sorkine. This does not mean that the researchers solve a simple problem. They find a solution by looking at the problem from another, more abstract side. "Even if something is very complicated and looks visually very difficult, there are actually only a few parameters that control the entire dynamics", explains Sorkine. "We think about how these parameters can be found and how the problem can be presented such that it is characterised by these few parameters."

Markus Gross, who also developed classical physical simulation models as an engineer years ago, such as those used in the construction of a new turbine, explains the approach of computer graphics researchers as follows: "The simulation of an engineer must be calculated precisely, for instance the pressure when water flows through a turbine. Computer graphics designers, on the other hand, are not interested in whether the pressure is precisely 100 bar – it just has to look like it." While quantitative plausibility is the important measure in the classical engineering disciplines, computer graphics aims to generate a qualitative – that is to say, a visual – plausibility.

Engineers can also assume that their simulation system is operated by an expert who knows how unstable it is, when it works and when it does not. However, the tools that are developed at DRZ are used by animation artists and game developers who have no idea about physics. "Our systems need to be very robust", says Gross and refers to another matter: "We need the artistic oversight in the process." Artists will only use technology if it contributes to the storytelling; by making it possible to exaggerate a movement, for instance. However, this piece of exaggeration does not obey the laws of physics. "Here, we need to make sure we integrate the artistic element by consciously distorting physics, but only to the extent that the rest remains intact", explains Gross.

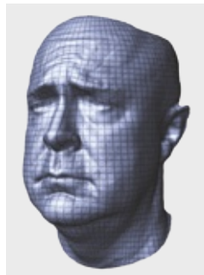


THE PERFECT HAIRSTYLE
Today's scanners cannot identify hairstyles correctly. 3D printers either reproduce hair very roughly or print a generic hairstyle. A new kind of technology makes it possible to print real hairstyles, either without colour (centre image) or with colour (image below).

One of the biggest challenges in the area of computer graphics for animated films and games, however, is reproducing realistic human faces: the matter of face capture. To allow an animated figure with a human appearance to speak, the facial movements of the artist need to be recorded and converted to a format that is suitable for further processing. But because we humans have a very fine sensor system for facial features, we immediately notice when this conversion does not work completely or when something is not quite right with the animated figure's proportions or facial expression.

In this area, DRZ has made major progress in recent years and caused a major stir with the new Medusa Performance Capture system. The hardware consists of a series of sources of light and cameras arranged in a semi-circle, which record an actor from various sides. They are connected with a software that reconstructs the speaking face from the images. The unique thing about this is that the system does not need the so-called motion capture dots that need to be fitted on the faces of the actors in conventional systems. This allows the production of more efficient and cost-effective high-resolution 3D images, which track speakers' every pore and wrinkle. The system was used in the *Maleficent* film, which was in cinemas in 2014. Here, the makers were faced with the special challenge that they had to reconstruct the faces of three actors who appear as humans as well as adopting the roles of many smaller fairies. Anyone who has seen the pixies knows that the result speaks for itself.

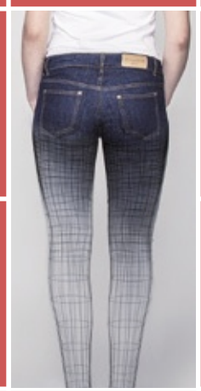
As the example from architecture has shown, computer graphics is not only a real boost for the entertainment industry. It can also facilitate learning, as Markus Gross knows: for instance, his Computer Graphics Laboratory has developed a software that supports children with dyslexia. This resulted in the ETH spin-off Dybuster in 2007, which has already trained more than 100,000 children in Switzerland. In this process, machine intelligence is used to create a profile of the learning child, strengths as well as weaknesses are recorded, and learning ability and attention deficits are noted. Then the child is presented with the content in a multimedia form, graphically in 3D across many receptive channels – and as individually as possible – in order to optimise the speed and success of the learning process. "This kind of playful learning also constitutes such a disruption", Gross says with conviction. "We will learn differently in the future compared to today. We will use the entire spectrum of the brain." ○



REALISTIC FACIAL EXPRESSIONS
An algorithm uses images from Medusa's cameras (image above) to compute the geometry of the head, which is then verified with a gridline network (centre). The face is then definitively rendered and can be used for an animated film.

Disney Research Zurich: → graphics.ethz.ch/drz
Computer Graphics Laboratory: → graphics.ethz.ch
Interactive Geometry Lab: → igl.ethz.ch

Picture credits: Disney, Disney Research



SELFNATION
Algorithms create a 3D model of the buyer using just eight measurements, providing the basis for perfectly tailored jeans.

Successful in 3D

Since virtual reality acquired a third dimension, 3D has also become fertile ground for setting up companies. Here, *Globe* showcases some ETH spin-off ideas.

1 PERFECT MADE-TO-MEASURE JEANS

Enough is enough, said two young ETH engineers to one another, as they tired of hearing the constant complaints of their girlfriends and acquaintances about badly fitting women's jeans. Their idea was to manufacture perfectly fitting jeans for every figure based on clever algorithms, which calculate a precise 3D model of a person using just eight measurements. Last November, the founders of Selfnation celebrated their first year in business. The small, Zurich-based start-up already has more than two thousand customers and now also wants to help men find those elusive perfectly fitting jeans. In January 2015, Selfnation also launched in Germany, a market which already accounts for around 20 per cent of their jeans orders.

2 YOUR SMARTPHONE AS A 3D SCANNER

While they are yet to establish a spin-off, the app they are developing is already generating a great deal of interest. The team around Marc Pollefeys, a professor at the Institute for Visual Computing, is working on turning every standard smartphone into a 3D scanner. The software they have created makes scanning three-dimensional objects nearly as easy as taking pictures. Suitable for everyday use and valuable for all those who work with three-dimensional models, it can be used in construction, plastic surgery, architecture or even for reconstructing crime scenes in the field of criminology. The project has now been awarded a Proof-of-Concept grant from the European Research Council, which will enable the researchers to carry out testing on their business idea.

3 ARTIFICIAL URBAN WORLDS

The ETH spin-off Procedural was set up in 2007 by the Computer Vision Lab at the Department of Information Technology and Electrical Engineering. It made a name for itself thanks to its CityEngine software, in particular, which can be used to generate 3D cityscapes from two-dimensional data. The software is used by urban planners and architects as well as game developers and film studios. In 2011 the spin-off was acquired by Esri (Environmental Systems Research Institute) for a seven-figure sum. Esri is one of the biggest private software companies in the world.

4 MORE EFFECTIVE DRUG TRIALS

Insphero, a spin-off established in 2009, is also on the road to success. The fast growing ETH spin-off, whose customers include the 15 biggest pharmaceutical and biotech companies, came first in the Top 100 Swiss Startup Awards and won the renowned ACES European start-up prize. Deservedly so, considering their three-dimensional micro-organs have the potential to revolutionise the development of new drugs. Insphero generates 3D samples of tumour and liver tissues, on which drugs can be tested in a far more realistic environment than on traditional two-dimensional tissue samples.

5 BETTER SPORTS VIEWING

When two ETH computer scientists enthusiastic about sports established a spin-off with their own development Liberovision in 2006, they could only have dreamed of TV stations around the globe using their software for their sports coverage. The software allows broadcasters to analyse match situations in football, rugby or other sports in real time. In 2012, the Norwegian company Vizrt acquired the successful spin-off. The software has since been used globally under the name of Viz Libero.

Picture credits: Selfnation

Revolutionising building sites

Digital technologies have already turned many areas of the economy inside out. Construction is the next sector set to undergo a change: more efficient processes, new materials and more varied houses are the objective.

INTERVIEW
Felix Würsten and Corinne Hodel

PICTURE CREDITS
Nicole Bachmann

Mr Kohler, the website of the new National Centre of Competence in Research (NCCR) Digital Fabrication states the following: "Digital fabrication promises to revolutionise architecture." Does architecture need a revolution?

MATTHIAS KOHLER – That is less of an objective than an observation: the construction process is still highly conventional. Other sectors of the economy have been profoundly transformed by digital technologies. This raises the question of whether architecture and its downstream construction processes are also set for a change. The NCCR Digital Fabrication addresses this question: what is the added value if components are fully assembled by machines? What conditions need to be fulfilled so that people can work together with robots on building sites? And what effect will this have on drafting, planning and the construction culture?

Yet it must be noted that houses were built by robots in Japan some time ago. Are you reinventing the wheel?

KOHLER – It's true that some initial steps towards automation on building sites were already taken in Japan in the 1990s. There was a boom, but it collapsed suddenly for economic reasons. The idea at the time was to bring serial mass production from factories to building sites. It worked, but this technocratic approach resulted in limits on the architecture and bland buildings. In today's construction culture, a fitting, "tailor-made" solution for each situation is the objective. The quality of our living environments relies on this. When we take our robots to the building site today, our motivation is quite a different one: we are trying to establish how the processes can be ›

> "Automatic, tailor-made construction is the novelty."
>
> MATTHIAS KOHLER

MATTHIAS KOHLER is Professor for Architecture and Digital Fabrication at the Architecture Department of ETH Zurich. In 2005 he established the world's first robot laboratory for non-standardised fabrication processes in architecture with Fabio Gramazio and thereby opened up an entirely new field of research.

BALZ HALTER is the owner and chairman of the board of directors of Halter Unternehmungen, which are active in the development, construction and operation of real estate property. He is an ETH graduate civil engineer and lawyer.

JONAS BUCHLI is Professor for Agile Robotics at ETH Zurich. His research focuses on model-based approaches to controlling robotic locomotion and understanding human locomotion as well as on machine learning and on dynamic service and field robots.

rationalised, but continue to allow tailor-made production at the same time. That's the actual novelty: every machine-made component can look different, even the individual production steps can be customised to a certain degree. That's what we're doing with our robots, for instance: depending on the task, the same robot uses different tools to assemble, process or shape something. This approach results in rational production already for relatively small lot sizes.

Mr Halter, is there actually any demand from developers for individualisation?
BALZ HALTER – Developers certainly want a more individualised appearance for their buildings. This is also having an impact on architecture: new shapes and materials are being sought. In the construction industry, we abandoned the mass production mentioned earlier because we noticed that this approach keeps resulting in the same buildings. The construction industry is indeed aiming for individualisation, because ultimately it also offers a way to stand out amongst competitors.

Mr Buchli, what is your motivation as a robotics expert to look at construction processes?
JONAS BUCHLI – Many sectors of the economy have been turned inside out by digitalisation. This has affected, above all, areas where either data play a key role or where problems can be easily structured. In robotics, however, we now need to take the next step, which is to say that these technologies need to be brought to areas that are less structured, where more flexibility is needed and the machines need to react in a more timely fashion. The construction industry is an interesting starting point for this. A building site is certainly less well-structured than a factory, but still not quite as open as the world of service robots, for instance, which perform activities independently in the household. The potential in the construction industry is huge. But we will only be able to tap it if we solve complex robotics problems. That's an interesting challenge for me as a researcher.

> "Today we can produce structures at a level of precision that a human cannot achieve."
>
> JONAS BUCHLI

What has it been like to work with architects?
BUCHLI – When working with architects, the challenges and possibilities are entirely different than when "only" collaborating with engineers. I am learning an awful lot and am facing an entirely new perspective. What has surprised me is how pragmatic their approach is to using technologies and how target-driven their work is.

What has been implemented to date?
KOHLER – We're currently still at an early stage of research, although some companies have already taken specific steps towards digital fabrication. It will take a great deal of time until the new production processes have become ingrained and until the experiences have been integrated along the entire production chain. In tile and timber construction, we have seen that implementation will take at least six to ten years. When applied across the entire construction industry, these changes will take several decades. What excites me is the question of what we will gain from these technologies in terms of quality in architecture and in the construction processes, and what benefits they will bring for Switzerland.
HALTER – In practice, digital fabrication is certainly a known concept today. In timber construction, in particular, a lot is already being done. The fact that these technologies are not yet broadly applied is not so much a matter of possibilities: the problem is that we can only produce digitally if the data are available in a corresponding form. In this area, our industry is simply underdeveloped. There is no integral process from drafting to production through to operation. If we were to start by handling the data correctly during the planning process, implementation would be far easier. We actually have all tools at our disposal already. But our industry is still not able to use these tools.

Why is that?
HALTER – First, this has to do with the fact that we still think in a very subsection-specific way. In other words, we don't understand the building as an overall system. Second, we keep interrupting the planning process because we transfer data from one place to another. And third, the construction industry is organised in a highly commercial and work-sharing manner. The production of a car is a unified procedure; that's not the case for buildings. But construction is not more complex than car manufacture – we are simply aligned in such a way that it becomes more complicated. That's why processes are still very antiquated on building sites. But that is also an opportunity, of course, in particular for the design process. What's important to us is that digital fabrication results in quality improvements and ultimately also generates commercial benefits.
BUCHLI – The entire development will likely happen in a similar way as in computer technology. When we had the first computers on our desks, processes were hardly productive yet. But there were early adopters, who were thinking ahead. Only now, after many years, are computers really productive for normal users. We will undergo the same development in the construction industry. However, the problem is far more complex here, which is why the time frames will be longer. We won't be looking back in two or three years saying whether it has worked or not.

Where do you expect to see the first steps?
BUCHLI – What will likely become established in the near future are transport applications as well as certain precision applications. Today, we can produce structures at a level of precision that a human cannot achieve, at least not within the same period of time and working under the same conditions that robots do. However, if we want to bring these things to building sites, we need to increasingly include information from the building in the planning process. This was a directed process in the past: first plan, then execute. What we need now is to close the circle.
KOHLER – The crucial question is, of course, how this vision is implemented. Up to this point, architecture has mainly focused on the mental work. The idea was to develop a sophisticated planning software that integrates everything. This still largely works in planning today. However, where the matter becomes physical, the processes mostly remain conventional. We are now changing our perspective and looking for solutions that can be integrated retroactively, in other words from execution to drafting. I'm convinced that this approach will make it far easier for the construction industry to initiate a sustainable transformation from within.

Do you share this view?
HALTER – A lot speaks for this approach. The development is driven strongly by architects who focus on the end product and who work with components and materials that can only be implemented in a digital process. For instance, there are facades that can only be planned and produced on a data-driven basis. It will also be exciting to see what influence 3D printers will have. This is precisely the point: we look at what options we have in production and go back to the draft with this as our vantage point until both ends meet.
KOHLER – 3D printing is a very interesting catchword: 3D printers cannot simply be applied to architecture, although it is often presented this way. In principle, additive processes are interesting for us, of course. This has to do with the fact that good architecture is based on the artistic assembling of ›

PIONEERING WORK IN FLÄSCH
One of the first buildings in which digital fabrication was applied is the Gantenbein vineyard in Fläsch, Graubünden. In 2006 an industrial robot assembled bricks in accordance with a pre-programmed pattern at ETH Zurich under the supervision of architecture professors Matthias Kohler and Fabio Gramazio. The facade elements this process created were mounted to the building shell on-site. The bricks were slightly twisted towards one another, and the resulting openings reveal a pattern of oversized grapes on the facade, depending on the light and shade.

Built by robots, appreciated by wine enthusiasts

Picture credits: Ralph Feiner/Gramazio Kohler Architects

OFFICE BUILDING AS RESEARCH LABORATORY
For the new Arch_Tec_Lab building on the ETH Zurich Hönggerberg campus, the Chair of Architecture and Digital Fabrication is planning a new kind of roof construction made from small wood elements. The project displays the potential of linking digital production techniques with sustainable and locally available building materials such as wood. The construction consists of more than 45,000 individual elements that are woven together to create a rolling wooden roof. The building will be ready for occupation in autumn 2016.

Roof construction as an area of research

Picture credits: Gramazio Kohler Research, ETH Zurich

elements to create rooms that are larger than the machines that build them. This is where 3D printing comes in: how do we find the structuring strategies in architecture that are based on digital technologies, but nevertheless take into account the requirements and economy of architecture? For instance, it makes little sense to print an entire building. Due to the resolution at which the printer works, the construction process takes a very long time and the material is also very expensive. However, if larger construction elements are used, a construction-aligned resolution can be achieved.

Can you elaborate a little on this?
KOHLER – I am speaking about new digital material systems, for instance: suddenly it's possible to handle a building material in an entirely different way thanks to digital technologies. It is very possible that this will result in developmental leaps. We also need to consider the ecological aspects: today, concrete walls are designed in such a way that they withstand the worst load scenario. These walls are built with a straight mould system. This results in about one third of the concrete not actually being needed from a statics perspective. If we use systems that don't need moulding, there are direct consequences for our handling of material resources. If the construction culture develops in this direction, we will thereby also be able to create added value in this area with the use of digital fabrication. Our research projects allow us to generate knowledge which Swiss companies will be able to use internationally. We would be delighted if the industry were to pick up on these stimuli and if our projects were to result in interesting collaborations.

What effects do these developments have for the people involved in the actual construction process?
HALTER – It's becoming increasing difficult to find the experts required. For that reason, we need to try to support the processes on building sites in terms of information technology in such a way that the required skills are more limited. This objective is also driven by commercial considerations, because the individual worker is becoming increasingly expensive.

What do you think of the roll-out of the new MAS Digital Fabrication programme at ETH Zurich, which is starting for the first time this year?
HALTER – No question: we need a programme like this. Because the development we have just been discussing can only happen if we also make changes to education. We need people who can handle these types of technologies. We are consistently initiating innovations, but are also noticing that people are out of their depth in practice, because they are faced with something that they don't know. A planner doesn't see why he should do something differently, because he doesn't get paid more but he does have to take on more risk. If he has no inherent drive to try a different approach for a change, and cannot even know the opportunities, then he simply won't do it. That's understandable. ○

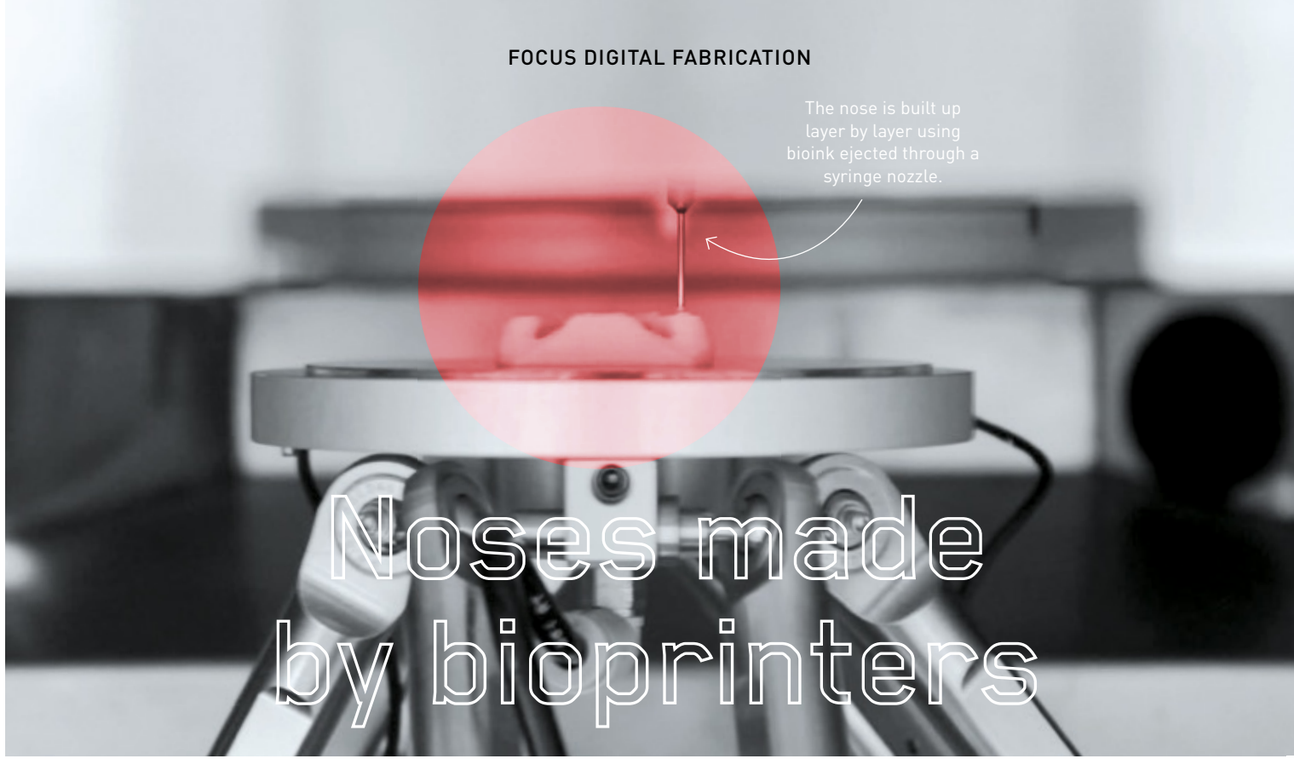
"We need people who can handle these types of technologies."

BALZ HALTER

New Master's programme in architecture and digital fabrication

The MAS ETH in Architecture and Digital Fabrication is an interdisciplinary further training programme from the National Centre of Competence in Research (NCCR) Digital Fabrication at ETH Zurich. The focus is on methods and techniques of digital fabrication and their meaning for the architecture of the future. The NCCR Digital Fabrication is an ambitious research initiative that combines top research in the areas of architecture, engineering and robotics as well as material and computer sciences. As the central education platform of the NCCR, the programme is located at the heart of the latest research findings. The NCCR's unique robotic production plants will offer students the opportunity to research digital design and construction processes and implement them directly in large-scale prototypes.

The MAS ETH in Architecture and Digital Fabrication is designed as a 12-month full-time programme aimed at university graduates with proven design skills. The MAS will be supervised by the Gramazio Kohler research professorship at ETH Zurich. The programme is scheduled to begin on 14 September 2015. Applications can be submitted online until 30 April 2015.
→ www.dfab.ch/mas



Noses made by bioprinters

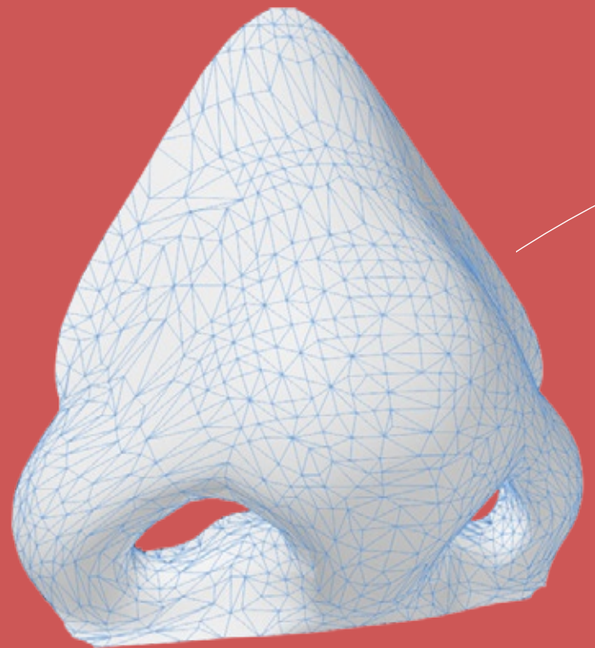
3D printers are opening up new opportunities in medicine too. A group of researchers in a team led by Marcy Zenobi-Wong is printing cartilage transplants using the body's own cells. They are personalised and grow with the patient.

TEXT Samuel Schlaefli

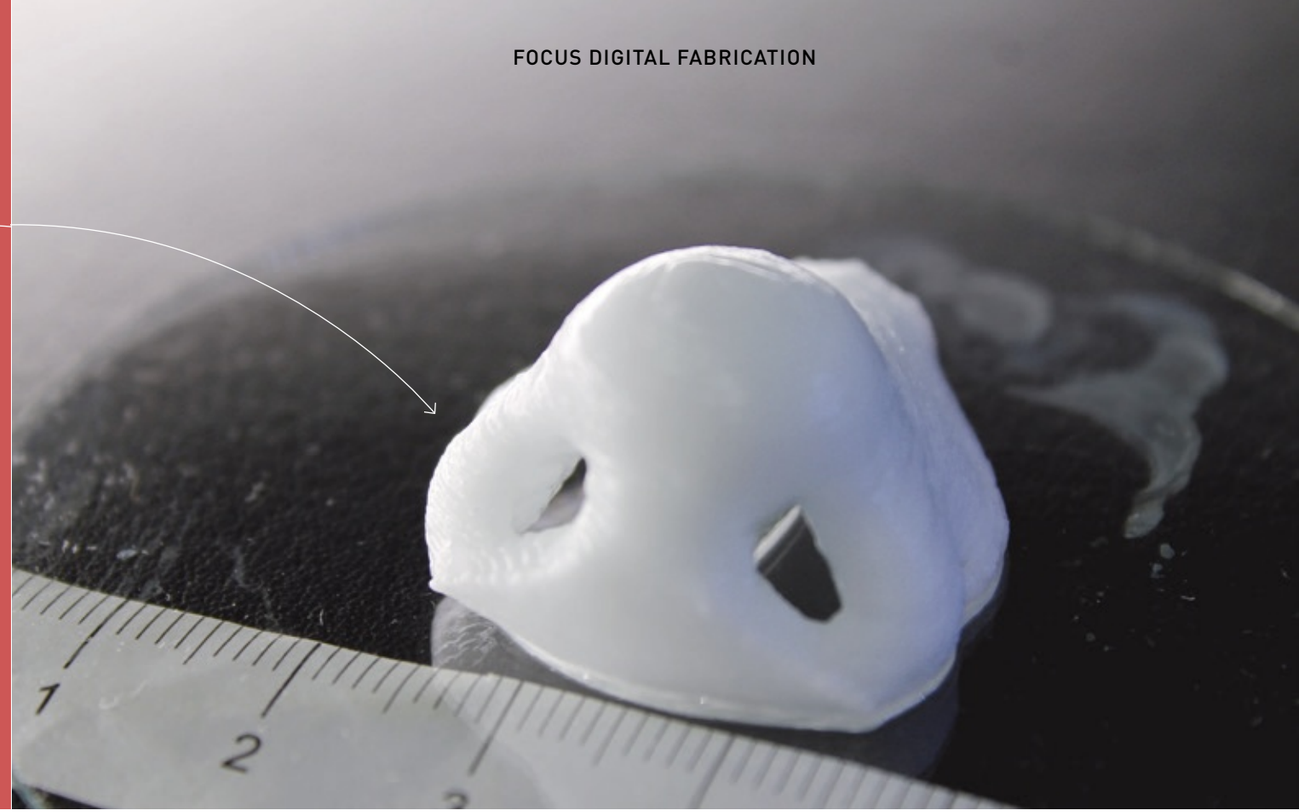
Bioprinting, 3D printing with cellular materials, is currently well on the way to becoming the next big thing in personalised medicine. In the laboratory of the Cartilage Engineering and Regeneration group at the Department of Health Sciences and Technology, Matti Kesti presents the latest results of their research: a bowl filled with nutrient solution contains murky white cartilage forming a nose and miniature ear. The doctoral student created both of these from a mix of biopolymers and living cartilage cells using the laboratory's own bioprinter, a 3D printer for biological materials. This remarkable printer is as big as a laboratory hood and at first glance resembles a protected extraction device in the laboratory. The heart of the system is a wheel with eight syringes that can all be filled with a different suspension. Using a computer outside the lockable printer, the pistons of the syringes are controlled using digital data from a three-dimensional model. The suspension is then ejected from the syringe nozzle at the highest level of precision and a random structure is created on a platform below, which whizzes to and from at rapid speed, using the layering method. This method can be used to create structures such as a joint cartilage or a nose cartilage, which the bioprinter takes just 16 minutes to create.

Kesti outlines how this method may revolutionise reconstructive surgery in the future: A serious car accident results in a passenger's nose being shattered. It is possible to reconstruct this as a 3D model on the computer. At the same time, a biopsy is performed on the patient and cartilage cells removed from his or her own body, for example from the knee, finger, ear or splinters of the shattered nose. The cells are spawned in the laboratory and mixed with a biopolymer. From this toothpaste-like suspension, a nose cartilage transplant is created using the bioprinter, which is implanted in the patient during surgery. In this process, the biopolymer is used merely as a form of shaping mould; it is subsequently broken down by the body's own cartilage cells. After a couple of months, it is impossible to distinguish between the transplant and the ›

Picture credits: Cartilage Engineering and Regeneration Group



A computer model of the nose is created based on medical records. The model then serves as a template for the bioprinter, which produces a faithful copy thanks to this data.



body's own nose cartilage. This procedure has significant benefits compared to traditional implants, for instance those made from silicone: the risk of the body rejecting the implant is a lot lower. A particularly crucial factor for young patients is that the cellular implant grows together with the patient, because it is controlled by the patient's internal growth engine, as is the case for other body parts.

Stringent requirements for bioink

There are many reasons why cell printing is finding its way into medicine just now: "3D printing has been around for nearly 20 years. The fact that it is only just being discovered for surgical purposes is, in particular, down to the lack of bioinks," explains Marcy Zenobi-Wong, professor and head of Kesti's research group. Commercial cellular printer cartridges do not yet exist due to the extreme requirements placed on the materials used in transplants. All materials used in clinical procedures are subject to strict international and national guidelines and need to undergo years of testing before being used in hospitals, a process that can cost millions. For that reason, Zenobi-Wong and her group of researchers use biopolymers, with which they are already familiar given their widespread use in everyday hospital procedures. These biopolymers include alginic acid, which is extracted from seaweed and is easily tolerated by the human body, or chondroitin sulfate, a macromolecule generated by the human body, which is responsible for the resistance in cartilage tissue.

Such biopolymers are prepared for the bioprinting process by adding human cells (or for laboratory use, animal cells) and processed to create a hydrogel comprising up to 90 per cent water. The liquid properties of this bioink need to be just right for the gel not to block the syringe cannulas, but the gel must also be sufficiently viscous so that the structure of the object to be built actually holds. If the gel were too liquid, the layers would melt during printing. The gelatinisation properties must also be taken into account, because for the gel to become a solid structure that doctors can use, it must have a fixed form. This is done by polymerising the hydrogel, which is initiated by light, temperature, a change in pH value or by adding ions. "We have very little room for manoeuvre here," explains Zenobi-Wong, "because we need to be careful at all times that the cells are not damaged during the printing process." She therefore devotes a large part of her research to looking for suitable biopolymers and forms of polymerisation that do not damage the cells.

Third dimension as a pointer

One of the first applications for printed cartilage transplants could be in treating injuries to knee and ankle joints. Cartilage transplants are already performed on younger patients with sports injuries, as part of which the patient's own cartilage cells are cultivated on hydrogel bands in the laboratory. A suitable section of this band is chosen and then sewn into the injured area. Although this is a good approach, it is not ideal because two-dimensional cell growth in the laboratory lacks key spatial information for the future functioning of the patient's joint. The cells therefore form scar-like tissue instead of cartilage mass. As cells and their supporting structure – the so-called cellular matrix – are printed in the same step using a bioprinter, their future use is clear from the very outset. This allows the cells to retain their original features and reproduce new cartilage from the patient's body.

The first transplants involving a bioprinter are to be tested in sheep and goats as early as this year. Such tests in large animals must be carried out before clinical trials can be performed on humans, which in turn, paves the way for everyday use in hospitals. "Whether we will see bioprinters in hospitals in the future, however, is less of a technical question; instead, it depends on whether the technology will be accepted by doctors, patients and insurers," says Zenobi-Wong. Her group of researchers is therefore already collaborating closely with health professionals from the Schulthess Clinic.

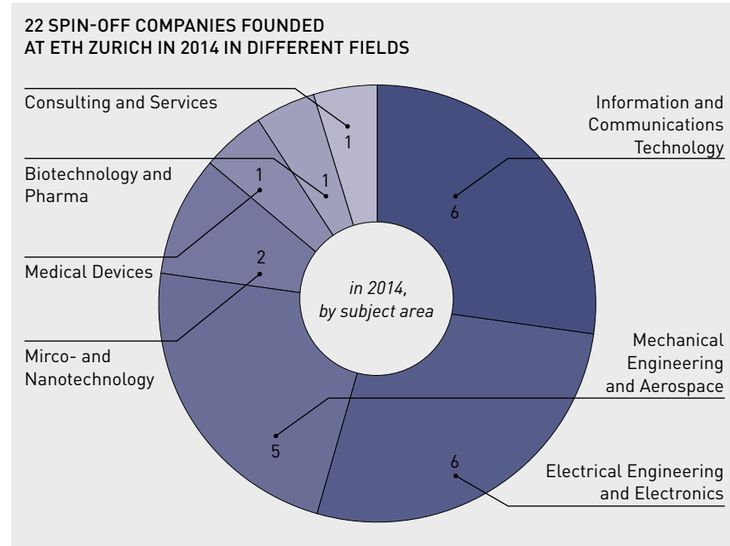
Hearts out of the printer?

Since the first international workshop on bioprinting was held in 2004, this area of research has grown continuously. More than 80 research groups are currently working on potential applications in clinical procedures and the first commercial providers of "printed" cell structures for clinical trials have already entered the US market, backed by a healthy amount of venture capital. Does this mean that hearts and kidneys will soon follow the first printed and implanted cartilages, as some are forecasting? Zenobi-Wong is not so sure: "While there's great deal of hype around bioprinting at the moment, our research is a long way from offering things that are already being promised today." Producing cartilage is relatively simple compared to body organs, which need to be supplied with blood and large quantities of oxygen immediately. When it comes to the heart, lungs or kidneys, hundreds of capillaries would need to be printed to supply the organ, and this needs to be done to a degree of precision and using materials that will likely not be possible for a long time to come. In contrast to cartilage, various cells need to communicate with one another in such organs in order to perform a whole series of different functions. "Our expertise is in cartilage, probably the easiest bodily tissue for bioprinting," says Zenobi-Wong, "but even today we know that this is anything but easy to print." ○

Research projects of Marcy Zenobi-Wong:
→ www.cartilage.ethz.ch

Picture credits: Cartilage Engineering and Regeneration Group

COMMUNITY



Most spin-offs were founded in the information and communication technology and electrical engineering sectors.

Innovative spirit

SUCCESSFUL YEAR FOR ETH SPIN-OFFS

ETH Zurich's researchers are renowned for their innovative spirit. The university has produced more than 300 spin-offs since 1996, including 22 in 2014. Numerous awards and prizes testify to the success of ETH Zurich's spin-offs. No fewer than 18 of the university's offshoots made the Top 100 Swiss Start-Ups published by the Institut für Jungunternehmen in 2014, including three in the top ten. The founders of InSphero even managed to clinch the top spot. Similarly, three spin-offs from ETH Zurich were able to win over the venture kick initiative's judging panel: Selfnation, Noonee and Bitsplitters won the advancement awards and CHF 130,000 each in prize money. Moreover, ETH Zurich spin-offs are often popular acquisition candidates for large companies. According to reports in the media, for instance, a subsidiary of Johnson & Johnson snapped up Covagen for more than 200 million Swiss francs last year.

Eight of the spin-offs founded in 2014 sprang from ETH Zurich's own promotional programmes. With the Pioneer Fellowships programme, the university offers grants to Master's and doctoral students who are looking to develop an innovative business idea into a product once they graduate. ETH Zurich also has two Innovation and Entrepreneurship Labs (ieLab), where young researchers develop initial prototypes and receive help and advice from experienced coaches from industry. And the recently launched ETH Founders Community encourages the exchange of ideas among the founders of ETH Zurich spin-offs.

Rector Sarah Springman

Polybahn pitch

NEW EXECUTIVE BOARD ON THE MOVE

To mark the inauguration of the new Executive Board in January, all five of its members took to the Polybahn to issue a video statement. Braving the elements, they each sum up their work in a nutshell. The new rector Sarah Springman, for instance, explains why teaching at ETH Zurich is important for Switzerland.
→ www.ethz.ch/video-springman-en

ESOP scholarships

GENEROUS ALUMNI

Almost 2,000 ETH Zurich alumni and friends donated more than half a million Swiss francs to support the Excellence Scholarship & Opportunity Programmes (ESOP) last year. This enables ETH Zurich to fund 12 out of 50 ESOP scholarships in 2015. ETH Zurich uses ESOP to support outstanding students who are looking to do a Master's degree at ETH Zurich. The scholarship covers their tuition fees and living expenses during the degree.

Graphics: ETH Zurich; picture credits: ETH Zurich

Wyss Translational Center Zurich

A centre of research fit for practice

ETH Zurich and the University of Zurich are launching a new translational centre at the interface between medicine, the natural sciences and engineering – all thanks to a generous donation from Dr. h.c. mult. Hansjörg Wyss.

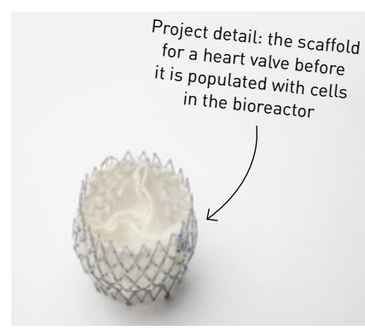
The two Wyss Zurich co-directors: Simon Hoerstrup, a professor of regenerative medicine at the University of Zurich, and Roland Siegwart, a professor of robotics at ETH Zurich.

"An opportunity like this doesn't come your way every day", stresses Professor Roland Siegwart from ETH Zurich, who is co-director of the Wyss Translational Center Zurich (Wyss Zurich). This new centre, which ETH Zurich and the University of Zurich will co-run, has a clear goal: to take results from basic and preclinical research and put them more quickly into practice. The initial phase is to focus on regenerative medicine and robotics, which will enable Wyss Zurich to support the current efforts of the two Zurich universities and their associated institutions to transform the city into one of the world's leading centres of university medicine (see Globe No. 4, December 2014). In this sense, the generous donation from ETH Zurich alumnus Hansjörg Wyss, founder of the medical engineering company Synthes Global and Chairman of the Wyss Foundation, couldn't have come at a better time. "The basic research conducted here in Switzerland is among the best in the world. However, it can often take a long time before the results can be utilised in practice and for the patient's benefit. I'd like to help speed up this transfer with new models of interdisciplinary collaboration", says Wyss, explaining the motives behind his donation at the contract signing. This isn't his first initiative to accelerate medical engineering research. Wyss also made a similarly generous donation to set up the Wyss Institute for Biologically Inspired Engineering at Harvard University in 2008, and he funds a Wyss Center for Bio- and Neuroengineering in Geneva.

"We can only benefit from such outstanding competitors in related research fields", says the Wyss Zurich co-director Siegwart. A meeting with colleagues from the Wyss Institute at Harvard is already in the pipeline, with plans to brainstorm potential common fields of interest. There is also a direct link: Simon Hoerstrup, a professor of regenerative medicine at the University of Zurich, is Wyss Zurich's second co-director as well as associate faculty member at the Wyss Institute in Harvard.

Robotics and regenerative medicine

For now, however, the aim is to get Wyss Zurich up and running. The new research centre in Zurich is due to kick off with four concrete projects. There is the Zurich Life Matrix project, where scientists will be working on blood vessels and heart valves produced in the lab from human cells. Implanted in a baby or child, such a heart valve could even adapt to and evolve with the body's growth phases, thereby avoiding many complications and additional operations.



The Zurich Liver project is concerned with extra-corporeal tissue: researchers are looking to grow pieces of a patient's liver outside the body before transplanting them back into the patient – a technique that should en-able patients suffering from serious liver diseases to generate their own donor material. As a result, the process could dramatically reduce the demand for donor organs. Organ donations are also a major problem in patients with life-threatening heart failure, which motivated the idea behind the Zurich Heart/Ventricular Devices project: to improve artificial heart support pumps. Finally, in the field of robotics, the aim of the Zurich Eye project is to develop a camera-based positioning system that generates maps of the surrounding area and can pinpoint an exact position by itself. This would enable autonomous vehicles and aircraft to navigate independently and help people with various tasks.

Interdisciplinarity is the name of the game in all the projects. Siegwart dreams of a common location for the centre, to foster synergies between researchers from the University of Zurich, ETH Zurich and the various specialist areas. While this is still a long way off, Siegwart states that we can already expect concrete research results in two-and-a-half to three years.

— Martina Märki

Further information:
→ www.ethz.ch/wyss

Careers

VIKTOR SIGRIST

Viktor Sigrist has been named the new director of The Lucerne School of Engineering and Architecture. He had previously served as vice president for university development and professor of design and construction at the Hamburg University of Technology (TUHH). Sigrist, a civil engineer who grew up in Lucerne, earned his undergraduate and doctoral degrees from ETH Zurich.

SWISSHAUS

Marko Virant is the new CEO of Swisshaus AG. The company is Switzerland's market leader for the construction of detached houses. Virant holds a doctorate in civil engineering and is an active ETH Zurich alumnus.

EASTERN SWITZERLAND

Nicolas Rohner, head of sales engineering at Axpo Trading AG, has been appointed as the new head of Energy and Sales and a member of the Executive Board at the Canton of Thurgau's power company. Rohner completed a doctorate in the Department of Management, Technology and Economics and is a member of ETH Alumni's Executive Board.

Picture credits: Robert Huber (2); Lina P. A. Nguyen

Student numbers

ENGINEERS ON THE INCREASE

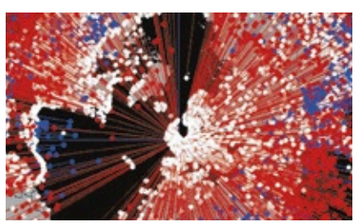
Never before have so many new students enrolled at ETH Zurich: 2,657 Bachelor's students embarked on their degrees in autumn 2014, up slightly from the previous year. With 426 new entrants, mechanical engineering remains by far the most popular course. Given the shortage of qualified engineers, the continual increase in engineering student figures is extremely positive.

ETH Zurich is educating the next generation of specialists.

Singapore-ETH Centre

MORE RESILIENT SYSTEMS

In countries with a high level of organisation, infrastructural systems are becoming increasingly interconnected. With its recently launched Future Resilient Systems (FRS) project, the Singapore-ETH Centre is looking to develop innovative approaches to make these systems more reliable and resistant.



The FRS's main focus is power supply systems.

ETH Zurich Foundation

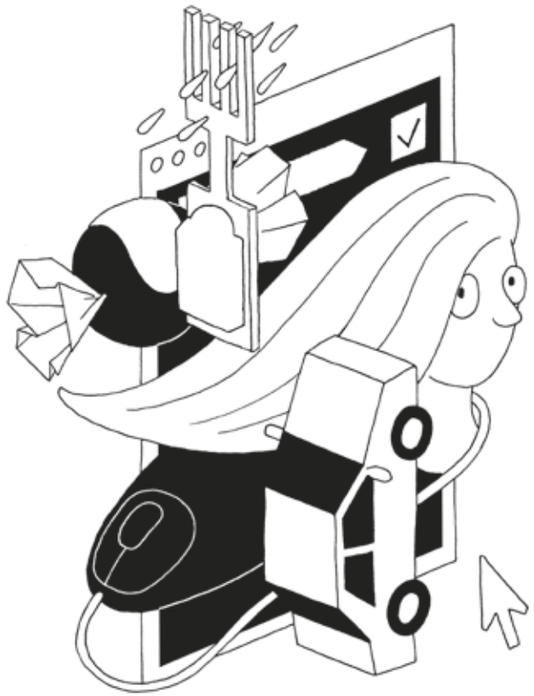
BEQUEST FOR ELECTRICAL ENGINEERING AND ENERGY RESEARCH

Dr Alfred Spälti first read about the possibility of making a bequest to ETH Zurich in an article about the entrepreneur and ETH Zurich alumnus Branco Weiss. Shortly afterwards, Spälti approached the ETH Zurich Foundation to find out about the options open to him to make a donation in his will. This was the beginning of a long and fruitful relationship between Spälti and the ETH Zurich Foundation.

Spälti passed away peacefully on 13 November 2014 at the age of 97 having lived a long, fulfilling life. He grew up in the Canton of Zurich and embarked on a degree in the Department of Electrical Engineering at ETH Zurich in 1935, where he wrote his doctoral thesis under Karl Kuhlmann, a professor of theoretical electrical engineering and electrical machine construction. Later, Spälti worked for Albiswerk Zürich AG; Brown, Boveri & Cie (now ABB); and for a long time Landis + Gyr, where he was technical director and patented several of his inventions. He was also involved with the Swiss Physical Society for many years and even continued to travel around the world during his retirement as an official for the International Electrotechnical Commission.

As requested by the donor, the newly inaugurated Dr Alfred and Flora Spälti Fund will promote science and technology, especially in the fields of electrical engineering, energy research (including nuclear technology), communication engineering and physics.

Illustration: Dirk Brockmann; picture credits: Alessandro Della Bella



President's column

ETH inside

In my first column, I would like to take you on an imaginary little journey. Nowhere exotic. Just your run-of-the-mill working day: We jump in the car early and drive to work. The screen on the dashboard warns us about the risk of black ice. Once in the office, we answer the first few emails, scan a document and send out a couple of polls to help schedule upcoming meetings. Then the day shifts up a gear; lots of meetings. We just about manage to squeeze in a sandwich at lunchtime, washed down with an espresso and a Lindor chocolate. On the way home, a report comes on the radio about the latest statistics regarding the punctuality of Swiss trains. Home at last: our granddaughter is coming over this evening and wants to watch *Rapunzel* together. How could we refuse?

That's all well and good, I hear you say, but what has it got to do with ETH Zurich? Quite a bit, actually. Major automakers around the world use software made by AutoForm for sheet metal forming. The company is a spin-off of ETH Zurich – just like Sensirion, the company whose humidity and temperature sensors are built into one in every five cars. A computer mouse that doubles up as a scanner stems from technology developed by the ETH Zurich spin-off Dacuda. And many of us rely on Doodle to create scheduling polls – an application that also originated at ETH Zurich. Our food technologists made sure that Lindor chocolates melt so delicately in your mouth, and algorithms developed at ETH Zurich have been used to optimise Switzerland's increasingly hectic train timetables for years. Finally, Rapunzel's hair gleams so magically in the fairy-tale film thanks to the expertise of the Disney lab located at ETH Zurich. You could call this ETH inside, or how ETH Zurich accompanies you and me through daily life without us even noticing. The list of technologies that started out at our university goes on and on.

Usually the spotlight falls on the larger and more spectacular collaborations. Today I deliberately wanted to draw attention to ETH Zurich's numerous contributions behind the scenes. Competitive advantages, technological leadership and product innovation are the hallmarks of our new companies, emerging from small- and large-scale collaborations between our university and industry. These partnerships play an even more important role for Switzerland as an export nation now that the Swiss franc has become stronger. So consider this the next time you are sitting in your car or enjoying a piece of chocolate: many products have ETH inside, even though it might not say so on the outside.

Lino Guzzella has been president of ETH Zurich since 2015 and a full professor of thermotronics since 1999. He was rector of ETH Zurich from 2012 to 2014.

Illustration: Tomas Fryscak

Full steam ahead

A training centre, not a games room: students and SBB trainees alike learn their trade in the ETH railway operations laboratory.

TEXT Corinne Hodel PHOTOGRAPHS Oliver Bartenschlager

Michael Fürer welcomes his class: "I'm delighted that you're all on time – despite the driving snow." And he should know. In his job, the rail traffic controller has seen first-hand how the weather can bring public transport to a standstill. He works in the signalling centre in the Zurich district of Oerlikon, where he directs trains to Effretikon or Niederglatt three days a week. The rest of the time he spends training budding rail traffic controllers. Today he has brought his class to ETH Zurich's Hönggerberg campus, where there is a railway operations laboratory in the building that houses the Institute for Transport Planning and Systems. Despite its location in a basement room with no natural light, the laboratory is still guaranteed to set any railway enthusiast's pulse racing.

More than half a kilometre of track winds its way around the model railway. Space enough for Jonas Bühler, Manuela Marty and the other eight trainees to let off steam,

Aspiring rail traffic controllers: Manuela Marty and Jonas Bühler are fascinated by railways.

practise and play out various scenarios from their everyday work. The aim of today's visit to ETH Zurich is to cement their background knowledge and practise normal operations. Dealing with faults will come later. "That would be overshooting the mark", says Michael Fürer. This is only his fourth visit to the railway operations laboratory with his class. The model railway belongs to ETH Zurich, but the university shares responsibility for its upkeep with SBB and Siemens.

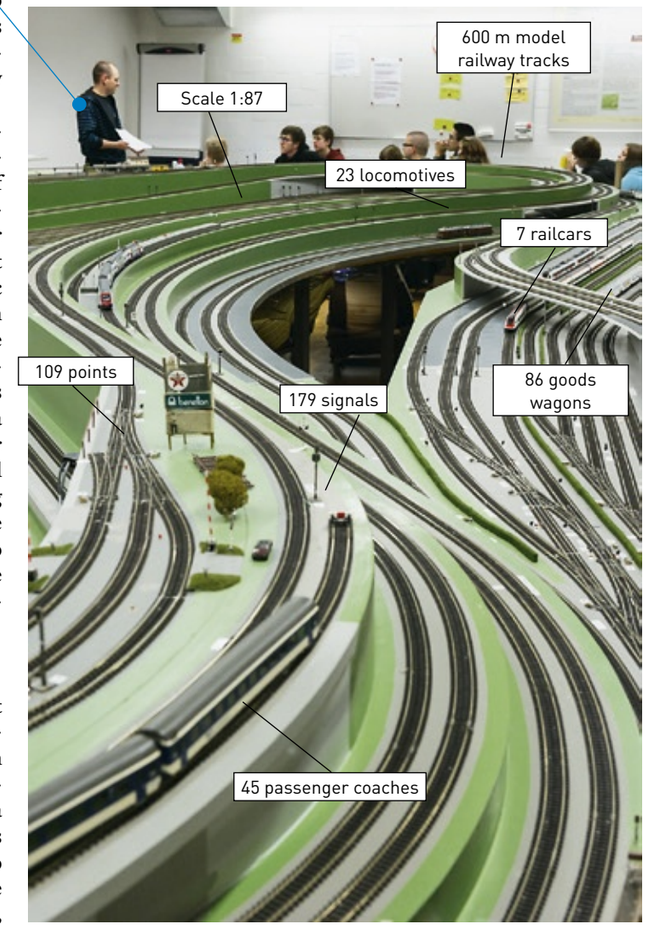
Manuela and Jonas like to visit the railway operations laboratory. "Unfortunately, it's a bit dull at school", comments Manuela. Jonas adds: "And in our day-to-day work we aren't allowed to do anything by ourselves yet." But here they can work the levers, switches and buttons themselves – and make mistakes. "This is where the mistakes have to be made that can't happen at work. That's how they learn the most", says their instructor Fürer. "I would only be unhappy if they were to keep repeating the same mistakes."

Overall, he is very patient with his students because they are still absolute beginners. They are currently in their third year of training as public transport managers specialising in the railways. Since last summer they have been enjoying their first contact with their future occupation as rail traffic controllers. As they have selected this option in their third and final year of training, the additional instruction for rail traffic controllers will be reduced from eight to six months – if they decide to go for it, that is. Manuela und Jonas did not have to think about it for very long. They are both sure that they will sign up for the six months after completing their training. "I like the technical side of the job", says Manuela as she turns the switch to set the points. "I wouldn't want to spend the whole day in front of a computer screen writing letters."

Not a computer game

Manuela works for the Rhätische Bahn at Landquart station, Jonas in the SBB Operations Control Centre East located at Zurich Airport. But today they are both in Zetthausen for a timetable simulation. Zetthausen is a fictional station in the model system and has the second oldest signal box, dating back to the 1940s. While operating a signal box like this one will not be part of their future duties, a few stations in Switzerland still have these electromechanical signal boxes. Most of the routes today have ultra-modern control systems; everything is done electronically by computer. In the past, the railway service manager had to use all his strength to move the large lever to control the cables and set the points outside, but today, points, barriers and signals are controlled with just a few clicks of the mouse. This is why the training sessions at ETH Zurich always focus on helping the trainees develop a feeling for what is happening outside when they are in front of the computer. "Every red line on the screen is a train with passengers", stresses Fürer. "This is not a computer game." The model allows the trainees to see the direct results of ›

OUT OF THE AUDITORIUM
ETH Zurich also uses the railway operations laboratory for its own teaching purposes. The curriculum for the Master's programmes in Spatial Development and Infrastructure Systems and in Civil Engineering includes practical exercises with the model railway for students specialising in transport.

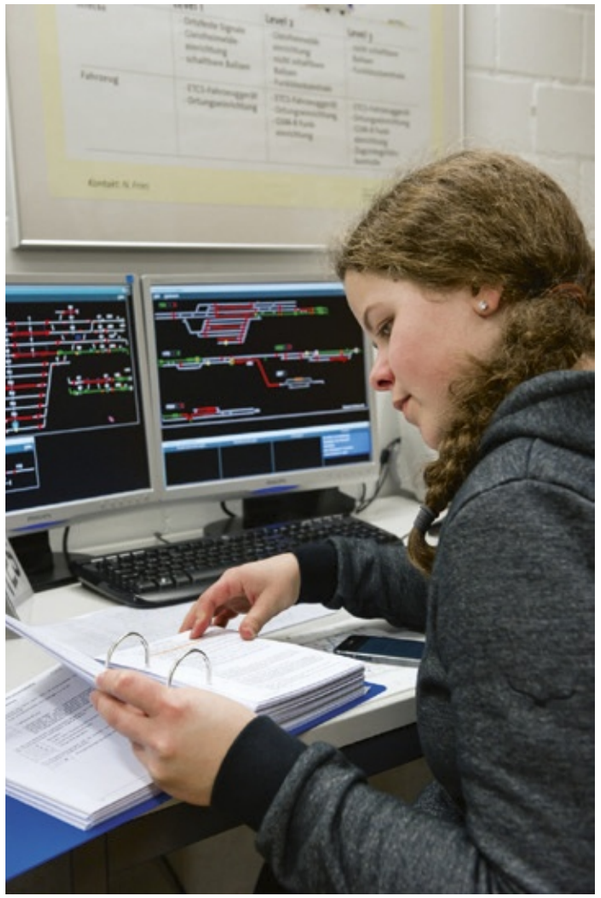


Michael Fürer is an instructor and enthusiastic railwayman.

"There's no margin for error in our line of work."

their actions. Not only do the drive mechanisms make a noise – you can also hear the relay switches click-clacking in the next room. The model railway promotes an awareness of participants' radius of action.

At Operations Control Centre East at the airport, Jonas watches planes taking off every ten minutes but does not see the trains arriving and departing. Even Zurich's main railway station has been controlled from the airport since May of last year. In a few years there will be only four SBB Operations Control Centres left: at Zurich airport, and in Lausanne, Olten and Pollegia. This development is likely to break the heart of many an old stationmaster who once directed trains on the platform with a signalling disk.



The operating regulations must be learned by heart.

But the Zetthausen model railway is operated manually – by Manuela und Jonas. It is actually close to midday, but Fürer has set the large screen clocks, which you cannot miss hanging on the wall, to 5.55 a.m. A one-hour timetable simulation is scheduled to begin in five minutes. Fürer could also make the clocks run faster, but that is only in training sessions for advanced students. For the trainees, the normal speed is already fast enough. In one hour the six passenger and goods trains will be running a good 20 minutes late – at least, the ones which are still running at all.

But Fürer is right in his element and very happy. He sees every mishap and false move as an opportunity for the trainees to learn another important aspect – and never forget it. That is why he does not engage in a detailed round of evaluations in which every move is analysed afterwards. He much prefers to intervene in real time and gives Manuela and Jonas plenty of time to decide on the next steps. The fact that punctuality gets completely left behind is not important to him. Fürer succeeds in mastering the impressive balancing act between his two roles: today the understanding and patient teacher, tomorrow the conscientious and busy rail traffic controller.

A feeling for planning

Manuela and Jonas are needed. Fürer has contacted them by radio – which is still an important part of the job, even in the era of smartphones. A train is ending its journey unexpectedly in Zetthausen. Onto which one of the three tracks should it be shunted? The trainees practised this situation in the morning as one of four case studies. Fürer and the other two trainees played through various situations in small groups. Zetthausen is particularly tricky: as the station does not have an underpass, there is no ideal solution. Whenever there is a train at a platform, there is always the possibility that passengers may try to climb on board. In the absence of an underpass, dangerous situations can always arise when a train is shunted to a particular track and normal operations continue. "The model railway gives them a feeling for planning", says Fürer. That is why the little figures in the model railway scene are not just a nice decoration for enthusiasts – they render the situation more lifelike and tangible. Ultimately, it all comes down to passenger and

Appearances can be deceptive: the training day at ETH Zurich demands a lot from the trainees.

staff safety. Training is also about making the students aware of this responsibility. "As a rail traffic controller, there's no margin for error", says Fürer.

A thick folder with all the operating regulations ensures that everything goes smoothly on all the tracks. The Federal Office of Transport (FOT) regulations are on the white pages, and the SBB supplements are on the green ones. The trainees' folders still look rather new – unlike the teacher's copy. They are still cautiously looking up rules and symbols. Working with the file takes practice, which is why Fürer keeps telling them to "look in your folder" all day long. Spoonfeeding will not help his protégés at all. But Fürer, too, has to do his homework and make sure he knows the rules. "The trainees are an additional incentive for me to keep up to speed", he says. "Working with students helps me stay young."

Full of praise

The first simulation round is over. Fürer wants to know how his students fared. It quickly becomes obvious that there was some confusion – not because there was too little communication, but because there was too much. "You really must only communicate the essentials", sums up Fürer. What is of interest to a construction worker, what to a train driver? These are the questions that rail traffic controllers must ask themselves.

Even if some things went wrong during the simulation, Fürer is full of praise in the ensuing feedback session. He describes mistakes as "wonderful situations in which you can learn a great deal". He knows how to motivate his students. And they cannot wait to get their teeth into the next simulation. ○

Railway operations laboratory:
→ www.ivt.ethz.ch/oev/eisenbahn/index_EN

NO NOSTALGIA HERE

Although SBB now uses state-of-the-art technology, one in three stations still has a signal box dating back to the 1960s. These systems are extremely robust and highly cost-effective. There are even some electromechanical signal boxes from the 1940s that are still in operation in isolated cases.

CONNECTED

1 *Executive Board*

HANDING OVER THE BATON

The new members of ETH Zurich's Executive Board took over their functions at the beginning of January (from left): Robert Perich, Vice President Finance and Controlling, Sarah M. Springman, Rector, Lino Guzzella, President, Roman Boutellier, Vice President Human Resources and Infrastructure, and Detlef Günther, Vice President Research and Corporate Relations. The baton was ceremoniously handed over at the Executive Board's Christmas drinks reception in December. After almost eight years in office, ETH Zurich's President Ralph Eichler symbolically passed the reins to the new ETH President Lino Guzzella. The reception in the main hall for the Executive Board and members of ETH Zurich was an enjoyable event for all attendees.

2 *Optotune*

SUCCESS WITH OPTICAL LENS

The ETH Zurich spin-off Optotune, founded in 2008, has succeeded in simulating the human eye in a technical system with just one optical lens. The novel materials and underlying technology are truly unique. This makes Optotune a world leader in specific adaptive optical elements and products – reason enough for a group of alumni from MAS MTEC to visit the young company. After an introduction by the CEO and ETH alumnus Manuel Aschwanden, the visitors were shown around the laboratories and production cleanroom, which is normally closed to visitors in order to protect trade secrets.

1 *Executive Boared*

2 *Optotune*

Optotune received the Swiss Economic Award 2014.

3 *Landis+Gyr*

4 *Whisky Seminar*

5 *Watch pioneer*

3 *Landis+Gyr*

SITE VISIT

ETH Zurich alumni from the Supply Chain Management MBA course paid a visit to Landis+Gyr in Zug. The company is a market leader in measurement devices for energy, water as well as heat and offers comprehensive energy management solutions. The head of Supply Chain Management at the site, alumnus Matteo Birolini, showed the group around the modern production plant where they craft highly specialised products.

4 *Bernhard & Risto's Whisky Seminar*

HIGH-PROOF EXPERTISE

The second whisky seminar for ETH Alumni was held in the Alumni Pavilion on two winter evenings in January. The seminar, organised by ETH Zurich alumni and whisky enthusiasts Bernhard Leuenberger and Reto Schmid, was fully booked in no time. The two friends have been visiting Scotland and its distilleries for more than ten years and enjoy passing on their expertise.

5 *Watch pioneer*

UNBREAKABLE

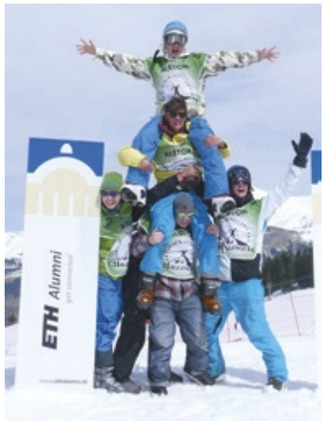
ETH Zurich alumnus Jack Heuer is one of the greats in the history of the Swiss watch industry. He studied at ETH Zurich from 1952 to 1957, eventually graduating as an electronics engineer specialising in management science and manufacturing technology. During a visit to his alma mater at the end of December, he shared his experiences as an entrepreneur with young ETH Zurich students in a discussion with moderator Rolf Probala.

Picture credits: Markus Bertschi; Heidi Hostettler (2); CFV (2)

Picture credits: Frank Nungesser (2); ETH Alumni; Tom Kawara

Agenda

EVENTS



26–29 March 2015
Challenge
Legendary contest between ETH Zurich and EPF Lausanne: For four days, the participants pit their wits against each other in different disciplines on and off the ski slopes. There are also extraordinary evening events and parties. The two universities take it in turns to organise the competition. The Challenge ´15 organising committee comprises 14 students from EPF Lausanne, who are supported by two students from ETH Zurich, all on a voluntary basis.

Alumni Club ChallengeX:
→www.alumni.ethz.ch/association/clubs/challengex/
General information on the Challenge:
→ www.challenge15.ch

A photograph of the spiral galaxy M74

Treffpunkt Science City

THE UNIVERSE

15–29 March 2015 What happened during the Big Bang? How big is the universe and where does it end? Will quantum physics revolutionise our view of the world? In the spring instalment of Treffpunkt Science City, we gaze deep into space. Researchers from ETH Zurich take you on a journey to the origins of being, humankind's view of the world and the question of what we will believe in tomorrow. And if the weather co-operates, you can peer through the telescope on the Hönggerberg, too.
Programme and registration:
→ www.treffpunkt.ethz.ch

BrainFair 2015

THE SENSES

16–21 March 2015 The senses enable us to be in touch with the world. Our sensory organs perceive and process stimuli from the outside world, but also from our bodies. Traditionally, there are five senses: sight, hearing, smell, taste and touch. Since the 19th century, however, the list has also included the vestibular sense – the sense of the body's position and movement. These were joined by proprioception – an individual sense of the relative position and movement of individual body parts in space. Are there any more senses? BrainFair 2015 reveals what we know about sensory functions today. Information at:
→ www.brainfair-zurich.ch

Picture credits: ETH Alumni; NASA

31 March 2015, 6.15–7.15 p.m.
From the lecture theatre to the trenches
Members of ETH Zurich in the First World War: materials and stories from ETH Zurich's University Archives.
Public evening tour (in German).
ETH Bibliothek
→ www.ethz.ch/abendfuehrungen

21 April & 19 May 2015, 6.15–7.15 p.m.
Underneath ETH Zurich
Explore the dynamic underground storage system on the Hönggerberg campus, which makes optimum use of waste heat (tour given in German).
Piazza ETH Hönggerberg by the information board
→ www.ethz.ch/abendfuehrungen

2, 5 & 6 June 2015, 7:30 p.m.
Alumni Symphony Orchestra Spring Concert 2015
Anton Bruckner: Symphony No. 8 in C minor, Conductor: Johannes Schlaefli
Steinerschule Wetzikon (2 June)
Stadtcasino Basel (5 June)
Tonhalle Zurich (6 June)
→ www.alumniorchester.ch

EXHIBITION

Until 29 March 2015
Matt Mullican: Prints and drawings
ETH Zurich's Collection of Prints and Drawings has been collecting works by the American artist Matt Mullican for more than 20 years. One of the highlights of the exhibition is a wooden box with 16 compartments containing 554 pastel rubbings, which was purchased in 1993. This extensive edition features illustrations from the Edinburgh Encyclopædia (published between 1808 and 1830).
Collection of Prints and Drawings, ETH Zurich
→www.gs.ethz.ch

15 April to 21 June 2015
Dan Graham – with an intervention by Günther Vogt
Dan Graham has been regarded as one of the most influential protagonists of conceptual art since the 1960s. His most recent works include the design for the Roof Garden at New York's Metropolitan Museum, which he realised in cooperation with the landscape architect and ETH Zurich professor Günther Vogt. Graham and Vogt now present their next collaboration.
ETH Zurich, Hönggerberg, HIL, gta exhibitions
→ www.gta.arch.ethz.ch/ausstellungen

Book tip

MILESTONES IN COMPUTER ENGINEERING

The front cover of Herbert Bruderer's latest book (in German: *Meilensteine der Rechentechnik*) features an extremely rare mechanical calculator from the 19th century, which was rediscovered in ETH Bibliothek's Sternwarte Collection in 2014. It was built by Jean-Baptiste Schwilgué, the creator of the astronomical clock in Strasbourg Cathedral. In his book, Bruderer describes new findings from Germany, Austria, Switzerland, Liechtenstein and France. He also mentions the early days of information technology in Switzerland: the Zuse machine Z4 at ETH Zurich (the only university in mainland Europe to have a working computer in 1950), Ermeth (the first Swiss computer) and Zuse calculator punch developed in Germany on behalf of the Zurich-based company Remington Rand. The findings from ETH Zurich's archive are commented on in detail in the extensive bibliography.

Picture credits: Alumni Sinfonieorchester; Metropolitan Museum; De Gruyter

Engineering on the brain, business in the blood

Dipl. Ing. Fust: a household name in Switzerland – the place to go for discount domestic appliances. What very few people know, however, is that the man behind it all is an entrepreneur in the tool engineering sector.

TEXT Martina Märki PHOTOGRAPH Daniel Winkler

His father would have preferred his son to become an electrician. When he persuaded his parents to let him go to grammar school, however, he already knew that he wanted to study at ETH Zurich one day. Even as a 16-year-old school boy from a modest background, he earned decent pocket money selling second-hand mopeds. He gained his first taste of the stock market and bought his first shares at the age of 19 – "Perhaps not always successfully, but mostly", explains Walter Fust. "Business is in my blood", says the now 73-year-old, "but I've always been an engineer, too."

The businessman

He founded the company Fust, which would eventually become Dipl. Ing. Fust AG, in 1966 as a dynamic young entrepreneur fresh out of university. He completed a degree in mechanical engineering at ETH Zurich as quickly as possible, not because it didn't interest him – "I studied mechanical engineering at ETH Zurich because I was convinced it was my calling", he says – but because he had to finance his own degree. How did he do it? By selling mail-order electrical domestic appliances alongside his studies. He spent one day a week importing lower-priced appliances from Germany, which he would sell in Switzerland via classified ads in the newspaper. "I didn't make a bad living from it, either", affirms Fust with a grin. "Those were the days!" He even managed to afford a fancy car, which he would park right outside ETH Zurich's mechanical engineering lab: "You'd be lucky to even leave your bike there these days."

The experience he gained from his little mail-order sideline during his time at ETH Zurich came in extremely handy when he eventually started his own business. Even in the company's first year, 1967, it recorded a turnover of 1.5 million Swiss francs. From that point on, the company kept growing.

Fust didn't exactly make many friends with the large-scale development of his discounter business. The response from the electrical appliance trade, which was virtually run like a cartel in Switzerland in those days, ranged from shock to spite. "The electrician and plumber associations controlled everything", recalls Fust. "I was a price-cutter and some suppliers boycotted me completely." He carried on building his discount business regardless, even taking over rival firms. Thanks to his entrepreneurial flair, branches soon sprang up all over the country. A map of Switzerland covering the entire wall still hangs in his modest office, which you eventually reach by weaving your way through the labyrinth of fridges, vacuum cleaners and bathroom accessories at the two-storey Fust headquarters in Niederwangen in the Canton of Berne. Colourful pins still mark the spot for Fust projects past and present. "That map's 30 years old – I don't get involved in Fust AG anymore", says the company founder.

The real estate mogul

This assertion is hard to believe, especially if one continues to look back on the company's history. Fust AG broadened its range of products to include small appliances, kitchen accessories and, in 1989, even consumer ›

"I studied mechanical engineering at ETH Zurich because I was convinced it was my calling."

ABOUT

Walter Fust

- Born in 1941
- Grew up in Uzwil (Canton of St. Gallen)
- Studied mechanical engineering at ETH Zurich from 1960–1964
- Founded the company Fust in 1966
- Stepped up his activity in the mechanical engineering industry from the 1980s
- Established the Starrag Group and invested in other companies such as Tornos

"If left to their own devices, engineers can sometimes be dangerous people."

ACTIVITIES

The company Fust
- Founded by Walter Fust in 1966
- Swiss specialist chain for electrical household appliances and consumer electronics
- Kitchen and bathroom renovations
- More than 160 branches and around 2,000 employees all over Switzerland
- An independent subsidiary of the Coop Group since 2007

Starrag Group
- Companies in the Starrag Group develop processing centres and flexible manufacturing systems for small, medium-sized and large pieces of machinery and deliver them all over the world
- Walter Fust takes over majority of voting rights and capital in the late 1980s
- Chairman of the Board of Directors from 1992
- Acquisition of the Heckert factory in Chemnitz in 1998
- SIP takeover in 2005
- Other companies that are integrated in the Starrag Group: Berthiez, Bumotec, Dorries, Droop+Rein, Scharmann, TTL, WMW.

electronics. He began to do a roaring trade in real estate, too. "The retail business always means having locations, too. We already bought key strategic property or built it ourselves from very early on", explains Fust. Then, much to the surprise of some people, the company was sold to Jelmoli in 1994. "By that stage, I'd realised that the company was too small to break into the European market", says Fust, justifying the decision. Besides, none of his three children had any interest in the business.

Fust became Jelmoli's second-biggest shareholder. However, the company was in trouble and Fust offered to buy back Dipl. Ing. Fust AG two years later: "This time, the boot was on the other foot: I bought the entire block of Jelmoli shares from the majority shareholder UTC and actually became the majority shareholder in the Jelmoli Group." With Fust at the helm, the department store chain was converted into a real estate group. During this period, for instance, the large shopping centres near Servette FC football stadium in Geneva and the St. Gallen stadium were constructed with Walter Fust as the building contractor – projects he recalls fondly. Dipl. Ing. Fust AG was eventually sold to Coop in 2007 in the course of the reorganisation of Jelmoli Holding.

The engineer

By then, Walter Fust had turned his attention to other interests because his passion for mechanical engineering was as strong as ever. "I'd always been interested in the mechanical engineering industry and made sure I kept myself in the loop", stresses the ETH Zurich graduate. He had already begun to buy shares in the company Starrag back in the 1970s and even gave a presentation on the global producer of so-called copy milling machines while he was still at school. "I've still got the notes for that presentation", says Fust as he lays a yellowed sheet of paper covered in neat handwriting and technical drawings on the table. Fust became Chairman of Starrag's Board of Directors in 1988, at a time when the company wasn't doing particularly well. "Actually, I used my block of shares to muscle my way in", he reflects.

He couldn't just sit back and watch: "They were running the place into the ground." The company, which had employed more than 1,000 people in its heyday, only had 200 employees by that stage. According to Fust's analysis, his predecessors made decisions that were geared too much towards engineers and lacked business acumen.

He is going change all this. With him in charge, one thing is clear from now on: "We can't afford to play games." The entrepreneur is also providing a sound capital base and succeeding in giving the company a new lease of life. A few years after the reunification of Germany, he took over the Chemnitz-based company Heckert, which was also in the mechanical engineering sector and had a good, traditional reputation. Nevertheless, it was in a desperate situation and teetering on the brink of bankruptcy. "A carefully considered gamble", says Fust. By doing so, he paved the way for today's Starrag AG with a global outlook.

Further expansion often takes place according to a well-rehearsed model. Fust observes well-reputed companies on a long-term basis and takes over as a controlling shareholder if they fare badly. This includes SIP, another traditional machine tool manufacturer, which first came to Fust's attention during his ETH Zurich years. "Eventually, I just had to say that they weren't doing a good job: nice companies, good reputations and there they are mismanaging it all – I simply had to step in." His philosophy: you need to invest blood, sweat and tears, have a grasp of engineering – and a healthy dose of business acumen. "If left to their own devices, engineers can sometimes be dangerous people", says Fust. Not enough business sense.

On the other hand, he appreciates solid technical knowhow, which, in his opinion, isn't taught enough in schools these days. He is glad that mechanical engineering once again enjoys a high profile at ETH Zurich. He is in regular contact with talented young ETH Zurich students and their ideas as the sponsor of the Pioneer Fellowships and co-founder of Inspire, the Technology Transfer Centre founded on the initiative of ETH Zurich and Swiss industry. "There are a few people in our development department who we got to know this way", says Fust. ○

5 QUESTIONS

As a climate researcher, Reto Knutti often seeks a dialogue with the public: *"I've never felt like I was stuck in an ivory tower."*

1 *What was your first encounter with ETH Zurich like??*

Let's just say it wasn't love at first sight. After I attended an open day as a secondary school student, I was convinced that it had been my first and last visit: ETH Zurich was too big and elitist for me. Now I visit secondary schools as part of "ETH unterwegs" – ETH in motion – a series of events to tell young people about the opportunities that science and a degree at ETH Zurich can offer. I often compare ETH Zurich to a city: at first glance, it doesn't seem particularly inviting. But once you realise how much it has to offer, you won't be able to tear yourself away.

2 *What makes a good teacher?*

It's easy to remember a tune that we like. But we find it extremely difficult to learn a telephone number off by heart as it is difficult to identify it with anything we know. Out of context, facts are meaningless. So it's more a question of arousing students' curiosity than teaching them as much information as possible. Students need basic knowledge, of course. But above all they have to learn to approach information critically, to place it in a wider context and draw conclusions from it. As a teacher, it's my job to help them develop these skills.

Reto Knutti is a professor of climate physics at the Institute for Atmospheric and Climate Sciences. → www.iac.ethz.ch

3 *How useful are large-scale projects?*

They're necessary if we are unable to achieve or fund objectives by ourselves. They are often successful when there is a precise goal and all participants can plan and deliver their part of the project, like on a satellite mission. But large-scale projects require clear structures and a great deal of coordination, and this limits innovation. The fact that you have to describe the result and utility beforehand in a research proposal restricts you. Research is creative and requires flexibility and freedom. None of my best scientific ideas have ever been in a research proposal; many of them came to me spontaneously during coffee breaks.

4 *How do you break out of the ivory tower?*

I've never felt like I was stuck in an ivory tower. This image represents an outdated attitude, where science regards itself as sacrosanct and doesn't participate in public debate. This doesn't make any sense for topics like climate and environment, which are relevant to society. We can only tackle these challenges in dialogue with society, which is why I approach students and the media, write blog entries and give talks. We're also trying to use new forms of communication, such as the "Workshop discussions" video series we post online.

5 *Which mistake have you learned from the most?*

I wouldn't call it a mistake as much as an adjustment of my world view: as a student, I often thought that you became an expert if you learned from lecturers for long enough. But life is a constant learning process, which – much like our personal development – is never complete.

— Interview by Felix Würsten

Picture credits: Giulia Marthaler