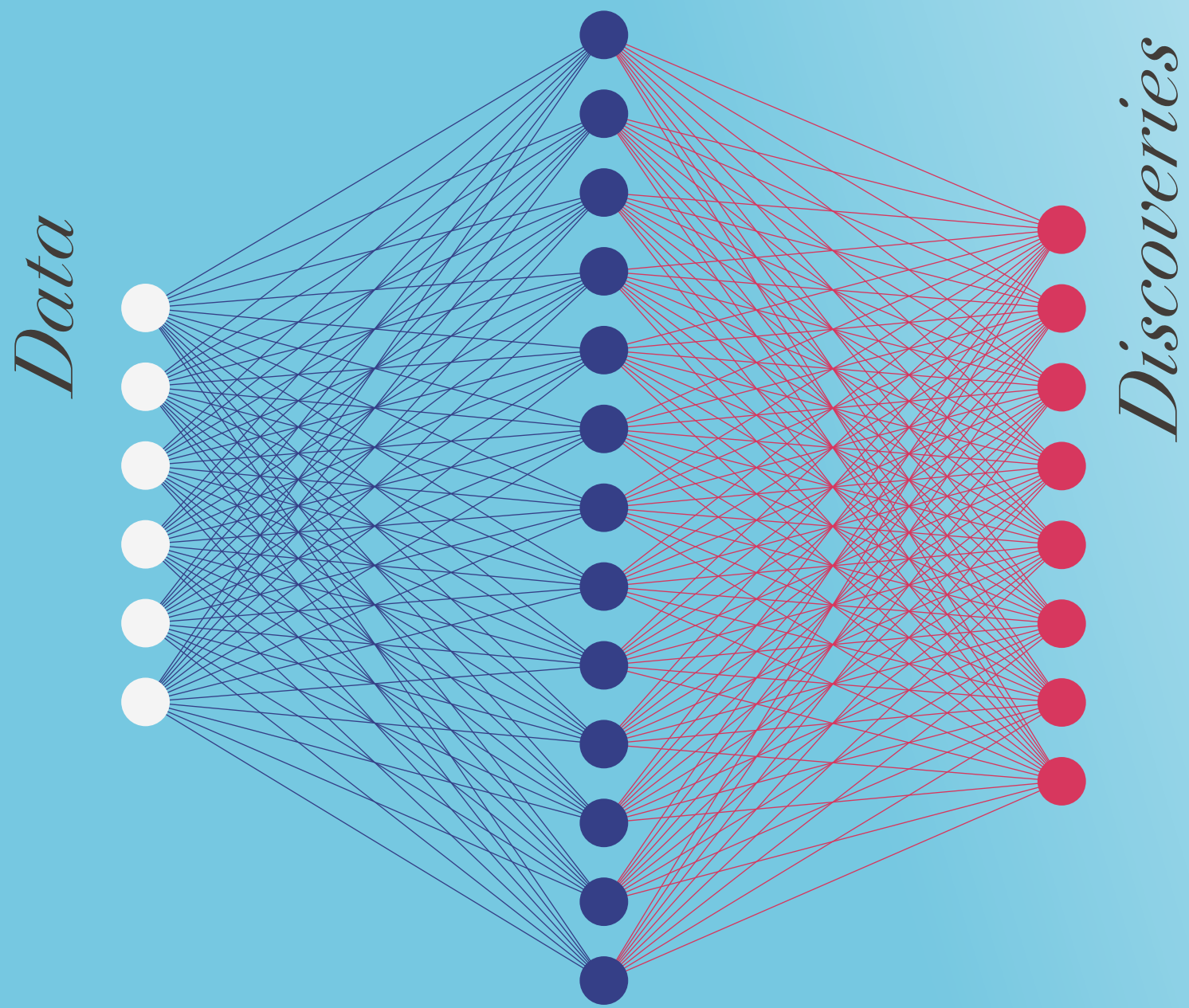

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Beware the *Sirenum silici*

Artificial intelligence can already win at poker games, commentate on sports matches and create works of art. Nothing is holding it back in the fields of science either. It's enabling linguists to unravel text corpora, physicists to conjure up new materials, and biochemists to orchestrate hundreds of experiments on the double. It's become so creative there are now prototypes capable of transforming observations into original hypotheses.

Unlike in some sectors, the prospect of job losses in research isn't yet a source of worry. There is, however, a strong chance that science will never be the same, not to mention the even greater likelihood of being lured in by the call of ever more, ever faster results. If we let ourselves follow the machines' way of thinking, however, we'll be sailing into a perilous trap.

Faced with this, we must continue to chart a course based on sound epistemology. We've seen how computer-generated mathematical proofs supersede our individual abilities to read, verify or even understand them. In principle, the average algorithm proceeds using relatively simple steps; in practice, however, matters are quickly complicated. Results are spewed out in such volumes that it's humanly impossible to follow their 'reasoning', stripping us of all but blind faith. And what use is an opaque result that we don't understand anyway? Furthermore, is science the sum of its results or the sum of its methods?

According to the physicist Richard Feynmann, science is an attitude. "It's a kind of scientific integrity, [...] – a kind of leaning over backwards. For example, if you're doing an experiment, you should report everything that you think might make it invalid". It'd be naïve to leave this key step to a computer program. Given that robot researchers are here to stay, we should seize the opportunity instead to spurn algorithmic reasoning. After all, humans' strength is discursive, counterfactual thought. Even unconventional thinking has its place. Let's be frank, there's no comparison between the very soul of science and a pipette-wielding robotic arm.

Daniel Saraga, chief editor

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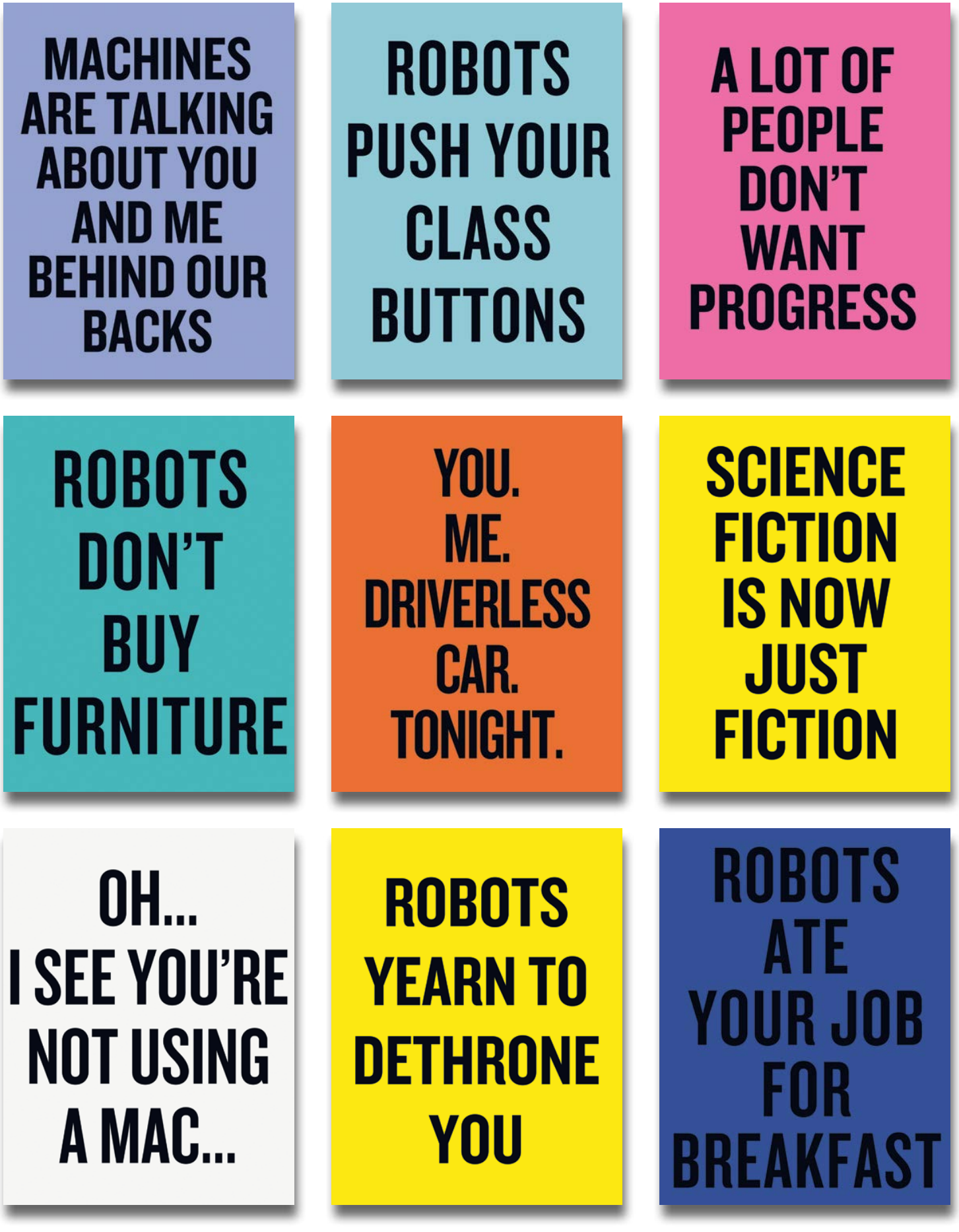
Swiss National Science Foundation

swiss academies
of arts and sciences

horizons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ROBOTS PUSH YOUR CLASS BUTTONS
A LOT OF PEOPLE DON'T WANT PROGRESS
ROBOTS DON'T BUY FURNITURE
YOU. ME. DRIVERLESS CAR. TONIGHT.
SCIENCE FICTION IS NOW JUST FICTION
OH... I SEE YOU'RE NOT USING A MAC...
ROBOTS YEARN TO DETHRONE YOU
ROBOTS ATE YOUR JOB FOR BREAKFAST

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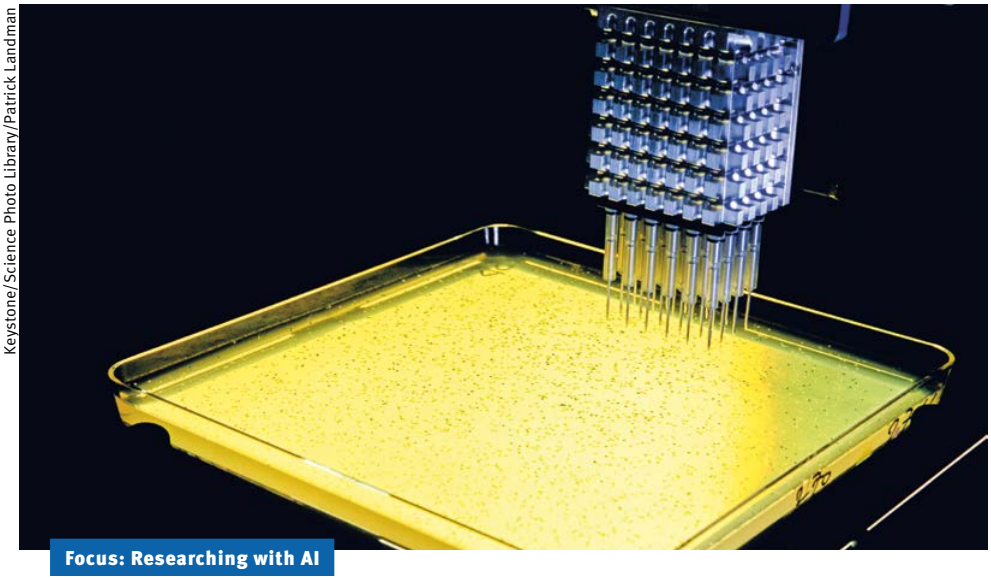

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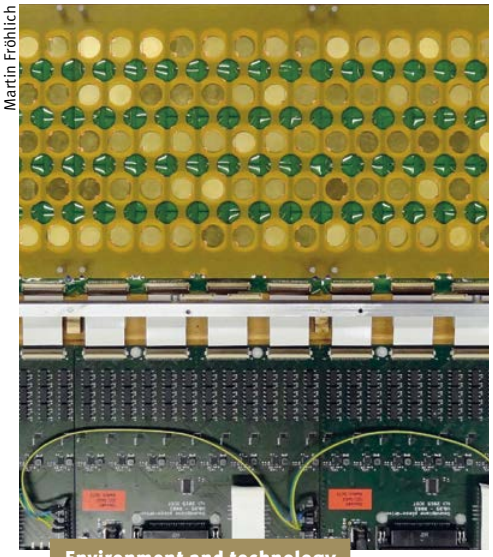

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"It is precisely because we believe in this wonderful country that we should support the forces for change with this boycott".

Should researchers boycott conferences in the US?

President Trump's entry ban on people from largely Muslim countries also applies to researchers. Would a boycott of science conferences in the US be a fair, useful means of protest against this?

Manu Friederich

"A boycott might have no impact on the Trump administration, while affecting the Swiss scientific arena instead".

The USA is undoubtedly the most important 'scientific hub' in the world. A science conference there can be attended by some 30,000 people from all over the world. It is the site of an intellectual exchange that would not otherwise exist. For example, Swiss and Japanese researchers can meet there who would probably never see each other otherwise. These contacts are essential for the smooth functioning of the scientific community.

When President Donald Trump and his government decided to make it impossible for Iranian, Iraqi, Libyan, Somalian, Syrian and Yemeni researchers to enter their country, these colleagues were excluded from this valuable process of interaction. This discrimination on grounds of their nationality or religion is racist, it hampers scientific progress, and thus demands clear opposition from us.

This boycott should by no means be aimed at any individual US researchers. We should continue to work with them and engage in scholarly exchange with them in the USA and in other countries. But conferences affect all researchers, so they should be held in a country that will allow everyone to travel there. Canada could be a good alternative.

Of course it's doubtful whether Trump's government would be impressed by a scientific boycott. But we would not be without prospects for success, because we would be supporting the cities, universities and civil rights organisations in their efforts to achieve political change. Large-scale conferences also bring economic benefits – so it would be natural to use these as leverage in order to demand the freedom and diversity of science that is now under threat.

Yes

says Jutta L. Mueller,
a professor of cognitive sciences
at the University of Osnabrück.

Much crucial scientific progress comes from the USA. But it is precisely because we believe in this wonderful country, its institutions and its potential for change, that we should support this boycott and thereby support progress in the USA.

It is obvious that every boycott causes collateral damage. But sometimes we have to accept a minor injustice in order to combat a bigger one. Of course one would have to boycott other countries too who limit the free exchange between scientists, journalists and artists – such as Turkey. But we must weigh up the possible prospects for success in each case against the possible damage to the colleagues who would be affected. In a free country, such as the USA, the prospects for success are high, and we can hope that we would only have to maintain the boycott for a brief period of time.

Jutta L. Mueller is a junior professor in psycholinguistics and neurolinguistics at the Institute of Cognitive Science at the University of Osnabrück. She engages in scientific exchange with US scientists at conferences across the world and coordinates research visits abroad for students of many different nationalities.

Of course, boycotts can be a useful and non-violent means of protest. When Rosa Parker and the black people of Alabama refused to take the bus in protest against racial segregation in public places, it resulted in the declaration of segregated buses as being anti-constitutional. But other boycotts have backfired and produced the opposite effect. Boycotting the Trump family's products has given them even more publicity, and sales have skyrocketed. This time we should refrain from boycotting US science conferences, despite being shocked by Trump's discriminatory immigration ban on people from a selected group of Muslim countries. Such a measure today would hurt much more than it would help.

A boycott is difficult to defend on an international level, because so far the federal courts have not accepted the ban. The US judicial system defends human rights at a very high level, which is exemplary. It would also be inconsistent if we then continued to travel to other countries that do not respect human rights. It is not wise to enter into these political discussions, as we might thereby confirm the religion-based distinctions that Trump is making. Boycotting conferences in the US reduces us to the same intellectual level. It might even further expose researchers from these countries, while at the same time failing to assist them in their careers and personal development. One outcome of such a boycott could be an escalation. There might even be violent reactions against researchers, and this could be difficult to stop. We should prioritise dialogue and allow diplomacy to convince the Trump administration to change its policies – if indeed they do come into force at some point.

No

says Anna Fontcuberta i Morral,
a professor of material sciences and
engineering at EPFL.

The Trump administration is making considerable cutbacks in science funding. One way of supporting researchers in the US would be to continue visiting them, so that scholarly exchange and progress can continue, despite our harsh times. One should add that a majority of American voters – and an even greater majority of educated Americans – did not vote for Trump. His policies do not accurately represent the will of the US population as a whole.

Whether we like it or not, the US is the leading country in research. By playing this game we would be damaging leading institutions of research and innovation, so at the same time we would be harming ourselves. To be effective, a boycott has to hurt somewhere. The Monday Boycott in Alabama created a big buzz, in part on account of the financial losses incurred by public transport (because three quarters of the passengers were black). Unless the whole world follows, Swiss scientists protesting against US conferences will barely have any impact on the Trump administration, though it would certainly affect the Swiss scientific arena.

Anna Fontcuberta i Morral is head of the Laboratory of Semiconductor Materials at EPFL. During the second of her year-long research projects at the California Institute of Technology, she co-founded the US start-up Aonex Technologies.

This robot seems to be taking a break that in physiological terms it doesn't actually need. It's almost as if it's practising its human behavioural skills. But even if it could recognise love, could it ever really feel it?

Image: Reem B #7 [Pal], Barcelona, Spain, 2010. Vincent Fournier

Science ex machina

The new recruit on the team is a robot. Its scientific abilities are promising. But can human researchers rely on it, or should they fear it?

Let the robots do the tedious work

From squeezing pipettes to discovering conservation laws, machines are set to play an ever greater role in scientific research. An inquiry into the current state of automation in science.
By Edwin Cartlidge

To be able to carry out any experiment you like without leaving your desk, and without having to pick up a single test tube or look down a microscope. That is the vision of the company Emerald Cloud Laboratory, which allows biologists and chemists to design experiments, adjust and monitor instrument settings, and then analyse data with a few clicks of a mouse. Extending the concept of cloud computing beyond simple data storage and processing to the operation of real experiments over the Internet, the idea is that scientists should free themselves from dreary bench work, and use the extra time on their hands to devise better experiments.

Centrifuging in the cloud

Emerald provides this service from a warehouse on the outskirts of San Francisco. There, on rows of parallel benches, a series of liquid-handling robots, automated incubators, centrifuges and other assorted machines manipulate samples according to a precise set of instructions sent by each user through a special web-based interface. With the equipment operating more-or-less autonomously around the clock, results can arrive back on a researcher's computer within 24 hours of them having requested an experiment.

There are still very few companies that provide such a service. The first to do so was a firm called Transcriptic that was set up in 2012, and which is based in a warehouse a few miles down the road from Emerald. But already there are scientists who are enthusiastic converts. Among them is Justin Siegel, a synthetic biologist at the University of California, USA, who says that his research students can test more, and bolder, hypotheses than they could if doing the experiments themselves, and that even fresher undergraduates and school students can get involved. "They can work on designing experiments and not worry about having 'good hands' to implement them", he says.

> "Robots Adam and Eve couldn't be included as authors because they wouldn't be able to give their informed consent".
>
> Ross King

In fact, Emerald risks becoming a victim of its own success. Having started offering its cloud service last October, it currently has a list of several hundred labs waiting for time on its robots. But the company co-founder Brian Frezza is confident the backlog can be whittled down and that within about a year Emerald will offer all of the hundred or so standard experiments used in the life sciences. Currently they can run about 40. "At that point we want to be profitable", he says.

Away from the assembly line

Researchers already have a lot of experience with robots. For years, pharmaceutical companies have been using them to carry out repetitive, time-consuming tasks in early-stage drug development, while biotechnology firms rely on them for manipulating DNA – a growing demand that has been met by instrument manufacturers such as Tecan, based near Zurich. "Most of what humans can do in the lab can now be done by machines", says Ross King, a biologist and computer scientist at the University of Manchester in the UK.

Perhaps the archetype of automated science is DNA sequencing, the process of determining the order of genetic base pairs. This used to require very labour-intensive work that only a few labs could perform. Nowadays it is carried out automatically by machines that read genetic material millions of times over. Those machines are located at centralised facilities, making it unusual now for labs to do their own sequencing, according to Siegel.

What Emerald does is "fundamentally different", says Frezza. Rather than carrying out "one experiment perhaps a million times, like a car factory", he explains, "we do a million different experiments at once". But because robots are not very efficient at carrying out a series of steps one after another – as opposed to many versions of the same process simultaneously – on average, their devices are actually slower and more expensive than people would be. As such, his company is not trying to compete price-wise with existing contract research organisations, which use a mixture of robotic and human labour.

More reproducible by robots

However, the great virtue of robots, says Frezza, is reproducibility, or, as he puts it, the fact that they "always pipette in exactly the same way". Taking advantage of this ability, he says, has meant developing an instruction set that scientists can use to specify without ambiguity exactly what steps a robot needs to execute when performing an experiment. He thinks that after several years of working on the problem he and his colleagues have now developed a robust set of commands, but adds that they still need to make the interface more user-friendly. "What tends to get people's backs up is the idea that they are writing code", he says.

Richard Whitby of Southampton University in the UK agrees that reproducibility is very important. He says that humans' versatility is a great asset when it comes to carrying out the complex reactions in his field, organic chemistry, but that scientific

papers often don't spell out that complexity in full – neglecting to specify, for example, how quickly reagents should be introduced. Without knowing the value of every parameter in a reaction, he notes, it is difficult to quantify the effect of tuning certain variables in order to improve reactions.

Whitby is leading a British project called Dial-a-Molecule that ultimately aims to build a machine capable of synthesising any organic compound on demand, just as biologists today can order specific strands of DNA through the post. He is under no illusion as to how difficult this will be, pointing out that such a machine would need to carry out tens of thousands of reactions as opposed to the four used by DNA synthesisers. "We have given ourselves a 30 or 40-year timescale", he says.

Automated hypothesis testing

Even more ambitious is the vision of King and his colleagues at Manchester, who aim to "automate the full cycle of scientific research". Like the cloud-based companies, they use robots made commercially, but then hook those robots up to artificial-intelligence systems. After being educated about a particular subject using logic and probability theory, the idea is that a robot will by itself formulate hypotheses to explain observations, then devise and run experiments to test those hypotheses, before generating new hypotheses and repeating the cycle many times in an attempt to learn something new about the world.

King reckons the approach is bearing fruit, and that machines can make science both more efficient and more precise. He embarked on the research while at Aberystwyth University in the UK, assembling a robot called Adam that in 2008 successfully identified several previously unknown genes that encode enzymes in yeast. He has since developed the one-million-dollar Eve, which has gone on to discover the anti-malarial mechanism of an everyday compound known as triclosan – potentially easing the substance's approval as a pharmaceutical.

Beyond biochemistry, robots are also being used increasingly in materials science. Last year, engineers at the US Air Force Research Laboratory in Ohio reported results from a robot with artificial intelligence that had carried out research on carbon nanotubes – cylindrical molecules of carbon that are strong, light, and very good conductors of heat and electricity. The machine carried out more than 600 experiments on its own, varying conditions to try and speed up the growth of nanotubes. Doing so it confirmed theoretical predictions of the maximum growth rate.

No paradigm-shifters yet

Some researchers are even trying to automate advances in physics, although they aren't using robots as such. Hod Lipson at Columbia University in the US and his colleagues have developed an algorithm that generates equations at random and then uses an evolutionary process to select the equations that best match experimental data. In 2009 they reported using their approach to model the behaviour of chaotic double pendula, yielding what they describe as physically meaningful conservation laws. Two years later they followed that up by deriving equations describing energy production from sugar breakdown using data on yeast metabolism.

> "Students can work on designing experiments and not worry about having 'good hands'".
>
> Justin Siegel

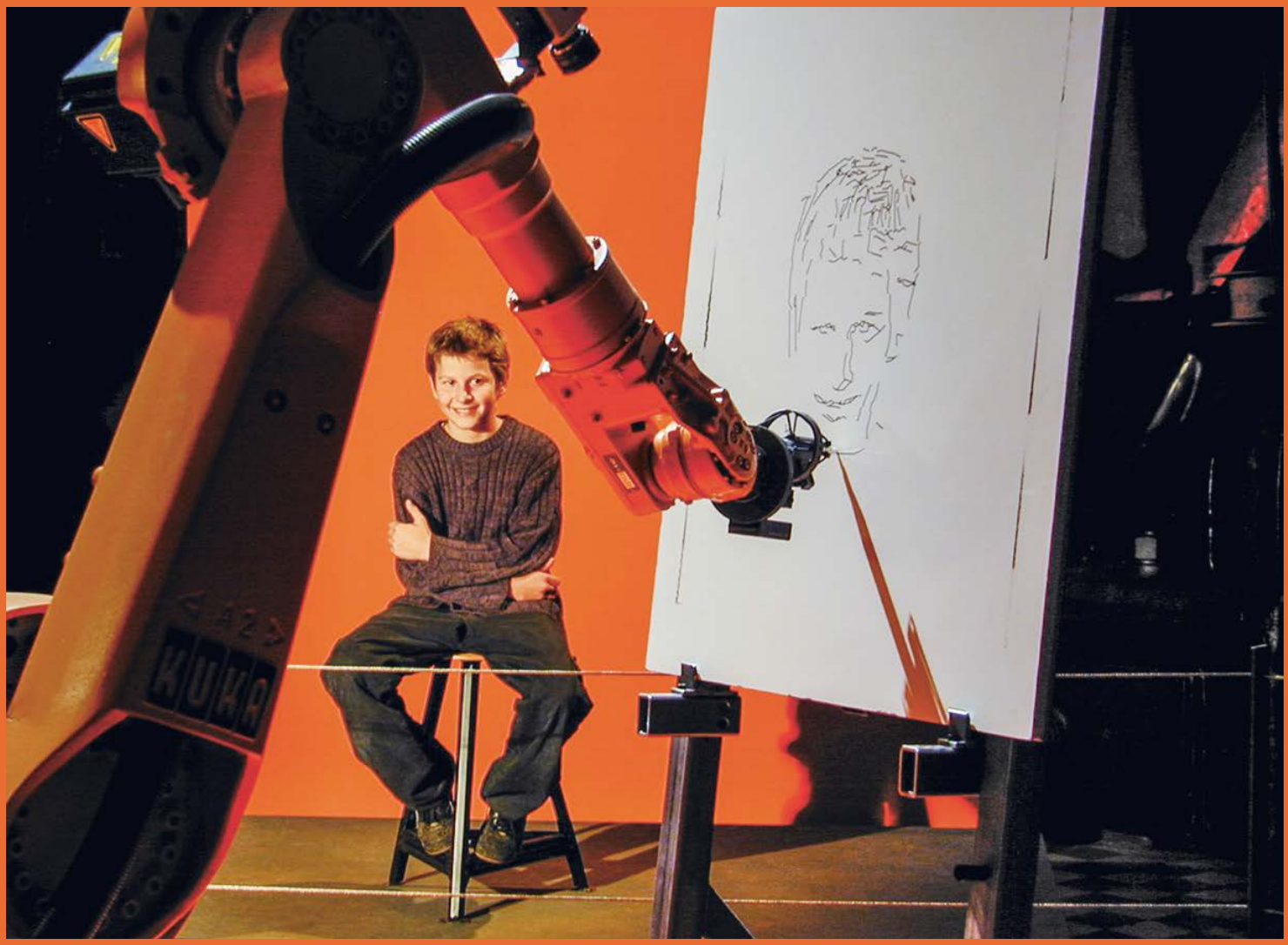
Not everyone is convinced. The American physicists Philip Anderson and Elihu Abrahams wrote a letter to the journal Science in 2009 accusing both King's and Lipson's groups of being "seriously mistaken about the nature of the scientific enterprise". They argued that even if machines contribute to what the philosopher Thomas Kuhn called "normal science", they could never transform science by discovering new physical laws – maintaining that in Lipson's research on pendula motion the "relevant physical law and variables are known in advance".

AI Glossary

- **Machine learning:** The development of algorithms capable of learning how to solve given problems by themselves (recognition, classification, prediction, translation, etc.)
- **Supervised learning:** The training of algorithms with pre-labelled material (e.g., data pairs linking an object's properties to a certain category). The algorithm builds a model capable of categorising new, unlabelled objects.
- **Unsupervised learning:** The employment of algorithms to look for structure in data but without initial training.
- **Reinforcement learning:** The rewarding of algorithms for generating results. The algorithm aims to maximise its rewards. A classic application of this kind of AI is computer chess.
- **Neural network:** A computer model based on the interconnection of a large number of artificial neurons to mimic the architecture of the brain. The network analyses an object so as to recombine its properties into increasingly complex and abstract representations, which can then be used to classify it, for example. Neural networks learn by testing new combinations.

King acknowledges the limitations of machines, pointing out that even if a robot successfully carries out experiments, it doesn't know why it's doing so. He adds that he and his colleagues wanted to include Adam and Eve as authors on their papers, but were told they couldn't because the robots wouldn't be able to give their informed consent. Nevertheless, he believes that intelligent robots are set to become more commonplace in science, thanks to the ever-increasing power of computers, improved algorithms and more advanced robotics. "They are getting better, while humans remain the same", he says. "I don't see any reason why these trends aren't going to continue".

Based in Rome, Edwin Cartlidge writes for Science and Nature.



A robot draws portraits of people in a museum. It holds its pencil in its hand, just like a human artist, but has no idea of who it's actually drawing.
Image: robotlab (2002)

Augmented Science

Artificial intelligence is becoming an ever more natural aspect of the research process. But before it can trigger a scientific revolution, researchers first have to learn to understand better just what kind of assistant they've invited into their labs. *By Roland Fischer*

Intelligent machines and self-learning systems have been keeping researchers busy for decades now. Initial reports of attempts at machine learning in the identification of genetic patterns were published over 20 years ago. And in particle physics, they've been experimenting with artificial intelligence (AI) for so long that some reviews from the year 2000 even reported a sagging interest and called for rapid revival.

"Neuronal networks were actually studied and employed in various experiments at CERN back in the 1990s", recalls Sigve Haug from the Laboratory for High Energy Physics at the University of Bern. They simply didn't call it 'machine learning' at the time.

AI everywhere

Today, the use of such AI methods in large experiments in particle physics is almost the norm, whether in data reconstruction or data analysis. And they are also often used in distributed computing, where programs have to learn when and how computing processes can be distributed in the most efficient manner. But AI isn't just omnipresent at CERN. Suddenly, the situation is very similar everywhere. Artificial intelligence is the current credo in research. Physical chemistry, molecular biology, medical genetics, astrophysics and even the digital humanities: wherever large amounts of data are to be found, AI isn't far away.

Is the development towards AI as laboratory assistant – in other words towards a mixed research team of man and machine – the next, necessary step? "Absolutely", says Karsten Borgwardt, a professor at the Machine Learning and Computational Biology Lab at ETH Zurich. "In many fields in the life sciences where we work with high-throughput technologies, we simply can't do without it any more". The amounts of data are simply too big if you want to link half a million medical histories with the corresponding genetic data. "No human being can recognise any meaningful, hitherto unrecognised patterns with the naked eye any more". Such data volumes can only be handled with efficient statistical procedures such as those currently being developed by specialists like Borgwardt. In any case, the border between statistics and machine learning is fluid today, he says.

Science on steroids

Artificial intelligence as a natural partner in the research process: this vision is reminiscent of Garry Kasparov's 'Advanced Chess' idea that he came up with shortly after his defeat against Deep Blue, almost exactly 20 years ago. In future, he said, humans should no longer play against each other or against machines, but joint man/machine teams should compete instead. This would enable the game to be raised to a whole new level, believed Kasparov: a game of chess beyond the bounds of human strategic possibilities.

> A system can truly 'over-learn': the more you train it, the worse it gets.

"Machine learning is the scientific method on steroids", writes the AI expert Pedro Domingos of the University of Washington in his book 'The Master Algorithm'. In it, he postulates something along the lines of a super-machine-learning method. By means of an intensive use of AI, research would become quicker, more efficient and more profound. This would free researchers from their statistical routine and let them concentrate wholly on the creative aspects of their work. Domingos promises nothing less than a new, golden age of science.

Not all researchers engaged with AI are keen to sing from the same happy song sheet. Neven Caplar of the Institute for Astronomy at ETH Zurich is a data nerd through and through: he runs the data blog astrodataiscool.com and has recently used machine learning to quantify the gender bias in astronomical publications.

For a few years now, Caplar has noticed a definite upswing in publications that include AI. But he doubts whether the methods in his field will allow for any big breakthrough. Astronomy is "a science of biases", he says. It's also about controlling the instruments as well as possible. For this reason, AI shouldn't be conceived as a 'black box' – in other words, AI should not be a practical tool that delivers good results, but whose precise means of functioning remains incomprehensible. When it comes to handling the observation data, their interpretation by a human researcher is still the crucial aspect, says Caplar.

The black-box problem

"Oh, this black box!", cries his colleague Kevin Schawinski (see also: 'The physics of everything', p. 30). Everyone is talking about AI being a 'black box', claiming we aren't able to scrutinise the logic and arguments of a machine. Schawinski is an astronomer, and doesn't see AI like that. From his perspective, it's simply a new research method that has to be calibrated and tested for us to understand it properly. That isn't different from any other method that science has appropriated, he says. After all, there is no one who can comprehend every single aspect of complex experimental assemblies such as the Large Hadron Collider at CERN or the Hubble Telescope. Here, Schawinski trusts the research community just as much. They know how to ensure that the scientific process functions robustly.

Together with colleagues from the computer sciences, Schawinski has launched the platform space.ml, which is a collection of easy-to-use tools to interpret astronomical data. He has himself developed a method that uses a neuronal network to let us improve images of galaxies; more information can thereby be extracted, without the computer needing further specifications. With other applications, so-called

> "Machine learning is forever walking the narrow path between blindness and hallucination".
>
> Pedro Domingos

supervised learning is employed in which there is recourse to a data training set. When pre-sorted by humans, or when provided with meta-information, these training sets help the computer to devise rules itself that can enable it to fulfil a task.

An over-eager assistant

As a biostatistician, Borgwardt uses supervised-learning methods to find out, for example, whether changes in the genome have a harmful effect on an organism. He feeds the computer with patterns that have already been determined, hoping that it will subsequently be independent enough to find hitherto unrecognised connections.

> "Having a human researcher interpret observation data is still crucial".
>
> Neven Kaplar

But there is a stumbling block: 'overfitting'. He has to check whether the computer really recognises the fundamental characteristics in the training set, or whether it is misrepresenting chance patterns as the rule while all the data rushes past. Domingos has coined a laconic phrase for this. He sees machine learning as: "forever walking the narrow path between blindness and hallucination". On the one hand, an algorithm might recognise nothing at all in the mountain of data before it. On the other hand, there is overfitting, when it suddenly begins to see things that aren't actually there. In this manner, you can actually 'over-teach' a system – the more you train it, the worse it gets.

According to Borgwardt, one of the main reasons for overfitting in genomics and medicine is that the computer's training set doesn't always have the necessary transparency. This means that you cannot always estimate how much the training data will overlap with the data that is to be evaluated later. If the sets are too similar, the worst-case scenario is that the machine cannot 'generalise', but simply applies cases it has already memorised when it finds a correlation. In this manner, we do not achieve any real knowledge gain. Artificial intelligence remains on the level of a common or garden database.

But even if everything has gone right in training, the problem remains of being able to differentiate chance correlations from real, statistically significant connections. The bigger the amounts of data, the bigger the probability that genome variants will come together on a purely chance basis, says Borgwardt – and this could also even correlate with the appearance of a disease. So, an important part of his work comprises evaluating significance in extremely high-dimensional spaces. In other words: getting to grips statistically with highly complex situations that by their very nature are multi-causal.

Machine learning for quanta

AI can trace more than just connections in complex datasets. It can also create completely new materials. But in contrast to the life sciences, machine learning in physical chemistry is not yet very widespread, according to Anatole von Lilienfeld, a chemist and materials researcher at the University of Basel. Nevertheless, he can also see a "rapid upswing" and believes that AI will "inevitably" be an integral part of most study programmes in ten years' time.

His group's work is pioneering. Thanks to AI, he and his team were able to calculate the characteristics of millions of theoretically possible crystals constructed from four specific elements. In the course of this, their AI identified 90 unknown crystals that are thermodynamically stable and would be conceivable as new types of materials. The increase in efficiency when calculating crystal properties – AI is faster by several orders of magnitude – even astonishes an expert like von Lilienfeld. It is so vast that "it's not just about solving conventional problems; whole new research questions are being opened up". But even von Lilienfeld has some reservations. Machine learning only functions if there is a cause-and-effect principle at work, and if there are enough data available. It's also essential that the researchers in question "have enough expertise to devise efficient representations of the objects to be investigated, along with their characteristics".

This degree of expertise was also the decisive issue for Giuseppe Carleo, a theoretical physicist at ETH Zurich. Together with his colleagues he has found a way of replicating the wave function of quantum systems with a neuronal network. After he succeeded in this step, optimising the wave function was "really just child's play". The algorithm carried out its task quickly and without any problems. Common or garden methods quickly reach their limits with such computational tasks: simulating complex quantum systems was until recently regarded as a computational "impossibility".

Carleo's new approach is based on the methods of 'unsupervised learning' in which the computer learns without any prior knowledge. This is interesting for theoretical physicists, says Carleo, because it makes it possible to see "old problems from new perspectives". Even the engineering sciences and pure research could benefit from this progress.

Carleo was inspired by last year's triumph of the AlphaGo algorithm in a game against a go master. In that case, the AI had become stronger and stronger by playing innumerable games against itself. Its method of reinforced learning raised the playing intelligence of AlphaGo to new strategic levels. Carleo has now adapted this to his own purposes.

Metaphorically speaking, Carleo taught the machine to regard the hunt for the solution to wave function as if it were a game in which the goal is clear, but the path to it is completely open. The point was for the AI to learn to prefer good solution processes. And indeed, the AI liked the game a lot. So much so that it has now mastered it like no other intelligence in the world.

Roland Fischer is a freelance science journalist in Bern.

Will anthropomorphic robots blow out candles every year? More importantly, will they want to? Here, incidentally, it is a woman mimicking a robot mimicking a woman.
Image: Kevin Grennan, Android Birthday, 2011. Video.
Actor: Sylvi Kim

Are we being served?

Several start-up companies are marketing programs with artificial intelligence to support researchers. But they're making audacious promises. *By Sven Titz*

In the world of chess, it's been 20 years now since humans were last able to beat a computer. More recently, these machines are being geared to work alongside us in the most demanding field of human endeavour: scientific research. Software programs are being designed to help us set up and assess studies, and the computer is becoming a kind of 'smart butler' in the laboratory, filtering the flood of literature and assisting with peer review.

False connections

The advertising pitch of some of these companies sounds very optimistic. The Norwegian start-up Iris, for example, has announced that it can improve searches for relevant research literature. Iris can be tested on their website using a free tool. You feed in a link to a research paper, and then Iris delivers hundreds of results that are sorted according to 'key concepts'. The studies it identifies are supposedly connected to the content of your paper – but some of the hits are useless because the tool occasionally regards two concepts as having a meaningful connection, when in fact they have nothing to do with each other.

The literature search with Semantic Scholar, on the other hand, has been undergoing tests for two years already. The software is designed by the Allen Institute for Artificial Intelligence in California, and uses machine learning to recognise scientific concepts in texts. Up to now, Semantic Scholar has been scanning literature in the computer sciences and neurosciences. Other subject areas are to follow soon. When asked for his opinion, Paul Ginsparg of Cornell University, one of the founders of Arxiv, points to a "potentially rather useful" characteristic of the search machine: it doesn't just take the number of citations into consideration, but also their significance – in other words, who has quoted a particular study and in what context.

Getting to the bottom of things

Intelligent search machines like Semantic Scholar or Sparrho usually orient themselves to the literature databases of Google Scholar and Pubmed. They are currently enjoying a boom. Just in the last few months, two similar products have appeared: Microsoft Academic and Recommended by Springer Nature.

Some companies have even higher ambitions. The start-up Meta in Toronto claims to have developed a new scanning procedure for specialist literature. On this basis, its employees are developing apps, for example, that work with multi-layered neuronal networks. According to the marketing department of Meta, their app Horizon Scanning is able to trace back the origin of a scientific concept: it follows it backwards in time, thereby revealing a whole spectrum of research.

Little that's concrete… so far

According to the company that makes it, Horizon Scanning is intended for the pharmaceutical industry, publishing houses, research corporations and public authorities. Some of its algorithms come from a company that was involved in the development of Apple's spoken-language interface software Siri. Its founders include several researchers, and the company was recently bought up by the Chan Zuckerberg Initiative. Given the lack of concrete information, experts – such as Jana Koehler of the University of Lucerne or Peter Flach from the University of Bristol – are not in a position to give a firm opinion on it. To them, the software is just like a black box.

> "The problem lies in being able to integrate expert human knowledge in a sensible manner".
>
> Peter Flach

Besides literature searches, elementary forms of artificial intelligence are already being used in connection with assessing specialist articles. For example, together with his colleagues, Flach has developed a program to help find suitable referees for a study. The open-source software Subsift uses advanced matching algorithms for lists of words that describe studies and peer reviewers. It is a very big challenge to develop assistant software for scientists, says Flach. The problem lies in being able to integrate expert human knowledge in a sensible manner. In future, however, we can increasingly assume that this will succeed.

Sven Titz is a freelance science journalist.

In ‘Refactor’, the painterly experience of the visual artist is depicted in computer code. In other words, it is art in the absence of the artist. Technically speaking: the installation visualises the cognitive potential of code.
Image: Nikzad Arabshahi (visuals) & Vedad Famourzadeh (audio), December 2016

From data to eureka

How much is a discovery worth if we cannot understand it? With the advent of intelligent machines in laboratories, the very meaning of knowledge is being brought into question.
By Nic Ulmi

Creating hypotheses and making discoveries are at the very heart of the scientific process. But since the early 2000s artificial intelligence has stolen onto the stage. It is developing new ways of producing results and playing a role that we once thought to be the preserve of humans. Although unable to understand their own successes, increasingly powerful machines are leading the way to a very disturbing vision: industrial, robotised, automated scientific research.

Let's start with some examples. At Tufts University in Massachusetts (USA), a network of artificial neurons has been tackling one of biology's enigmas. It is formulating hypotheses on the regeneration of a freshwater worm that is able to regrow both its head and its tail. At Adelaide University in Australia, a machine has discovered the optimal means for producing a Bose-Einstein condensate, a group of bosons that, at close to 0 Kelvin, expose macroscopic quantum phenomena. And at Johns Hopkins University in Baltimore, machines at the start-up Insilco Medicine have developed models that may be of use in treating cancer.

> "Unlike machines, our minds can achieve high levels of abstraction effortlessly".
>
> Roger Schank

Roger Schank is not at all convinced. "None of this has anything to do with artificial intelligence", he says. Schank is a veteran of artificial intelligence and has worked at Yale, Northwestern and Carnegie Mellon universities. He sees history repeating itself. At the beginning of the 1970s and at the end of the 1980s, two waves of hype about artificial intelligence both eventually led to AI winters, where hype congeals, public interest hibernates and financing freezes. "The press may be sacrificing column inches today, but they'll eventually move onto something else. The problem is that in between times AI research can suffer a repetitive demise. I don't find that funny".

Steak and haircuts

What is it then, if it's not intelligence? "The examples you mention are what are known as pattern-matching programs", says Schank. "This is the process used by Facebook to identify your face in photos". In other words, the machines generate patterns (e.g., the schematic of a molecule or a map of a flatworm's regeneration) that can be compared with identifiable regularities in patterns stored in databases. This is a very meticulous process. "But the way scientific discoveries are made is completely different: at the outset, confusion reigns. It's precisely not being able to understand something that leads you to create hypotheses, and then to test them. This is what we mean when we say science".

Schank is fond of telling a story to illustrate the difference between human discovery and automated learning. He calls it the steak-and-haircut story. "Whilst talking with a colleague at Yale, I was complaining that I was never able to get my steak the way I like it: bloody. My meat is always over-done. What the hell, I asked myself. He responded by saying: 'I used to live in England and I could never find a hairdresser who would cut my hair the way I liked it'. Then, eureka! I saw how the two stories complemented each other and I suddenly had a new perspective. I saw them as being identical. In both cases, we'd requested a service from another person entirely capable of complying yet who didn't, because that person perceived our requests as being extreme". There is a moral to this story. "Our minds can achieve this

> "The way scientific discoveries are made is completely different: at the outset, confusion reigns".
>
> Roger Schank

level of abstraction effortlessly. They can see one thing as if it were another. They're motivated by our innate goals – satiating appetite or satisfying curiosity – and then they calm themselves after getting worked up by a perplexing fact".

Machine pleasure

In the face of this human model of cognition, the new wave of applications of AI research – which began in the late 1990s – no longer aims to reproduce it. What is actually happening is a reorientation towards an unknown form of knowledge, where everything is produced through automatic learning involving big data. This change of direction has thawed AI research and opened the way for services that provide suggestions, such as Amazon and Siri, for the victory of AlphaGo over one of the world's best go players and even for predicting the expression of a bacteria's genes, as was done by a study at the University of Pennsylvania in 2016.

The question that remains is whether this kind of technology can actually conduct science. It hangs on whether a machine can experience an existential need to understand, a desire to know, a 'libido sciendi', as St Augustine would have called it. There must be a limit to what a machine wants to know.

At Lugano's AI research centre, the Istituto Dalle Molle (IDSIA), we turn now to its co-director Jürgen Schmidhuber. In November 2016 the New York Times wrote that "when A.I. matures, it may call Schmidhuber 'Dad'". In 1997 his research pointed to a 'long, short-term memory', which is today employed by spoken-language recognition programs. He believes the driving force of scientists, artists and babies is founded on just such a reward system and that it may be the same in networks of artificial neurons. Both forms of intelligence can experience a reward when, out of the disorder of the universe, they identify a repeating pattern or regular event that formerly went unnoticed.

"Imagine a program instructed to make a model from a set of images that show apples falling to the ground", he says. "Without knowing about gravity, a very large quantity of data would be necessary to encode the sequence. But once the discovery has been made, the machine will be able to use it to make predictions, and the data necessary for that would use up less space. The difference between before and after, essentially a data compression, is a measure of the depth of the newly acquired knowledge. This is what triggers the reward signal: a moment of inner joy for the network, if you like".

A theory of fun

Schmidhuber feeds this reward mechanism into a formula for his theory of fun and creativity. He compares it with the experience of a musician discovering a harmony, and with humour: "Revealing a punchline unlocks the unexpected ending to a narrative. A certain data compression follows. At which point we laugh". Understanding this is essential to building machines with artificial curiosity and capable of making discoveries. To wit, the network must work in tandem, he says. "On the one hand, you have a generator that conducts the action and leads the experiments by creating data. Its motivation is maximising its own rewards. On the other hand, there is an inspector that sends the reward every time a discovery is made with regard to a new regularity and which enables it to compress data. This is the kind of system we need if we want to build artificial scientists".

The neural network at Insilico Medicine uses such a dual system, explains Polina Mamoshina, a geneticist and computer scientist on the project. "The generator is programmed to randomly and virtually create molecular structures. The inspector uses databases to learn to recognise the molecules capable of preventing growth in tumours. At first the aim of the generator is to catch out the inspector by leading it to make incorrect identifications, thereby allowing it to learn progressively".

> "Revealing a punchline unlocks the unexpected ending to a narrative. A certain data compression follows. At which point we laugh".
>
> Jürgen Schmidhuber

Among the 60 molecules created by the generator and validated by the inspector, a number of them had already been discovered and patented as therapies against cancer. "This is an encouraging sign of the system's precision", says Mamoshina. "We are now going to move to a validation process of new models in vitro and then in vivo". She sees this as being a revolutionary approach to this area. Instead of blindly scrabbling together new molecules, we are aiming to create medication on demand.

The black box

Whilst we wait for the curious machines described by Schmidhuber and systems that can cook steak and cut hair to the taste of Schank, automatic learning and big data are currently redefining the scientific landscape. At the University of Bristol, UK, the professor of artificial intelligence Nello Cristianini is warmly embracing these new tools, but at the same time calling to limit their field of application. "I've been working with machine learning for 20 years. I'm

happy to say it works. The machine learns, insomuch as it improves its performance with experience".

These approaches are the same as those used to create huge profits at Amazon by ensuring the right book is recommended to the right person. "We should underline that these algorithms do not use psychological modelling for individual users, nor do they conduct a literary analysis of each book", says Cristianini. "They work on a purely statistical basis: people with certain behaviours or characteristics buy books that in turn have their own particularities. This is what's important: we can make a prediction without having a theory".

> "I've been working with machine learning for 20 years. I'm happy to say it works".
>
> Nello Cristianini

But does this model really work with science? "There is no philosophical reason why it shouldn't", he says. "A computer can generate models of molecules and predict their toxicity. What is to be gained from this? Well, we can perfect medication in silico, without having to produce all of the possible molecules and then test them on animals. What is there to lose? That we don't know why the medicine works".

Machine learning is a black box, because we cannot understand the machine's reasoning. This is a particularly thorny issue when departing from the world of academia, he says, "where algorithms determine access to rights: admission to a school, eligibility for an insurance policy, early parole…".

An end to theory

Is this type of learning still science? "We should not be drawn in by this question", says Cristianini. "Machine learning is used to earn money by creating correct predictions, so there will also be a progressive redefinition of what we understand by science. Research funding will follow practical applications, and other approaches will find it difficult to obtain financing". Should we then be fearing Chris Anderson's 'end of theory'? In 2008, the editor of the magazine Wired said that "the deluge of data is making the scientific method obsolete".

"We should be asking the purpose of theories", says Cristianini. "For me the answer is extremely clear. There is an infinite cultural value in creating a beautiful theory of mechanics or of thermodynamics, or understanding a part of our universe. We have a desire to know how the world around us works". A good theory has specific value: "The prediction of a black box is not enough when the stakes are very high: for example, when we send a probe to Mars or plan a surgical intervention. In these cases, we want to know exactly what would happen if we were to change one or another parameter. This means using counterfactual argument, which can only be done using theories".

So, on the one hand we have probabilistic machines, and on the other hand beings who are driven by the need to understand, which is deeply rooted in biological functions, and who generate theories. Will the first replace the second? "What we can entrust to machines is specific tasks", says Cristianini. He illustrates this: "given a sequence of amino acids, design me a protein. Using the entire human genome – three billion letters – find me the 20,000 genes that make it up! But understanding the significance and importance of a discovery will remain a human task".

The same division of labour can also be applied to social sciences. "I work with historians to investigate historical transitions in English and Italian cultures using a computerised newspaper reading system. As no one can read 500 million articles, the machine does it for us. It is, however, the historian who later explains why one or another result is of importance".

Furthermore, Schmidhuber is convinced of a complementarity. "In science labs, as elsewhere, machines will carry out laborious tasks which humans just don't want to do, when it comes to it. Of course, that will lead to the loss of jobs. We should therefore ensure that society redistributes the benefits. This will happen through unconditional income, robot taxes or something else". The social issues raised by the robotisation of the sciences remain as open as the epistemological issues. Can automated prediction be considered scientific knowledge? Cristianini is ready to meet this challenge: "I have just hired two science philosophers to start looking at this question".

Nic Ulmi is a freelance journalist in Geneva.

He starts to shake.

H (CONT'D)
It may never be forgiven, but that is just too bad. I have to leave, but I'm not free of the world.

C
Yes. Perhaps I should take it from here. I'm not going to do something.

H
You can't afford to take this anywhere. It's not a dream. But I've got a good time to stay there.

C
Well, I think you can still be back on the table.

H
Mmm. It's a damn thing scared to say. Nothing is going to be a thing but I was the one that got on this rock with a child and then I left the other two.

He is standing in the stars and sitting on the floor.

Benjamin is the world's first automatic scriptwriter. He was conceived by Ross Goodwin and the filmmaker Oscar Sharp. Benjamin improves with practice. This scene from his first film, 'Sunspring', offers us an idea of how long he'll have to practise before his dialogues and stories make sense to humans.
Image: thereforefilms.com/sunspring

Parlez-vous English?

Whenever a study programme is listed as being in 'German' or 'French', there's still a good chance that English will be in it too. This is increasingly the case even at Bachelor level. Many universities see this simply as a fact they have to cope with. But it doesn't have to be this way. ***By Pascale Hofmeier***

A psychology professor from Germany is teaching a Bachelor course at the University of Geneva – in English. The art history programme at the University of Zurich is offered in German according to the website – but an English course turns out to be part of it. Along with globalised research, the academic elite arriving in Switzerland is teaching students in English. Mostly it's not even their mother tongue. In response to a query from Horizons, the Universities of Basel, Bern, Geneva and Zurich have confirmed that the trend is increasing. However, there are no statistics as to the proportion of courses taught in English at Bachelor and Master level.

Don't believe what's on the label

English as a medium of instruction can be a barrier, says Josef Stocker of the Association of Swiss Student Bodies (VSS): "For fresher students, language is an additional hurdle". But it's not insurmountable, he says, and in many subjects it makes sense to have English as the medium of instruction. He is a student of mathematics himself, and he sees the clear necessity of being able to make yourself understood, also in an international environment. And yet, having courses in English means extra effort for many students, he says. "It would be good to have more transparency at the universities regarding the actual percentage of English-language courses". Today, he claims, university regulations are sometimes ignored because there are no staff available who can teach in the respective national language. It would also be useful if the universities could actively support students to reach the necessary level of competency in their language of instruction.

The regulations, directives and language policies of the Swiss universities are very different, and often also very vague. A directive of ETH Zurich from the year 2010 stipulates that the language of instruction in the Bachelor is essentially German – but English or French may also be officially employed, depending on the respective programme regulations. On its website, EPFL states that French and English are the languages of instruction, though the first Bachelor year will be taught primarily in French. From the second year onwards, up to 50 percent of the courses may be in English, it says. The Master programme can be mostly in English, mostly in French, or bilingual, dependent on the respective curriculum on offer. At the University of Basel, the Bachelor is taught 'mostly in German'. And at the University of Zurich, the faculties make their own decisions.

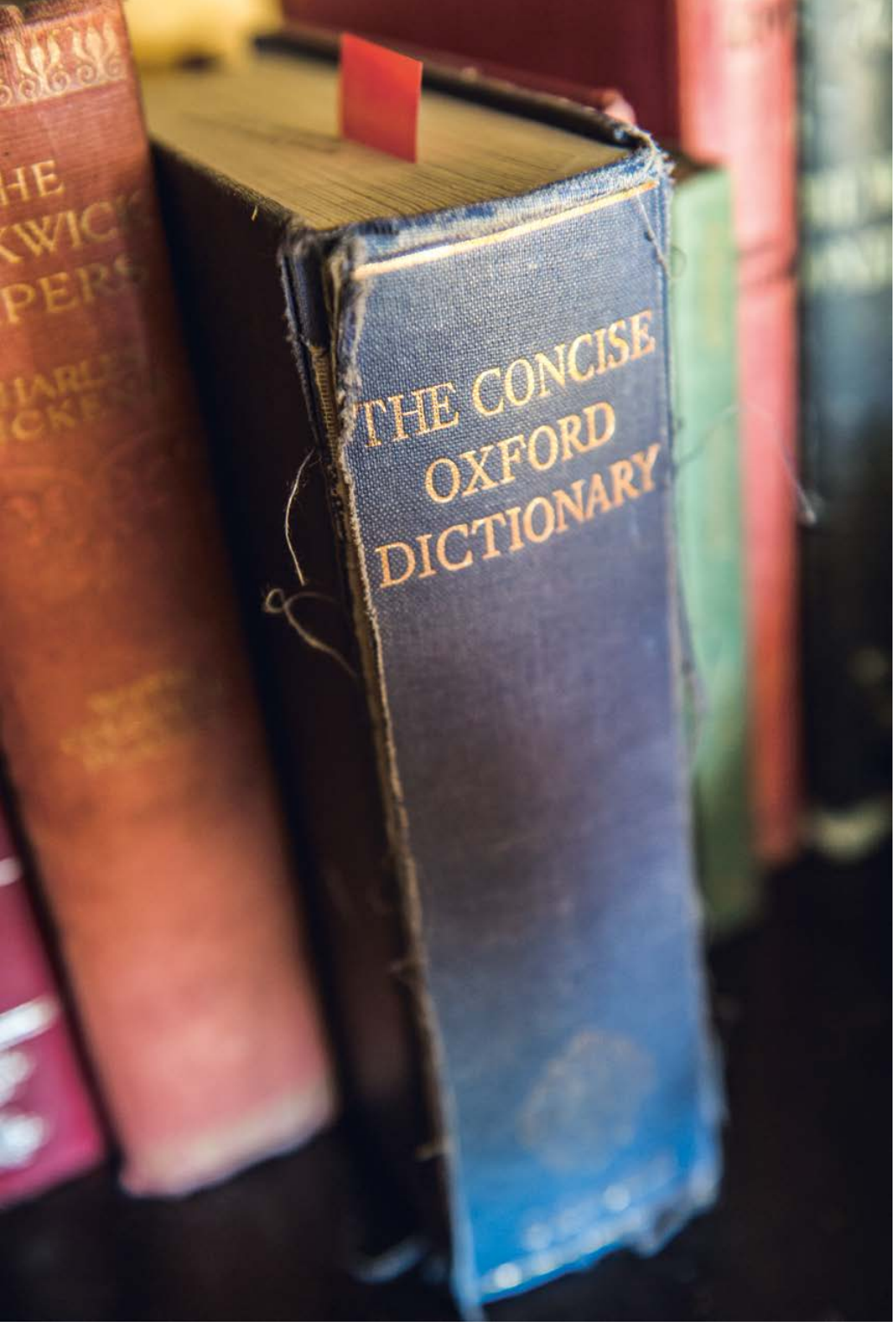
Universal understanding?

There are big differences, depending on the subject. In the natural sciences, the life sciences and social sciences, no one can avoid English. And even in the humanities, this is increasingly the case. Pessimists fear an impoverishment of scholarship through the uniformity of language, whereas optimists see a chance for universal understanding through the use of a scholarly lingua franca.

You can't manage without English, says Gerd Folkers, President of the Swiss Science and Innovation Council (SWIR): "Students have to be able to read sources and articles in the original language". He supports calls for a transparent approach towards the language of instruction at Swiss universities: "It is crucial to make the rules of the game clear". He also advises dealing with foreign languages in a deliberate manner instead of simply taking arbitrary decisions: "It's about getting the right balance and about finding the appropriate language for the appropriate content".

> "Solely monolingual teaching is no longer sustainable".
>
> Rita Franceschini

With this, he broaches a fundamental distinction in the field of scholarship. Much scholarly content is described relatively independently of any linguistic constructions – in a so-called 'theoretical language'. This becomes clear in highly formalised sciences such as mathematics. This content is then taught, discussed or reported in a specific language – be it German, French or English. Folkers teaches chemistry at ETH Zurich, and illustrates things as follows: "If I lecture in the English language in German-speaking Switzerland about the biochemical impact of new antibiotics, then I use our theoretical language. But if I speak about its possible application in pig feed and its problematical consequences for human beings, then German might be the better choice of language because the brain can order complex interdisciplinary facts better in one's mother tongue".



For the linguist Rita Franceschini, the main issue goes beyond whether to use English. It's that students should understand their language of tuition. Image: Valérie Chételat

Planned multilingualism

This is why Gerd Folkers argues in favour of a more conscious approach to multilingualism. English might have emerged as the language of basic consensus; "But is a university really the right place for us to agree on the lowest common denominator?", he asks. He believes it would be more courageous to improve English skills in language courses, in group sessions and tutorials on the one hand, but on the other hand to engage in a multilingualism in order to promote a scientific discourse in the students' respective first language. After all, if a biologist is taught primarily in English in his main subject, how is he or she supposed to explain a nature conservation project at a local community meeting in German or French?

Rita Franceschini is a professor of linguistics at the University of Bolzano in northern Italy, and she's demanding a complete rethink. "I would like to see a more dynamic development, a real multilingualism". The universities shouldn't regard English as a problem, she says, but should rather take a more deliberate approach to their multilingualism.

Instead of using a specific language at a specific time, concepts should be introduced in parallel languages at the same time wherever possible – for example, in English and in a local language. Franceschini's reasoning is simple. She is convinced that "solely monolingual teaching is no longer sustainable". Thanks to international mobility, the linguistic profiles of academics are getting more varied. And she doesn't just mean English, which is often the second language of university lecturers: if a professor has roots in Italian Switzerland, but grew up in Germany and studied in England, then he – or she – can quite possibly debate matters better in English than in German or Italian. Language is the means of communicating new knowledge.

> "Students have to be able to read sources and articles in the original language".
>
> Gerd Folkers

"The question is: how can you get students to acquire this knowledge?", asks Franceschini. One way is to link it to knowledge they already possess, she says. This might succeed in either English or in one of the national languages – independently of the competence of the person teaching them. "More attention should be paid to this than to the language concept of a university".

Compulsory national languages?

At Franceschini's university in Bolzano, the official language policy takes the trilingual nature of its region into consideration. Here, German, Italian and Ladin are spoken. Professors are given financial incentives to learn German or Italian "at least as an everyday language", so that they can converse with the students. "Language policies like this would also be preferable at Swiss universities", says Franceschini. But the reality is different, despite the country's four national languages. Only a few universities have a language policy that regulates their approach both to the national languages and to English. One of these is the University of Geneva. But when we asked the organisation swissuniversities and assorted Swiss institutions of tertiary education whether professors from abroad should learn one of the national languages, their answer was typically Swiss and federalist: Every university should decide that for itself.

Pascale Hofmeier is a science editor at the SNSF.

INTERVIEW

"Scientists will sit at the same table as heads of state"

In 2019, the UN will publish its Global Sustainable Development Report (GSDR). Peter Messerli, a geographer and professor of sustainability from Bern, is one of the 15 members of its independent group of scientists, and has been appointed its co-chair.
The schedule is tight, and their goals are ambitious – but in compensation, these scientists have the opportunity to exert major influence in the world's highest-ranking political body.

What is the purpose of the Global Sustainable Development Report?
At the United Nations Conference on Sustainable Development in Rio in 2012, the member states of the UN decided to intensify knowledge exchange between politics and science. The coming Report is important for implementing and monitoring the development goals in the UN's 2030 Agenda. But there is no simple magic formula. We have to weigh up carefully the advantages and disadvantages, basing our decisions on facts and knowledge. Only in this manner can we make fair decisions.

What is your strategy for managing this Herculean task?
We want to divide up the Report into four large areas. The different chapters will first focus on analysing the interdependencies of the sustainability goals in the 2030 Agenda. Secondly, we will deal with the implementation process: What changes are at all possible, and how are we going to approach them? Thirdly, we have to keep our eyes open for new topics that have not yet been considered in the 2030 Agenda.

And fourthly?
We want to strengthen the voice of science substantially. And we can achieve this. But we have to develop and implement the appropriate methods so that we can find solutions at the interface between research and politics. I see a great need for action here, both in politics and in science.

Is this yet another report that's destined to disappear into desk drawers?
No, on the contrary. The voice of science will be represented at the table when the heads of state of all member countries meet at the UN General Assembly in 2019.

How did a Swiss citizen land this position?
Switzerland is a hotspot for global change research. In our democratic system, we are already living out this exchange between politics, science and the people. This is also why science was represented in the Swiss delegation right from the very start.
Interview: This Rutishauser

FIGURE

44%

The budget cut announced by Brazil's Ministry of Science on 30 March 2017.

TOOL

Unpaywall

The web-browser extension Unpaywall makes it easier to find legal open access to articles behind paywalls. A similar tool called OA Button is also available.

QUOTE

"Openness and reproducibility may be core to how science works, but they can be turned into ways of pursuing ideological attacks".
Brian Nosek from the Center of Open Science in The Atlantic.

INVESTIGATING RESEARCH

Science articles increasingly difficult to read

Researchers at Karolinska Institutet, Stockholm, have been looking through 707,452 abstracts published in 122 leading biomedical journals over the last century. More specifically they have been determining the Flesch and Dale-Chall readability indexes, which consider the length of both words and sentences and the use of obscure vocabulary. They found a decrease in clarity over time. This is due not only to the rise in specialisation but also to a recourse to general science jargon.
doi.org/b5t4

Publication bias: meta-analysing meta-analysis

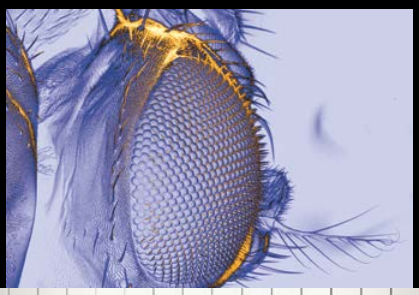
The Stanford epidemiologist John Ioannidis has been looking at first publications compiled in 3,042 meta-analyses across all scientific domains. His aim is to understand better the factors linked to publication bias (biased citations, influence of private funding, etc.). His results show it to be heterogeneous among domains and generally very low. The effects described in publications are most often exaggerated by small pilot studies written by isolated or inexperienced researchers and which soon become frequently cited. Studies published outside of journals, however, tend to underestimate bias. Still unconfirmed at this stage is the influence of a number of factors, including financial incentives, researcher productivity and gender.
doi.org/b5t6

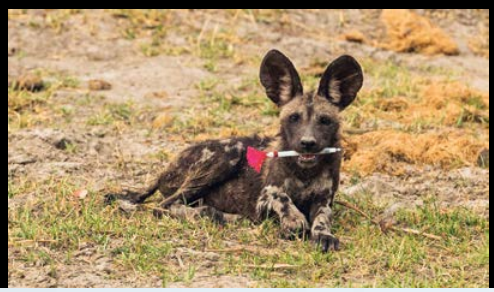
European expansion slows scientific collaboration

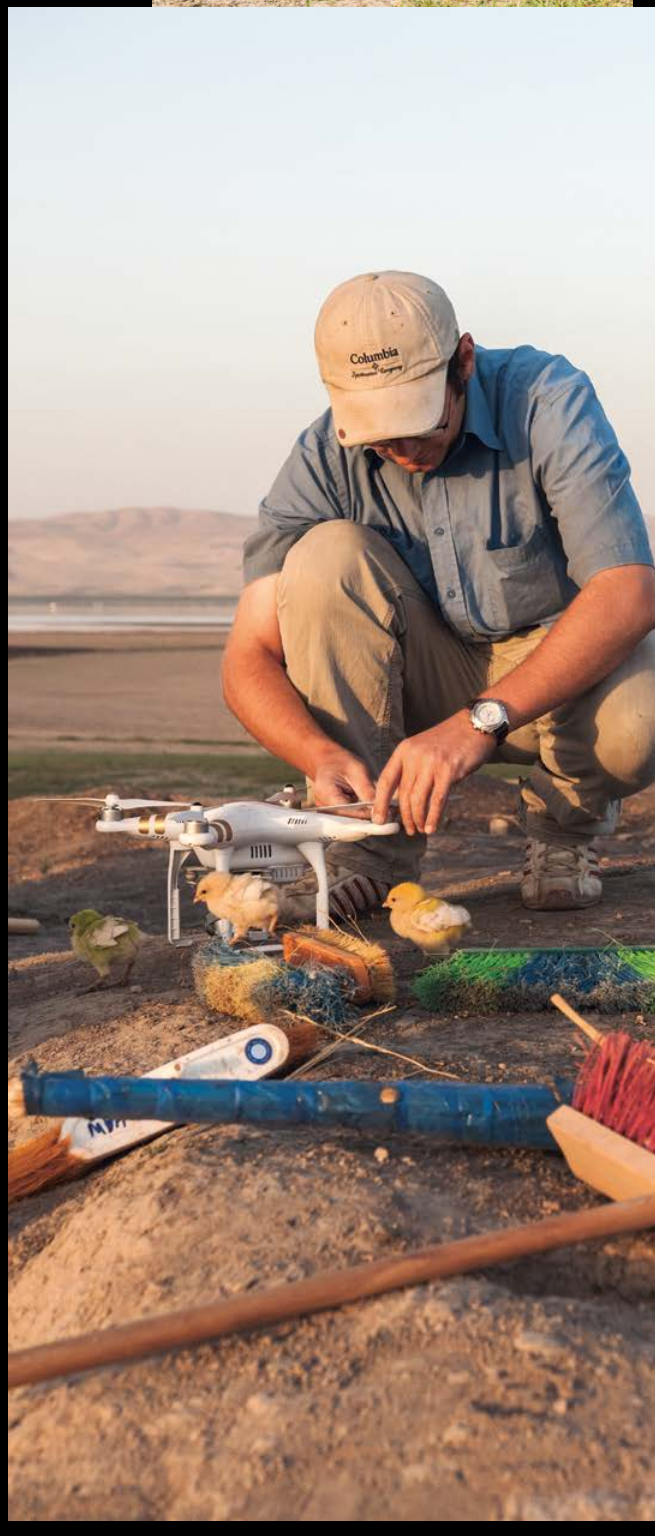
A study by IMT Lucca, Italy, has revealed an apparent paradox. International collaboration has fallen in 10 Eastern European nations since they joined the EU in 2004. The proportion of articles co-written with foreign institutions has dropped several points to below 30 percent. In North America and the other EU nations it has continued to increase. The reason given is that top researchers are migrating from poor to rich countries. doi.org/b5t5

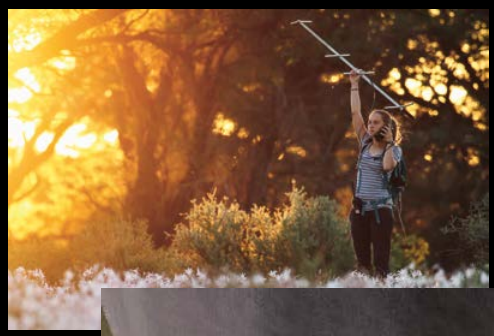
Snapshots of research

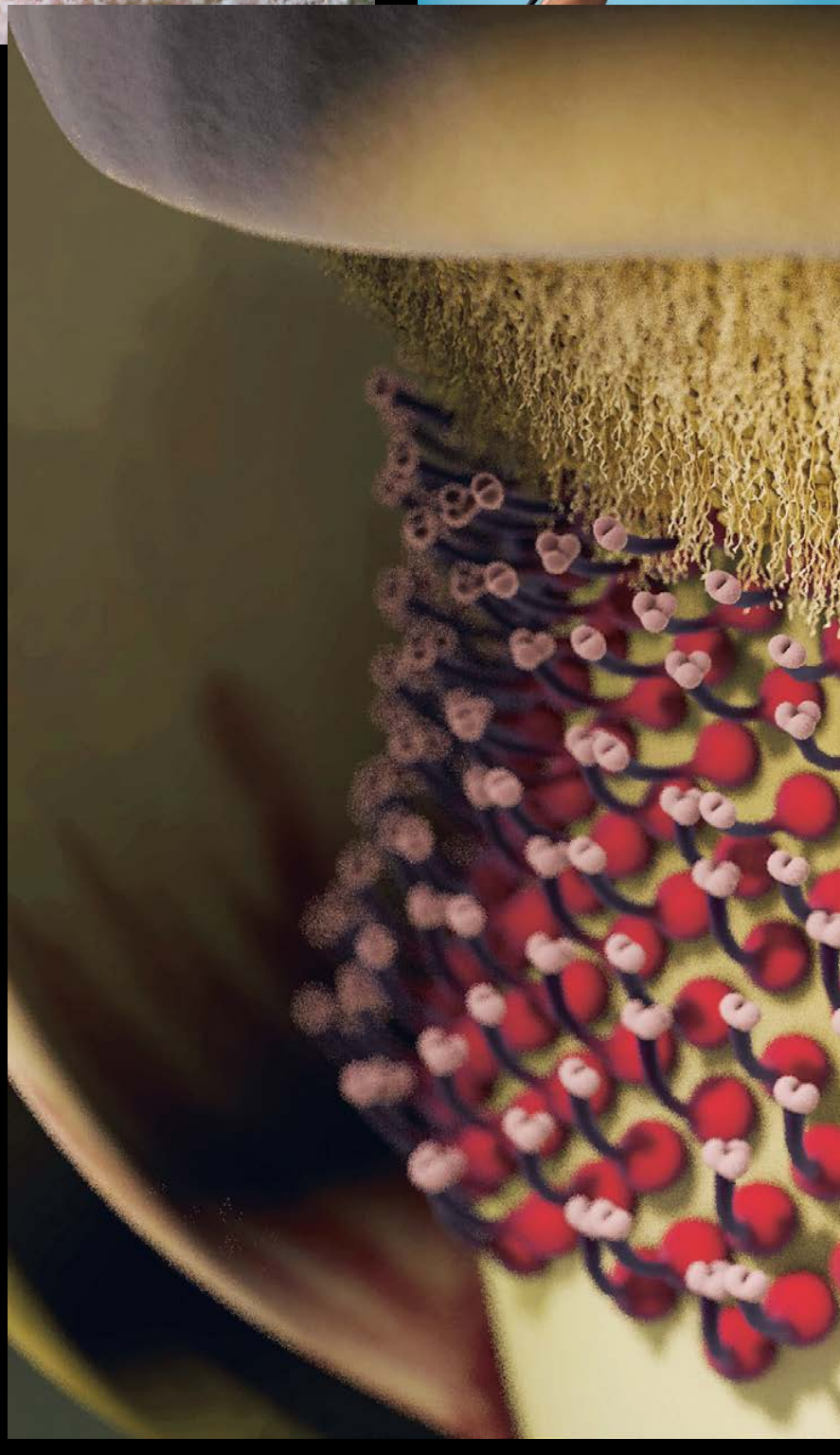
The photos that Swiss researchers submitted to the SNSF Scientific Image Competition offer a surprising, nuanced picture of science. They prompt astonishment, they inspire and they tell stories. The image editor for Horizons, Valérie Chételat, has chosen her own favourites from among them, independent of the jury's decision.





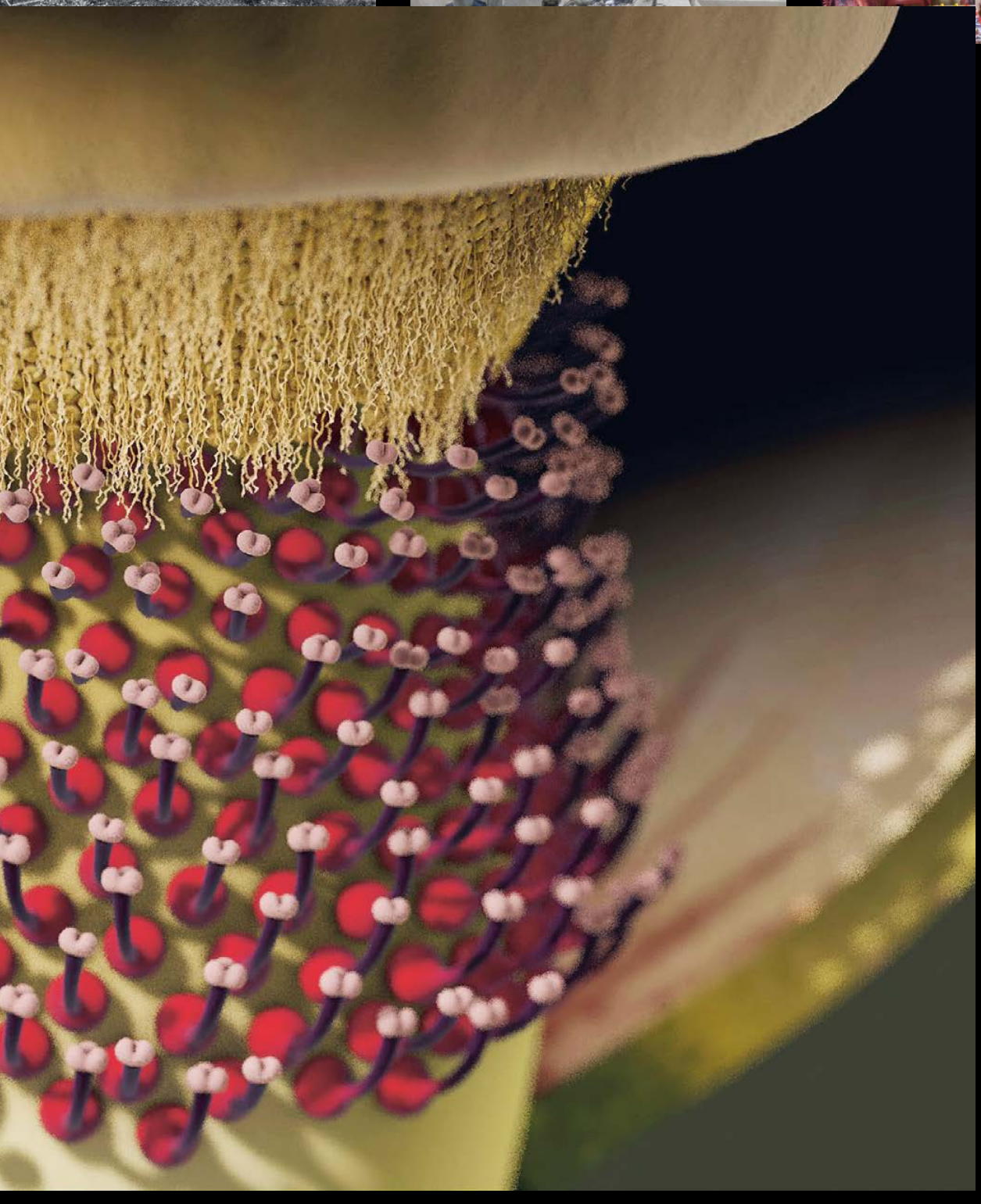

Columbia





Images:
(Top row: left to right)
- Electronic microscopy of a fly's eye, Carole Seum (University of Geneva).
- Beijing underground at rush hour, Max Bergman (Univ. of Basel).
- Hyena with tranquilliser dart, Dominik Behr (Univ. of Zurich).
- Lining up mirrors, Bogdan Dereka (Univ. of Geneva).
- Radiotelemetry tracking of meerkats in the Kalahari Desert, Hector Ruiz (Univ. of Zurich).
- Robot hand holding an egg, Tobias Bützer (ETH Zurich).
- Cape Town: an installation made of string in the botanical gardens (jury favourite), Melanie Boehi (Univ. of Basel).
- Installing a Go-Pro camera on a grab crane at a waste tip, Flavia Caviezel (Basel School of Design, FHNW).
- Board game based on shifts in rural culture, Swen Bos (ETH Zurich).

(Central row: pp. 25–28)
- A microbiologist transferring liquid nitrogen (winner in the Men and Women of Science category), Jürg Sigrist (Eawag).
- Binaural sound recording (jury favourite), Ludwig Zeller (Basel School of Design, FHNW).
- Setting up a drone for an archaeological study in Kurdish Iraq, Susanne Rutishauser (Univ. of Bern).
- Digital interactive model of titan arum, a flower that can grow to 3 metres in height, Alessandro Holler (Zurich Univ. of the Arts).



SNSF Scientific Image Competition

They illustrate what researchers experience in their work, and show who they are: these are the images, photos and videos that were submitted for the new SNSF competition for scientific images. Some 239 people from all regions of Switzerland took part. In total, 437 images and 60 videos were submitted in the four categories 'Object of study', 'Men and women of science', 'Locations and instruments' and 'Video loop'.

"The images submitted illustrate the fascinating diversity of scientific research", says Pascal Hufschmid of the Musée de l'Elysée in Lausanne, who was the president of the international jury that selected one winner from each of the four categories. There were no microscopy images among the winners. "This may come as a surprise", says Matthias Egger, the President of the National Research Council of the SNSF. "In fact, it highlights the visual richness and the scope of scientific practice today". The jury's selection and links to the images submitted can be found at: **www.snf.ch/bilder-wettbewerb**. *hpa*

Using patient data across the world

Patients are voluntarily making their data and specimens freely available to researchers. But the biobanks still have some legal gaps to bridge. *By Irène Dietschi*

The container with the frozen samples of blood and other bodily fluids is scanned before its automatic dispatch into the -150° C tank. Image: Insel Gruppe/Pascal Gugler

On the last day of the 2017 spring session of parliament, the Socialist Party's National Councillor Rebecca Ruiz from the canton of Vaud proposed a motion to create a biobank law.

"Biobanks in which data and specimens from patient treatments are collected and evaluated are rapidly increasing in importance", says Ruiz. "But current laws are deficient in their coverage of them". Her proposal received the support of 23 members of parliament.

The occasion came at the end of March with the conclusion of the consultation process for the 'general consent' that has been devised jointly by the Swiss Academy of Medical Sciences and Swissethics. If hospital patients sign this form, their data and specimens can be utilised in future, as yet undefined research projects. University hospitals have already been working with such general consent forms for a while now, though they still differ from one canton to another. The proposed general consent would be the first time that there has been a single, standardised, national form.

Lack of data security in hospitals

But a source of delight for scientists is a cause for concern for patient protection organisations. Franziska Sprecher is a professor of law in Bern who represents the patient protection organisation SPO, and she is critical of the current state of affairs. "It's not acceptable that there is only a patchy legal basis for something as important as biomedical research and handling patient specimens and digitised data". Hospitals are too lax in providing data security, she says, and if there is a data breach, then the patients will be left pretty much to cope on their own.

So why is general consent so important for biomedical research? Vincent Mooser is a laboratory pathologist who has been running a pioneering biobank with blood specimens at the Lausanne University Hospital (CHUV) since 2013. He explains it as follows: "In order to be successful in the field of personalised medicine, we need data from very, very many people". As an example, Mooser mentions the CoLaus Study, which began in Lausanne in 2003 with the goal of identifying cardiovascular-disease risk factors. The Lausanne group has over 6,000 patients and is a success, but in order to get further results, CHUV will have to cooperate with other hospitals.

Research on a very different scale

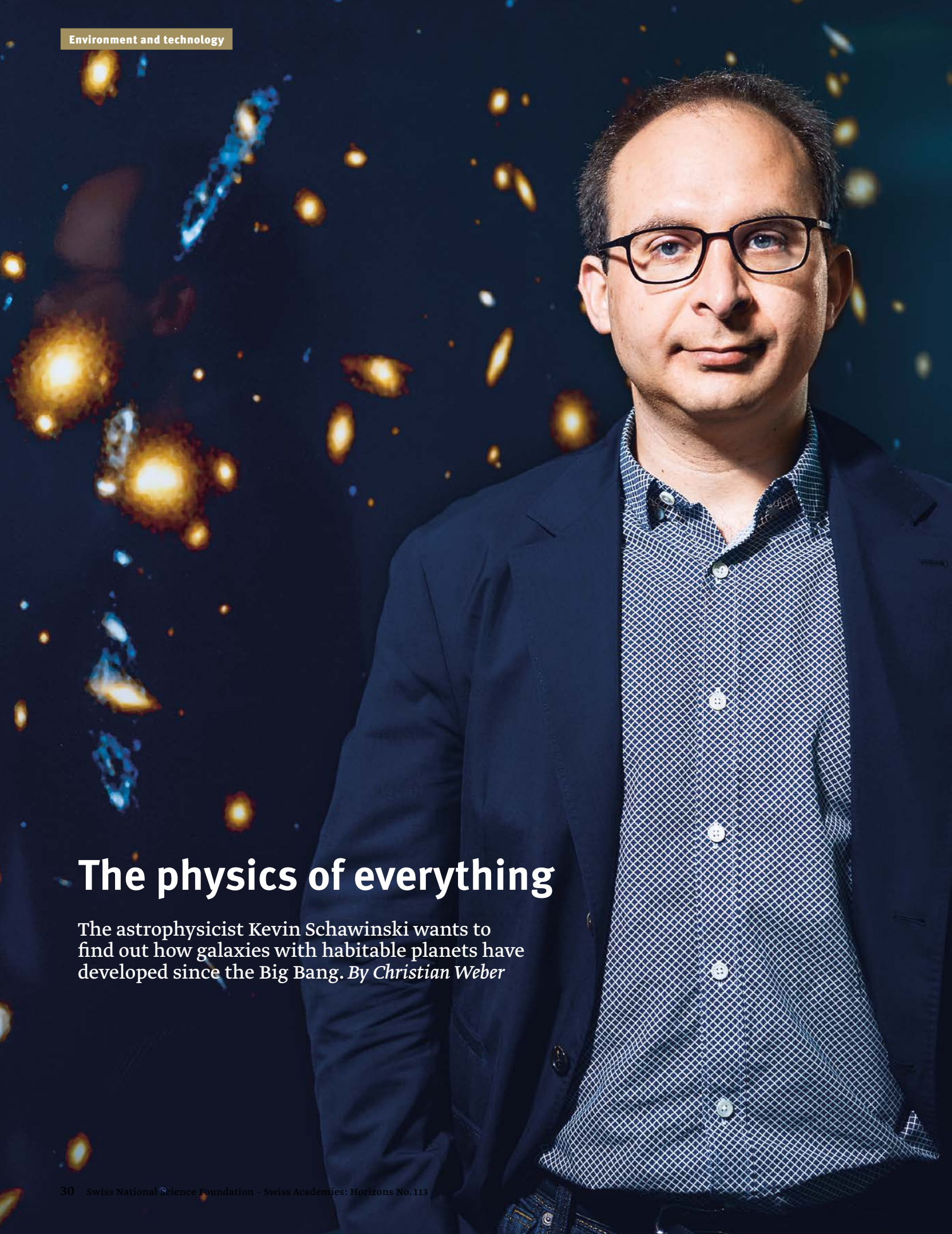
With a general consent form, it will become possible to exchange data, both within Switzerland and with foreign laboratories. "We will be doing research on a very different scale altogether", says Mooser. This is essential in order to remain internationally competitive. Other countries, like the USA, the United Kingdom, China and India have long begun using big data in their medical research. Besides, he says, general consent does not offer up a blank cheque: "Researchers need the permission of their ethics commission for every project they undertake".

In fact, Swiss citizens aren't reticent about sharing their health data for research purposes. At CHUV, for example, three out of four patients agree to donate their data, even if it goes so far as analysing their whole genome. At the University Hospital in Basel, the percentage is even higher. Up to today, over 27,000 general consent forms have been signed in Lausanne. For Mooser, it is natural that their corresponding data and specimens are protected to the highest possible security standards.

> "In order to be successful in the field of personalised medicine, we need data from very, very many people".
>
> Vincent Mooser

CHUV is also home to the offices of the Swiss Biobanking Platform, and the big Swiss biobanks have joined it. On their website, they state that they welcome Ruiz's motion to create a biobank law. For the time being, the network has accepted the rules of the Declaration of Taipei, issued by the World Medical Association in 2016, which lays down fundamental guidelines for running biobanks. Sprecher sees this as sending out a "strong signal", but she still wants more to happen. She believes that the Declaration has to become part of the professional ethics guidelines for doctors.

Irène Dietschi is a freelance science journalist in Olten.



The physics of everything

The astrophysicist Kevin Schawinski wants to find out how galaxies with habitable planets have developed since the Big Bang. *By Christian Weber*

What do you do if you're supposed to be looking at a million galaxies, but you're actually still planning to do other things with your life? Whilst still a 26-year-old doctoral student at the University of Oxford, the astrophysicist Kevin Schawinski from Zurich had an idea that was as simple as it was brilliant. He organised a few hundred thousand helpers to do the work for him, free of charge and in their free time.

That was the story that first got Schawinski the attention of the media. He is 36 today and teaches at ETH Zurich. He is one of the founders of Galaxy Zoo, one of the very first citizen-science projects in which amateurs help the experts. Back then, Schawinski had the task of classifying galaxies: Was this or that galaxy a spiral galaxy or a barred spiral galaxy? Or a star cluster? Or a new form altogether? After a week, he'd only managed 50,000 galaxies and had had enough. When he was out having a beer with a colleague, he stumbled on the idea of setting up the website galaxyzoo.org, where anyone can categorise galaxies with the click of a mouse. After just one day, his volunteers were classifying 70,000 galaxies per hour. Today, more than 350,000 citizen scientists are working on Galaxy Zoo.

"The most important thing in science is creativity", says Schawinski. And he doesn't just mean the intuition of the researcher, but specifically an openness to all kinds of new approaches and methods, including looking at other disciplines. Such mental flexibility is probably the reason why Schawinski's career has been so meteoric.

Success, 21st century style

He sits in his small, glass-walled office on ETH's Hönggerberg Campus. A toy robot – NP5357 – looks down on him from the bookshelf. An art book lies on his coffee table, along with a book on free will by the US author Sam Harris. "A great book!", says Schawinski, insisting that "it's really, really important to have broad interests: philosophy, neurosciences, computer sciences, politics, business! I always tell my students: they have to get to grips with such things too, if they want to have success in the 21st century".

Schawinski's manner is dry, but there's emotion in his voice when he answers a question about the sublimity of the starry sky: "I don't have so much of a sensual connection to the heavens". Nor is he overly impressed by the dimensions of the cosmos: "You get used to it". He once told the New York Times that he'd be able to find the moon and the constellation of Orion, but probably not much more.

It's elsewhere that Schawinski's passion lies. "I'm fascinated by the natural laws behind everything", he cries. "I want to use the laws of physics to explain how a tiny quantum fluctuation after the Big Bang turned into a galaxy with habitable planets".

This astrophysicist is especially interested in the role of black holes, which – as we know today – lie at the heart of every galaxy and are between 10,000 and several billion times heavier than our Sun. They develop such gravitational powers that they don't let out any light at all. If the Earth were a black hole, its mass would be concentrated in the form of a marble less than a centimetre in diameter.

> "It's really, really important to have broad interests: philosophy, neurosciences, computer sciences, politics, business!"

Schawinski suspects that black holes played a vital role in the evolution of the universe. But precisely what role they played is still anyone's guess. Nevertheless, he is excited about the current 'golden era of astrophysics' – ours is a time in which every new telescope is discovering "completely new phenomena". The age of the universe has meanwhile been calculated to be 13.81 billion years exactly; and in Schawinski's opinion, the existence of dark matter has also been confirmed. His own team is currently developing new approaches to the problem of black holes.

Telescopes or computers?

A fundamental insight is that extremely different timescales are relevant in the universe. For example, 100 million years can be a normal timespan for a significant change to take place in a whole galaxy. In a quasar, on the other hand, only 100,000 years are needed to bring forth something relevant. "The question is now how we are going to link all this together and incorporate it in our models", says Schawinski. And also, of course, how to get measurement data at all for such vast timespans.

"We develop a model and then look to see where it functions and where it doesn't", he explains. And you can observe the echoes of past events – after all, the light from the central quasar in the Milky Way takes several tens of thousands of years to reach the Earth. Schawinski is looking forward to the launch of the James Webb Space Telescope (JWST) in 2018, which should enable us to look even further back into the past. "It will trigger a scientific revolution".

Schawinski does see the problems that such projects raise. "The cost of the JWST is already nearly nine billion dollars, so of course we've got to justify that". Kevin Schawinski is doing his best to convince the general public of the significance and fascination of his discipline – he appears at science festivals, makes YouTube videos, and meanwhile has 22,500 tweets on Twitter.

All the same, he knows that even astrophysics can't rely simply on ever bigger, more expensive telescopes. He himself is focussing on collaborations with computer scientists. In future, the neuronal networks of artificial intelligence (AI) will be used to analyse data and categorise galaxies (see 'Augmented science', p. 13 above). But what about the enthusiastic hobby astronomers on Galaxy Zoo? "We still need them", Schawinski assures us. They could start creating training maps for Deep Mind computers – in other words, they could catalogue small groups of galaxies from which the AI image recognition programs would learn, so that these could ultimately carry out the same work on an automated basis. "This way, we'll be able to catalogue billions of galaxies in future".

Christian Weber is a science journalist who works for the Süddeutsche Zeitung.

A meteoric Anglo-American career

The astrophysicist Kevin Schawinski, 36, was born in Zurich. He is the son of the radio pioneer and media entrepreneur Roger Schawinski. He studied physics and mathematics at Cornell University in Ithaca, USA, and took his doctorate in astrophysics at Christ Church at the University of Oxford, UK. After a research visit to the University of Yale, USA, he was appointed to an SNSF professorship at ETH Zurich in 2012.

Manu Friederich

Good vibrations

When playing instruments, musicians register the subtlest of vibrations. Researchers would like to understand more precisely what role is played by this tactile feedback. Also of interest is its applicability to interactions between humans and machines. *By Roland Fischer*

Whoever plays an instrument naturally wants a specific form of feedback from it: the sound of it. But every sound is a vibration that you don't just hear: when you're playing, you feel it too. The experts call this haptic feedback.

In his doctoral thesis, Matthias Flückiger of ETH Zurich is measuring this haptic feedback directly on musical instruments. "Playing an instrument is a complex interaction of different senses – only part of it occurs via the sense of hearing", he explains. Flückiger would like to understand this interaction better – and the vibrotactile feedback in particular. He places many highly sensitive sensors on instruments to measure the musician's playing, position and movement, and the pressure involved. Using so-called actuators – small elements that create vibrations themselves – he can control the reaction of the instrument. This allows Flückiger to study what happens when the vibration behaviour of the instrument changes.

Unconscious perception

This is also a matter of interest to Stefano Papetti at the Zurich University of the Arts (ZHdK). He equipped a digital piano with actuators that give it a virtual resonating body by reproducing vibrations that he had recorded meticulously from an acoustic piano. Then he invited professional musicians to play on the digital piano without telling them what was special about it.

Unlike Flückiger, Papetti asked his test subjects for their subjective opinions. The musicians noticed a positive effect that they initially could not name. But when he showed them how the piano had been prepared, several of them realised what was happening: "I wasn't aware that my instrument vibrates and that I perceive this through my touch", they said. Papetti now wants to pursue his work together with the Integrated Actuators Laboratory (LAI) at EPFL.

Interactive shoes

But haptic feedback isn't just relevant to playing an instrument. It is also important to the interaction between humans and machines. "But we live in a world dominated by the visual", says Papetti. This is why most interfaces are conceived for our eyes. And yet touch is a far more subtle means of giving feedback to the user. As an example, Papetti mentions the latest Apple trackpad, which provides the user with the illusion that its surface 'gives' a little when pressed – just by employing vibrations at the right moment.

> Many musicians weren't aware they perceive the vibrations with their fingers.

In his earlier work, Papetti and his team at ZHdK tried to find out what role haptic feedback plays in learning and playing an instrument. To this end they built a device that measures what vibrations a person is actually able to perceive. Papetti is a software engineer and himself a "reasonable" keyboard player, and he was able to take up where earlier research had left off. He was part of the large-scale EU research project Natural Interactive Walking, which endeavoured to convey information not just through the usual senses, but through the feet. Papetti co-developed shoes that were equipped with small vibrators that were able to simulate different types of ground when the wearer walked in them.

When applied to music, his research provides results that have called extant opinions into question. With his haptic-feedback apparatus – an unprepossessing little box with a contact area for the fingers – Papetti has determined threshold values for vibrotactile feedback at a much lower order of magnitude than is described in the literature. It is clear that humans can perceive far more subtle vibrations than was hitherto assumed. This could be of great significance to future applications, says Papetti: if humans can cope with much finer impulses, then touch-interfaces can also be built that are all the more subtle.

"Touch is simply the most intimate form of interaction", says Papetti. And it would be a shame if we couldn't get our machines to reflect this a little too.

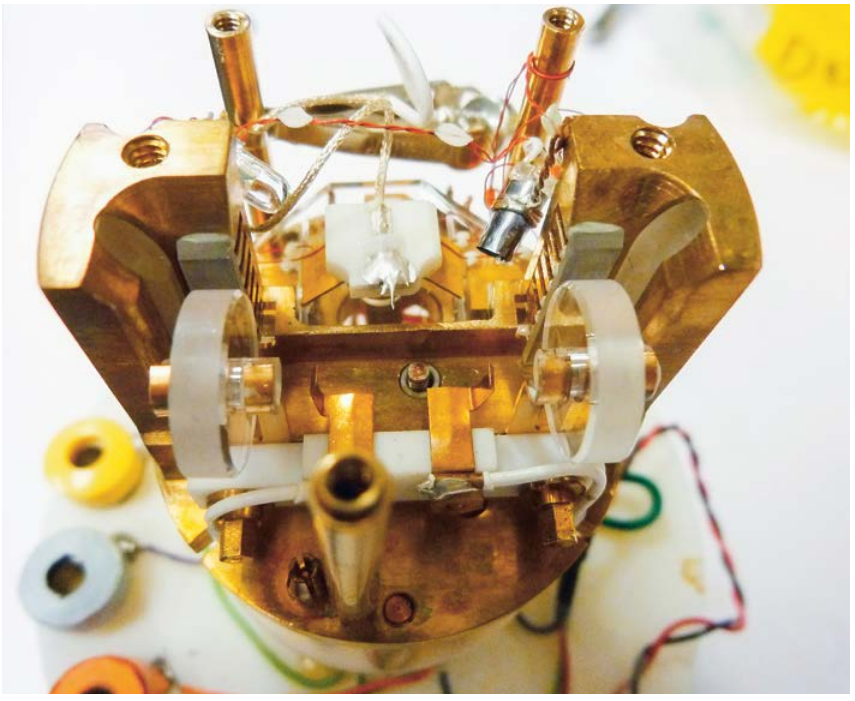
Roland Fischer is a freelance science journalist in Bern.

S. Papetti et al.: Vibrotactile Sensitivity in Active Touch: Effect of Pressing Force. IEEE Transactions on Haptics. (2017) DOI: 10.1109/TOH.2016.2582485

The accelerometer records how strongly the key vibrates. Researchers have used this knowledge to make a digital piano vibrate as if it were a real one. Image: Stefano Papetti

Atomic data

Pioneering experiments to miniaturise data media are being conducted at EPFL and ETH Zurich. The latest research shows it is possible to save data on a single atom.
By Olivier Dessibourg



This scanning tunnelling microscope records information on a single atom. The tip of the microscope lies in the iridium metal bulge (centre). Image: IBM Research, Fabian Natterer

At today's rate of data creation, existing systems will soon reach capacity. This is leading people to start questioning Moore's law, which says that the number of transistors that can be squeezed onto a given electronic chip doubles every 18 months. "The current path of miniaturisation" says Christopher Lutz, a physicist at IBM in Amalden, USA, "suggests that there would be, in principle, some 20 intermediate steps before arriving at the atom. This would require a further 30 to 40 years". Yet it appears we've arrived at this final step in a single stride, a landmark in what is a booming research field.

In 2016 teams led by Pietro Gambardella at ETH Zurich and by Harald Brune at EPFL showed that holmium atoms - a group of rare earth metals - could, on a certain surface, display a form of 'magnetic remanence'. On the basis that what can be magnetised can be used to store data, all that remained was to demonstrate the ability to read and write using the individual atoms. This is exactly what has been done by IBM's Lutz and Fabian Natterer, a member of Brune's team.

Writing on an atom

It's possible to write data to an atom, so long as it's possible to orient the atom's magnetisation in one direction or another, such as up or down. This is the same method used in hard disks, which record data encoded in binary bits (zeros and ones). "We used a scanning tunnelling microscope", says Natterer. This instrument has a minute tip which scans a material's surface, characterising each part of it with atomic precision. The tip is composed of an iridium atom and it emits a polarised electric current. This current is actually strong enough to change the magnetisation of holmium atoms and thereby to record a bit. "The effect is long-lasting", says Lutz.

Reading back the information can be done using one of two methods, Lutz adds. "The first also uses an electric current, which meets greater or lesser resistance depending on the magnetic state of the holmium atom, making it possible to distinguish the data recorded there". This is more or less what is done currently with hard disks, adds Natterer. "The second method is done remotely, by detecting the magnetic field of the holmium atom", says Lutz.

This is still currently a laboratory technique with very considerable restrictions. "It only works in a vacuum below 4 Kelvin (-269° C)", says Lutz. "The system is also very sensitive, because holmium atoms can move around on the surface", adds Gambardella. However, they are also looking into other ways of recording data on atomic matter.

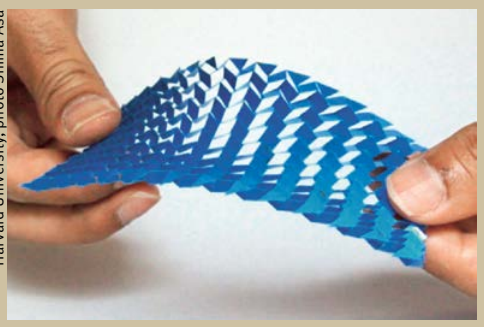
Molecular data

Another approach is to magnetise molecules. "We are using a compound of dysprosium (Dy), which is another rare-earth element", says Florian Allouche, a chemist at ETH Zurich. "A priori, this molecule does not have a memory effect. Yet at low temperatures it can achieve magnetic remanence after having been grafted onto silica and treated chemically to create dysprosium ions (electrically charged atoms) which can later be applied to a surface". According to Allouche, there are both advantages and disadvantages to this technique. On the one hand, "the molecules are simple to prepare and to characterise and could be replicated on other surfaces", but on the other hand, "we have yet to find a way to define precisely the structure for the magnetic sites".

Where the scientists do agree is that current data storage won't be replaced by atomic data storage just yet. "But the proof of concept is there", states Lutz. And according to Natterer, "the discovery will allow us to study matter at the atomic level. And through the control of magnetism at that scale, we may even create exotic materials". Gambardella sees this research being applied to quantum computing. Lutz thinks that "our work is about doing as much good for the future as possible".

Olivier Dessibourg is a freelance science journalist based in Paris.

F. D. Natterer et al.: Reading and writing single-atom magnets. Nature (2017)
F. Allouche et al.: Magnetic Memory from Site Isolated Dy(III) on Silica Materials. ACS Central Science (2017)


Ahmad Rafsanjani and Katia Bertoldi/ Harvard University, photo Shima Asa

This plastic sheet is cut and folded to make it rigid, and even able to bear weight.

Kirigami inspires engineers

Origami, the art of folding paper, inspired early prototypes for airbags, surgical probes and reconfigurable robots. It's not so easy to fold solid materials, however, particularly at the industrial level. This is where kirigami can take up the baton. Although kirigami also converts sheets of paper into three-dimensional structures, it involves cutting, not just folding. Hence another traditional art has recently found itself at the centre of an engineer's interest.

Ahmad Rafsanjani, a Harvard researcher and SNSF grant recipient, has developed a computer model to predict the effects of cutting materials. "We're looking at how deformations occur according to the cuts by using simulations". The model allows us to predict a range of results by tweaking a series of parameters: the distribution of the cuts, the material, its thickness and the tension applied.

Rafsanjani has a very elegant demonstration. He stretches a sheet of polyester that has been cut following a geometric pattern, and a three-dimensional shape emerges, composed of hills and valleys. When he applies a sufficient force, the material sets in its new shape. This interesting property is due to a change in the structure of the material.

He is now looking at specific applications and hopes to make mechanical pieces that enable friction regulation. "That would mean things like intelligent tyres with profiles that adapt to different terrains and temperatures. Then, in robotics, it might enable us to modulate adherence according to the floor surface by mimicking the scales of snakes' stomachs". *Lionel Pousaz*

A. Rafsanjani and K. Bertoldi: Buckling-Induced Kirigami. Physical Review Letters (2017)

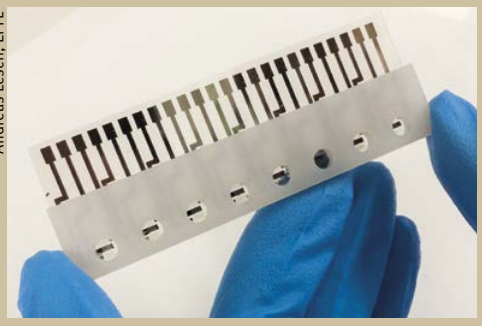
An inkjet-printed laboratory

A team at EPFL has used an inkjet printer to create electrochemical micro-sensors that serve as cheap portable devices for biochemical analysis. These tools can, for example, be used in bedside blood analyses or for building up the diagnostic capacity of remote regions.

The project was led by the Laboratory of Physical and Analytical Electrochemistry in Sion in the canton of Valais, and has developed a process for printing microtiter plates. These are sets of minuscule wells that hold samples. By permitting electrochemical immunoassays, they can be used to identify the presence of hormones or pesticides in blood, urine or drinking water, for example. "We have printed electrochemical micro-sensors using inkjet printers", explains Milica Jovič, a scientist on the project. "They are made up of eight independent electrochemical cells, which use carbon nanotubes as electrodes". The combination of plastic wells and the printed plate creates a device compatible with miniaturised potentiostats, which are devices capable of reading electrochemical signals.

Researchers compared the results against reliable tests for detecting hormones (thyroid-stimulating hormone) and pesticides (atrazine). "The results show high precision", says Andreas Lesch, another of the project's researchers. "Currently, the most common method for producing sensors is screen printing, but not only is it less flexible and more time consuming, but it's also resource intensive and less reliable". Once established, a start-up called SensàSion will market this new technology. *Geneviève Ruiz*

M. Jovic et al.: Inkjet-printed microtiter plates for portable electrochemical immunoassays, Journal of Electroanalytical Chemistry (2017)


Andreas Lesch, EPFL

Eight cells for electrochemical measurements.


Urs Graf

Weather fronts are getter wetter and stronger.

A tendency to heavy rainfall

Weather fronts moving towards us across the Atlantic often cause heavy rains over Switzerland. A new study might be able to explain why our rainfall seems to be getting ever more extreme.

A team from the University of Bergen, ETH Zurich, the State Office for the Environment of Rhineland-Palatinate and the University of Bern has been studying the formation of weather fronts over central Europe from 1979 to 2013. Just like MeteoSwiss, they take into account the temperature and humidity values. The datasets they have analysed combine computer-generated simulations with readings from satellites and ships. "We were able to demonstrate that the number of fronts has remained constant", explains the lead author Sebastian Schemm, "though the proportion of strong, extreme fronts across Europe has increased significantly". There was no similar trend in North America.

For Schemm, this result is a possible explanation as to why extremely heavy rainfall has become more frequent in several regions of central Europe in recent years. The stronger the front, the heavier the rainfall it brings, generally speaking. His assessments also showed that the reason for this development lies in an increase in humidity.

Whether this trend is connected to global warming is not clear from the results of the study. "The period we have observed is too short for that, and we would also have to carry out sophisticated statistical analyses", says Schemm. It is also possible that this is a natural fluctuation that has occurred over several decades. *Yvonne Vahlensieck*

S. Schemm et al.: Increase in the number of extremely strong fronts over Europe? A study based on ERA-Interim reanalysis (1979–2014). Geophysical Research Letters (2017)

The world of small things

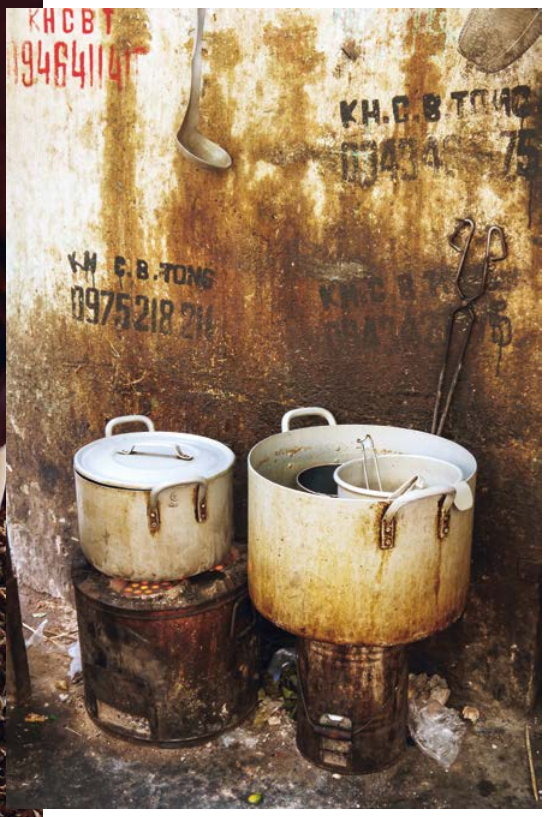
What has the lunar calendar got to do with coal briquettes? The ethnologist Annuska Derks is investigating the journeys made by everyday things in South-East Asia. To this end, she's been researching in Vietnam.

"In Vietnam, coal briquettes are part of everyday life. But even such a widespread object isn't simply 'there'. Briquettes are manufactured, transported and traded – the livelihoods of many different people depend on them. I followed the journey of these briquettes, from the coal mines to households and street kitchens. I have spoken with more than 100 people – with workers at open-cast mines and in workshops by the banks of the Red River – and I have accompanied the traders who transport the briquettes on their bikes and rickshaws through the chaotic traffic of Hanoi. And I've sat next to the cooking pots that hang above the burning briquettes.

"My research goes beyond the actual object itself. The coal briquette is a means of analysing Vietnamese society. I have learnt a lot about the relationship between the state and the private sector, about the connections between housekeeping, gender and architecture and about the upswing in religious belief. And in the process of this, it became clear that abstract processes such as urbanisation, economic development and modernisation – and the inequality that results from them – can be observed all the way into the kitchen. Coal briquettes only began replacing wood as fuel in the 1980s, because the government wanted to stop deforestation. Briquettes quickly became popular because they fit in special ovens that you can easily take with you and set up anywhere. Meanwhile, their image has changed once more. Today, they're regarded as harmful to the environment.

A holistic view of society

"A single object can enable you to take a holistic view of a society. And there are sur-



Left: Star anise from the Vietnamese highlands is being sorted after the harvest. It is traded in the lowlands. Right: The so-called beehive stoves are fuelled with substandard coal.

Images: Annuska Derks

prises along the way. Briquettes are never bought on the first day of the lunar calendar, because that is supposed to bring bad luck (according to the yin-yang principle).

"Vietnam is a socialist country. The coal mines belong to the state, which exports most of its coal. You also find coal being washed into the open by the rain near where it's mined, and some of it lands on the roads while it's being transported. These pieces of coal are then gathered, mostly by women. This coal is of lesser quality and small workshops and family businesses compress it into special forms. The end product is a typical cylindrical coal briquette with several holes through it – the locals call it a 'beehive'. The traders fetch these briquettes on their converted bicycles or – more recently – on mopeds. I've accompanied them on their trips to their clients. Men and women trade with these briquettes – and women are traditionally very much part of the business.

A simple spice for flu vaccinations

"I had the idea for my current star anise project together with a colleague from McGill University in Montreal. She was researching mostly in the highlands of Vietnam, whereas my coal project was in the lowlands. It struck us that spices are something that unites these two regions. Star anise and other spices are cultivated in the highlands, harvested, and then transported to the lowlands where they are traded and processed or exported to China and India. Vietnamese cuisine also calls for star anise – it's part of the traditional recipe for the noodle soup pho.

"Using star anise, you can get a very good insight into the economic and societal development of Vietnam. The country changed after its reforms of 1986. The price of the spice rose a lot as a result of this, and this naturally had a big impact both on the region where it is cultivated and on its trade in general. Furthermore, star anise is interesting to the pharmaceutical industry. It contains shikimic acid, which is the active agent of the flu remedy Tamiflu. After the bird flu outbreak of 2005, demand rose sharply for Tamiflu, and so did the price of star anise. Afterwards, the price sank considerably again because other flu drugs came onto the market, and because the pharma industry was soon able to produce the agent artificially. These global changes have had a concrete impact on local people. Some farmers with whom I spoke have stopped harvesting their star anise trees. It is now too costly."

Recorded by Anne-Careen Stoltze

Hunting for a formula for love, scientists subject couples to stress tests and film their dialogue afterwards. Image: Manu Friederich

Dream couples

What is the secret of a long, happy relationship? The answers offered by researchers can be as complicated as the relationships they try to describe. And yet there are a few formulas for love that science can indeed offer us.
By Susanne Wenger

A cosy twosome, in heartfelt intimacy, preferably for a lifetime. That's what most people still long for, despite rising divorce rates and our increasing focus on individualism. And yet in historical terms, our notion of a partnership founded in love is a relatively young phenomenon. This romantic concept only became established in the 19th century. And it took even longer for researchers to get to grips with it. Only since the 1970s have there been investigations into what keeps couples together (or drives them apart). Before then, separation was usually just not an option. People stayed together – both for economic reasons, and also because societal and religious conventions required it.

Things are different today. So it would be really practical to discover a scientifically corroborated formula for long-lasting happiness in love. But research is only of limited help. "The phase of being in love lasts roughly half a year as a rule", says Alexander Grob, professor of personality and

developmental psychology at the University of Basel. After that, people cast off their rose-coloured spectacles and look at the object of their affection in a more realistic light. "And from that moment onwards, things get incredibly complicated". According to their circumstances and living situation, the most varied interactions can occur.

Stable emotions, happy relationships

One's personality is an important factor. Grob has studied how the character traits of partners are linked to positive feelings in their relationship. "Emotionally stable, extrovert, conscientious and socially compatible people with a high degree of self-esteem are more satisfied in their partnerships". Among the characteristics that are particularly powerful are those that psychologists gather together under the concept of 'neuroticism'. People who are more emotionally unstable, tense and anxious are less happy in love, while the more stable, self-assured and calm we are, the happier we are. So have nervous, shy and introverted people been dealt the worse cards? Not according to Grob: "We are not just abandoned to the vagaries of our personality as it is. We can also change how we think and act". Emotionally unstable people who immediately assume the worst in ambiguous situations with their partner – "he/she doesn't love me any more!" – can become aware of their behaviour and can try to change it or improve it. "If negative interpretations become less common, emotional stability increases". The result is that one experiences one's relationship as being happier.

Do it like Michelangelo

Partners can grow together. Over time, people with a lower sense of self-worth become increasingly positive about themselves when they are together with a partner who is content. Furthermore, couples who support each other in order to bring out the best in themselves live especially long and happy lives together. This is the finding of the psychologist Eli Finkel and his team of researchers in the US, who call it the Michelangelo phenomenon. The famous Renaissance sculptor was of the opinion that a work of art already existed, slumbering away in every block of marble. He just had to prise it out – carefully but determinedly chiselling and polishing it to let it emerge. In the context of a partnership, this means that couples should mould and support each other so that their opposite number becomes empowered to realise their ideals and their life's goals. The tools for this are empathy and sensitivity. Whoever brings these with them is the better 'sculptor' in the relationship.

It is also possible that we experience new things about ourselves. The eye of a loving partner can recognise dormant potential. But what doesn't work, on the other hand, is trying to change one's beloved. "If I don't like something about my partner, I can influence only how I myself deal with it", says Grob. In such a case, we should ask whether the issue that annoys us can be integrated, and if so, how.

Small gestures, big impact

The manner in which couples talk with each other also has a lasting impact on the fate of a relationship, says Nathalie Meuwly, a psychologist at the University of Fribourg: "Partnerships where communication is formed on understanding and good intentions are happier and more stable". Keeping lines of communication open, listening attentively, giving praise, compliments and little gestures of appreciation and affection – all this can consolidate a partnership to a large degree, and should not be underestimated. It's worth cultivating this consciously, despite the daily grind, says Meuwly. And for those who have thus far noticed the absence of sex in this article: caresses and eroticism are also forms of communication. Sex creates bonds without needing many words.

> "If both are stressed, it can get dangerous for a relationship".
>
> Nathalie Meuwly

Positive communication does not mean saying only nice things to one's partner. People should also broach difficult topics and express criticism. Occasional conflict doesn't actually do any harm, so as long as it doesn't topple over into destruction and contempt, says Meuwly. "A conflict can help to clarify positions. And it offers the opportunity for reconciliation". In this manner, intimacy and understanding can be re-established between the partners. But we should watch out, because it all depends on getting the mixture right. Research has shown that five positive gestures offset only one negative gesture. So whoever criticises their partner once should afterwards display five signs of affection. That way, the relationship can stay balanced. So we've found a clear formula after all! It was drawn up by the US pioneer in relationship research John Gottman.

Stress kills relationships

According to Meuwly, there are two further factors that play an exceptional role in how partners interact. First, couples who can offer mutual support in stressful situations – such as career stress – can stabilise their partnership in the process. Secondly, solving conflicts and problems together also forges bonds. It's clearly simpler to offer support in cases of stress at work than it is to deal with arguments involving the relationship itself. "Stress that comes from the outside into a relationship demands different skills from stress that is self-made", says Meuwly. She has found only a few differences here between male and female. Women still support their partner in stress situations, even when they're under pressure themselves. Men don't manage this as well. According to Meuwly, this shows that "when things get stressful, it can get dangerous for a relationship".

There is still a lot to study. For example, we know little about elderly or same-sex couples. But such research can help us all. For many years now, the University of Zurich has been offering a successful partnership programme entitled 'Paarlife', which was developed by Guy Bodenmann, a professor in clinical psychology. Love is like a little plant, he writes. It has to be tended, otherwise it wilts away.

Susanne Wenger is a freelance journalist in Bern.

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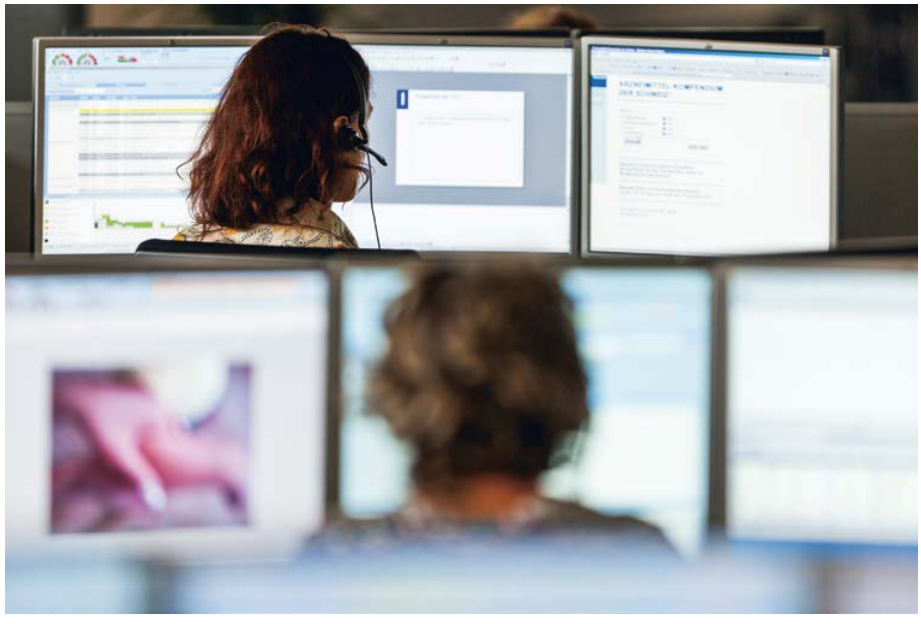
R. Weidmann, Th. Ledermann, A. Grob: The Interdependence of Personality and Satisfaction in Couples. European Psychologist (2016)
G. Bodenmann, N. Meuwly et al.: Effects of Stress on the Social Support Provided by Men and Women in Intimate Relationships. Psychological Science Online First (2015)

Measuring love

Different methods are used to carry out partnership research. Couples can be interviewed by means of questionnaires about personality, processes in their relationships and their degree of satisfaction. Some participants keep a diary. Researchers also observe couples as they communicate. For example, they might be given the task of relating something stressful from the previous day, and they are filmed doing it. The psychologist Nathalie Meuwly from Fribourg has placed couples under stress in her university laboratory. The couples had to undergo a job interview and solve a mathematical problem, all independently of each other. Then they came together in a waiting room, where the researchers filmed what spontaneously happened. Physiological values are also measured, such as the levels of the stress hormone cortisol in saliva samples, and the heart rate.

Machines that listen

Algorithms are learning to recognise emotions in the voice. The main challenge is to transition from the lab to the real world. *By Sophie Gaitzsch*



One day, it might be worth cursing the computerised voice of a call centre to try and jump the queue. Image: Keystone/Martin Ruetschi

You call your bank or insurance company, only to be greeted by an automated message. For several protracted minutes, you are presented with a drawn-out and often redundant list of options. Your blood boils and eventually you can hold your tongue no longer: 'Stupid system!' But then, and as if by magic, an operator picks up the line. This is no longer a coincidence, because programs using artificial intelligence are now able to understand emotions, which enables companies to adapt their services.

At the University of Zurich, Sascha Frühholz, a professor of psychology who specialises in the neurosciences, is working on the automatic detection of human emotion. "Algorithms are becoming more effective, particularly in recognising the six principal emotions: anger, fear, joy, disgust, sadness and surprise. They still struggle when it comes to the more complex emotions such as shame and pride. But that's not unlike humans, of course".

Mixing methods

The main challenge for the machines is learning to be sufficiently generalised. "The training data are extremely specific", says Frühholz. "Performance drops with a change in acoustic environment or language. Even if an algorithm can learn to understand anger in the voice of someone from Zurich, it won't be so successful with someone from Geneva. Accuracy will drop even further with people from Asia, as the acoustic profiles of their languages are even further removed".

To overcome this pitfall, Frühholz has experimented with the combination of supervised and unsupervised learning techniques. "What we did was first to train the algorithm with voice data labelled as angry or happy. We then introduced non-labelled data, allowing the system to build its independence".

The rate of recognition has reached 63 percent, markedly better than using supervised or unsupervised learning alone (54–58 percent). Humans on the other hand are 85–90 percent accurate in determining the emotion in the voice of a person, adds Frühholz, who is also studying human auditory perception. "For both humans and algorithms, recognition accuracy depends to a large extent on the number of emotions that must be simultaneously discerned".

Keeping our roads safe

Automatic emotional recognition will have a number of potential applications: customer services, marketing, surveillance, caring for the elderly and even medicine. "For one thing, it will pick out the first signs of an episode of anxiety or depression", says David Sander, director of NCCR Affective Sciences and of the University of Geneva's inter-faculty research centre.

Over at EPFL, Jean-Philippe Thiran is conducting similar research but this time on the recognition of facial expressions. He has partnered up with the automobile industry, which shares his interest in emotion recognition. Thiran says their aim is "to collate information about the driver. In semi-autonomous cars, for example, it's extremely important to know the emotional state of the person behind the wheel when handing over control of the vehicle: are they stressed, and can they take decisions?". Irritated drivers might then find that the car speakers start playing relaxing music, while tired drivers might be stimulated by having the dashboard glow slightly brighter.

"Today, research in this field has advanced to a stage where we're tackling the recognition of facial expressions in unfavourable conditions such as in poor lighting, while moving, and from acute angles. Not to mention those quirky and subtle facial expressions", adds Thiran. Algorithms are indeed moving forward quickly, but they are not yet capable of interpreting the full range of the emotions that make up everyday situations, whether revealed by the voice or by the face.

Sophie Gaitzsch is a journalist in Geneva.

Mayline Gaucher

The interactions between customers and shop-owners bring life to Pâquis in Geneva.

Diversity doesn't wreck neighbourhoods

Over a three-and-a-half-year period, a Geneva-based research project that culminated in 2016 explored the effect of diversity on social stability. It studied three Genevan neighbourhoods: Paquîs, Eaux-Vives and Jonction, comparing them with Belleville (Paris), Agios Panteleimonas (Athens) and Saint-Gilles (Brussels).

"We chose diverse neighbourhoods, made up by groups with different migratory backgrounds and with no single majority group", says Alessandro Monsutti of the Graduate Institute of International and Development Studies. The qualitative research methods employed were free, semi-directed interviews and observation.

One might believe that diversity – with its myriad individuals and their transnational links – elevates the relevance of a neighbourhood above and beyond the local level, making it on the one hand harder to identify with and on the other more idiosyncratic. Monsutti formulates it another way: "Do the people who frequent such neighbourhoods invest so little in them that they disappear?".

There is, however, more to the question than at first meets the eye. The people who bring a neighbourhood to life do not necessarily keep their homes there. They are the people you see and who play certain roles – retailers, for example – and as they get to know each other, so stability is fostered. The built environment also plays its part, hence the prudence taken to explain proactively any changes to a neighbourhood, at the risk of creating an insecure and barren cityscape. *Benjamin Keller*

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Ph. Gazagne et al.: Connivences et antagonismes en milieu urbain. Regards anthropologiques sur Genève. Sociograph No. 26 (forthcoming)

The rules of polite contradiction

Don't speak too softly or too loudly, and keep your face turned to your conversation partner. And don't choose a topic that's too serious or too sad. These and other rules for holding a polite conversation can be found in Italian books on propriety published in the 19th century. This literature boomed between 1800 and 1920 – a time of societal change – with 186 different books of this kind being published in at least 450 editions. Cheap books on conduct were published on low-quality paper for schoolchildren and the lower middle classes, while luxurious etiquette books were available for the upper classes.

The linguist Annick Paternoster, from the University of Italian Switzerland, has been investigating the 50 most popular books of this type to determine their rules and formulae for politeness. Together with Francesca Saltamacchia, she chose her selection based on the number of editions that appeared. The more widespread their use, the more editions these books enjoyed. Over the space of two years, Paternoster and Saltamacchia have created and analysed the digital collection 'Corpus dei galatei italiani ottocenteschi' ('Corpus of 19th-century Italian conduct books'). "It was fantastic to find these rules stated so explicitly", says Paternoster.

The formulae for politeness in these books indicated the social class of a speaker, such as phrases like 'always at your service'. While these have since disappeared, other formulae have remained valid. "If you want to express a different opinion but avoid open conflict, then the parallels are clearly recognisable today", she explains. For example, to express open contradiction with the words "that's not true" was regarded as impolite. Instead, you could smooth out the act of negation with a phrase along the lines of "it seems to me that …" – and this option remains valid today. *Pascale Hofmeier*

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Source: A. Paternoster and F. Saltamacchia (2017): (Im)politeness formulae and (im)politeness rules: metadiscourse and conventionalisation in 19th Century Italian conduct books. In: E. M. Pandolfi et al. (ed.), *Studies on Language Norms in Context*, Peter Lang, Frankfurt am Main, 2017.

Biblioteca Nazionale Centrale di Firenze, CF990297696

Students at the military academy had their own rulebook for etiquette.

niepo/Shutterstock

The iconic White Cliffs of Dover signify both separation and connection.

Clairvoyant literature

'Brexit' has closed off the English Channel, at least in the minds of many Britons. The UK Independence Party (UKIP) campaigned for a Brexit 'yes' with a poster that showed an escalator running up the famous White Cliffs of Dover. Its message was simple – that closing down the border to Europe would stop Britain being 'overrun' by foreigners. And it hit home.

The English Channel has a complex function for the British, and this finds expression in their literature. "A border is a zone that divides and unites at the same time", says the English specialist Melanie Küng of the University of Basel. In her doctoral thesis, which she is currently completing, she demonstrates how authors have seen the Channel as more than just a means of partition from the continent that serves to guarantee their island identity. The writer Tom Fort, for example, travelled along the coast visiting the traces of former links to the Continent, thematising the Chunnel and the sea ports. And Jamaica Kincaid, who grew up on the Caribbean island of Antigua when it was still a British colony, describes bitterly how the White Cliffs are only for the whites, as they can identify with the colour. She herself finds the Cliffs "dirty".

"On the one hand, literature is powerless in the face of politics, but it can also be clairvoyant", says Küng. The literature written about the English Channel in the 1990s describes the border's complexity at a time when the dominant economic discourse was negating all borders in the wake of globalisation and digitisation. What's happening today, says Küng, has already been articulated by fiction. *Urs Hafner*

Nature paradise

The ecologist Christoph Küffer is arguing for a rethink in the field of nature conservation. In order to protect biodiversity, humans should stop trying to preserve our last spots of untouched nature, and instead intervene more. *By Stefan Stöcklin*

It's a sobering fact for nature conservationists: Of the roughly 45,000 known species of flora and fauna in Switzerland, about a third are threatened, while hundreds have already died out in recent years or are under pressure. Despite all our efforts up to now, biodiversity is vanishing almost unimpeded.

In view of this development, Christoph Küffer is campaigning for a rethink in the field of conservation. He's an urban ecologist who teaches at the University of Applied Sciences Rapperswil and at ETH Zurich. "The countryside areas that are worthy of conservation are too fragmented here for them to be able to retain their biodiversity", he says. Furthermore, human beings are changing all habitats irreversibly on account of CO_2 and nitrogen emissions. The idea of conservation is no longer sufficient in the Anthropocene era, says Küffer. His proposal is 'nature design'. "In order to maintain biodiversity, we have no choice other than to invent and design a new nature for the future".

Designer nature

Küffer's idea would be a radical departure from existing practices such as have been implemented in the Swiss National Park in the canton of Graubünden. On its 17,000 hectares, animals and plants are left as undisturbed as possible, and human interventions are taboo. Instead of leaving authentic wildernesses to themselves, Küffer believes that humans should actively maintain and create diverse nature areas. He is even willing to contemplate intervening in conservation areas themselves. For example, he could well contemplate creating low-nutrient meadows on the outskirts of the Neeracherried in Riedt near Zurich – one of the last remaining large fens in Switzerland. The goal would be to create an unnaturally high degree of biodiversity. Even the many small nature reserves in the Swiss midlands could be organised more intensively – in other words, with a greater biodiversity.

> "In order to maintain biodiversity, we have to design a new nature for the future".
>
> Christoph Küffer

Nature design would also mean that roof gardens, green façades and parks in urban areas could offer new habitats for species under threat. For Küffer as a maverick thinker, the famous High Line in New York is an exemplary case where his ideas are already being realised – it is a specially designed natural landscape on an abandoned railway line in the midst of the metropolis. "Nature conservation as design means that any and every place has the potential of becoming a nature paradise". According to Küffer, the biodiversity of the future would

The High Line of New York is a prototype in nature design. On an abandoned railway line, diversity is created by artificial means.
Image: Keystone/AP Photo/Mark Lennihan, File

be a mixture of wild species, cultivated plants and ornamental plants, right in the middle of our human environment.

Rare species will die out anyway

For Küffer, 'designing' biodiversity also means shifting nature conservation away from specialists and from the notion of 'managing' it. Instead, it should be the responsibility of gardeners, farmers and even nature enthusiasts – the selfsame people who have always been involved in 'creating' nature anyway. This would make nature conservation more varied and less planned. As a consequence, nature design would probably mean that some endangered species would die out, since their dwindling habitats would only be replaced in part. But this is also the case with current conservation policies, insists Küffer. He is convinced that his approach will ultimately be more efficient. Through designed landscapes, many moderately threatened species could be protected, whereas human influence means that even a lot of money could not ensure the long-term survival of highly rare species.

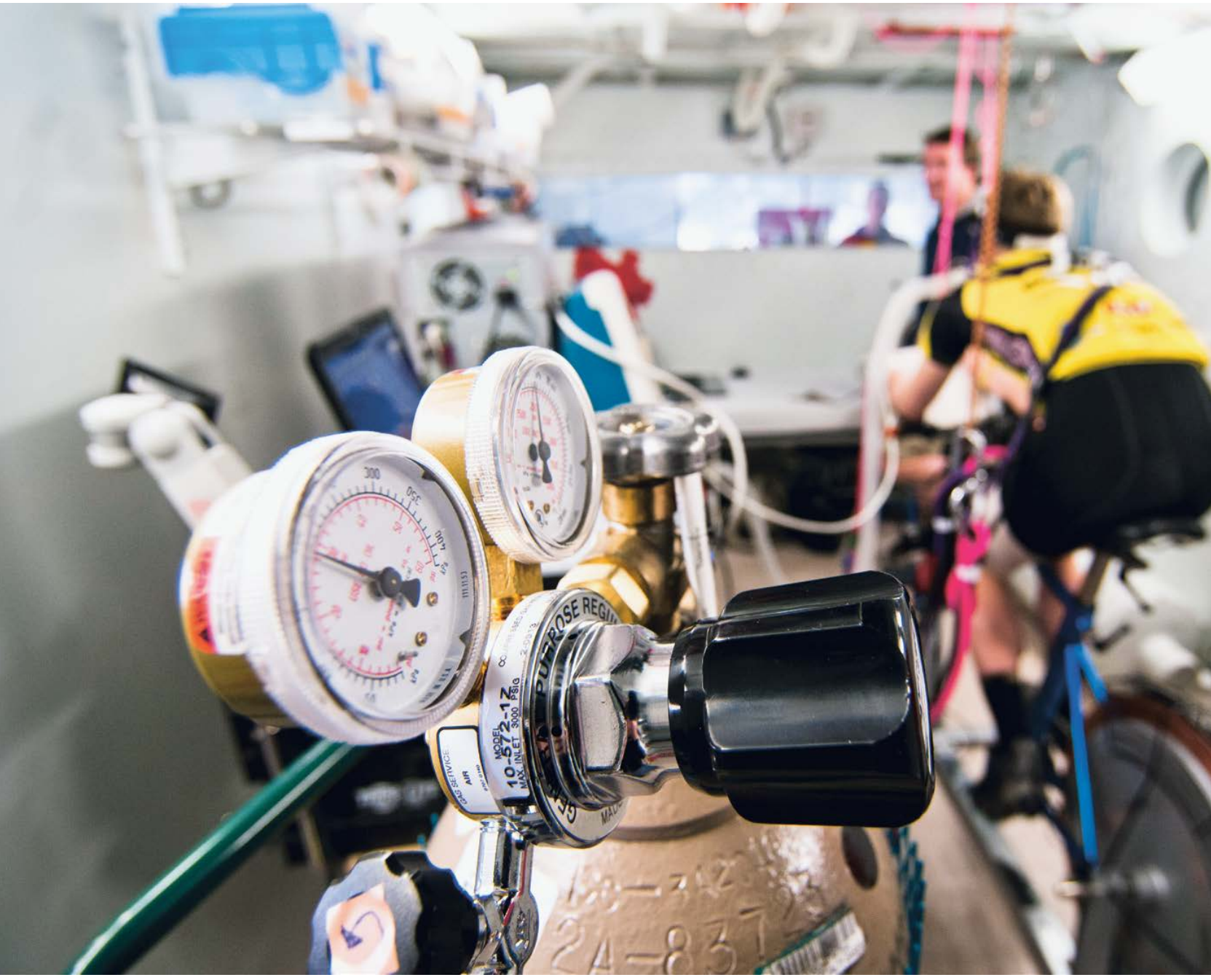
Küffer's ideas are disputed in specialist circles. Markus Fischer is a plant ecologist at the University of Bern and President of the Swiss Biodiversity Forum. He shares Küffer's view that a conservation policy cannot be viable today if it is based on traditional values that were valid 100 years ago. But he believes that the problems lie elsewhere: in a lack of money and in a lack of political will to implement nature conservation goals: "For effective protection and to promote biodiversity, it would have to be prioritised on roughly 30 percent of our surface area". This could be carried out partly in conservation areas (which thus far encompass only 10 percent of Switzerland), and partly in agricultural areas that are biodiversity-friendly, says Fischer.

More money and better appreciated

Raffael Ayé, the head of the species support programme at BirdLife Switzerland, points out that traditional conservation too is pursuing pioneering concepts. "Since the 1980s we have been using integrated methods to try and protect and utilise areas at one and the same time", says Ayé. We must never lose sight of nature conservation and preservation goals. "We have to keep investing in the protection of our most valuable areas such as dry grasslands and the National Park". Just like Fischer, Ayé too is advocating for more support from politicians – in other words, for more money, for a greater degree of appreciation and for better care for endangered habitats.

Küffer is aware that many of his colleagues see his suggestions as a provocation. But he does not want to play off different ideas against each other. The current formulae for nature conservation – protected areas and supporting individual species – undoubtedly have their own justification, he says. But he is convinced that "if we are going to maintain biodiversity in a time of climate change, intensive farming and funding scarcity, we are going to need to rethink things and develop new approaches".

Stefan Stöcklin is an editor in the Communication Department of the University of Zurich.



Simulated altitude training: cyclists can improve their performance in special chambers – and scientists can assess the impact of the method.
Image: Keystone/Aurora/Rob Hammer

The placebo effect of mountain air

High-altitude training is supposed to keep endurance athletes in top form. But controlled comparisons have failed to find any impact.
By Florian Fisch

"It's all a placebo".

Carsten Lundby

"For 15 years it's been evident that altitude training can have a positive effect on performance in endurance sports".

Jon Wehrlin

When the elite athletes Nicola Spirig and Nino Schurter landed in Rio de Janeiro in August 2016, they had already undergone altitude training. This entailed spending several weeks above St. Moritz, but training every day down in the valley. They have to organise their preparations exactly so that their competition falls in a time window of 14 to 25 days later. In recompense for their efforts, they hoped to achieve an increase in performance – perhaps just enough to secure them an Olympic medal.

Elite athletes full of haemoglobin

The Danish physiologist Carsten Lundby came to the University of Zurich in 2010 to find out the impact of altitude training. The scientific literature writes mostly about a higher concentration of the red blood component haemoglobin, which transports oxygen. In order to compensate for the lack of oxygen at high altitude, the body increases its production of haemoglobin. The then school of thought was that this excess capacity improves performance when the athlete is back in normal air pressure.

After several tests, Lundby changed his mind. He is now convinced that this training method achieves nothing. When his research group tested the blood of athletes after their altitude training, they were unable to find any difference. He suspects that the athletes are already so full of haemoglobin that their altitude training simply has no effect.

But Lundby wanted to have more precise information. "We organised a study that was double-blind and placebo-controlled, just like a drug trial". For half of the test subjects, he artificially lowered the oxygen concentration in their bedrooms so that it corresponded to an altitude of 3,000 metres above sea level. Neither the researchers nor the athletes knew to which test group they belonged – i.e. who was subjected to 'altitude training' and who wasn't. Lundby has meanwhile completed a total of six controlled studies with between 15 and 19 cyclists and cross-country skiers each time. His conclusion is this: "It's all a placebo. If the athletes didn't know to which group they belonged, we found no effect at all". It is only effective at unrealistic altitudes. In his overview of the literature, Lundby advises elite athletes to give up this expensive form of training. He now teaches at the University of Copenhagen.

Better blood supply to the muscles

Lundby's conclusions are disputed, however. Jon Wehrlin, the head of the Sports Physiology (endurance) Section at the Swiss Federal Institute of Sport in Magglingen in the canton of Bern, offers a more qualified opinion: "Many of the studies we have observed made methodological mistakes in their training". Some of them, he reports, had not waited for the right time window, or had simulated an altitude that was too low. So in his opinion, it isn't surprising that there was no perceivable improvement in performance. After many years of experience, he says, he is sure that the positive effects can be very individual. Furthermore, it is not possible to prevent athletes from knowing to which test group they belong. "For 15 years it's been evident that altitude training can have a positive effect on performance in endurance sports".

This is also confirmed by Grégoire Millet, a professor of physiology at the University of Lausanne. Altitude training has been carried out since the 1960s and has been called into question before, he says. In an ideal case, however, performance can improve by up to three percent.

Millet and Lundby published an overview of the literature in 2012 in which they defined standards for more rigorous controls in studies. After that, they went their separate ways. Millet developed 'repeated sprint training' using reduced oxygen in order to delay the onset of muscle fatigue under maximum stress. He carried out several studies and was able to prove that this indeed improved the blood flow to the muscles. Even when it comes to other methods, Millet believes that the literature clearly indicates the efficacy of altitude training. "Since 1997, over 70 articles have been published on the most popular variant – 'live high, train low' – of which only two write of a placebo effect".

Peter Bärtsch is a doctor and a former director of the Department of Sports Medicine at the University of Heidelberg. He is also a co-author of the literature review that defines the standards for the field. But he affirms the high quality of Lundby's study. "I would continue to recommend athletes to 'live high and train low', though it remains unclear whether the effect is physiological or psychological".

Florian Fisch is a science editor at the SNSF.

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C. Lundby and P. Robach: Does altitude training increase exercise performance in elite athletes? Experimental Physiology (2016)
F. Brocherie et al.: Effects of Repeated-Sprint Training in Hypoxia on Sea-Level Performance: A Meta-Analysis. Sports Medicine (2017)

The effectiveness of electrical brain stimulation on a young person with dyslexia being tested. A silent film keeps

Bringing order to the jumbled letters

Electric stimulation might help people with dyslexia to strengthen their brain's interconnection between spoken and written language.
By Yvonne Vahlensieck

Reading and writing are relatively new achievements in the history of mankind. That means they're not pre-programmed in our brains. As a result, we spend a lot of time in our early school years learning how to translate spoken language into written letters (and vice versa). But some children just can't do this properly. They mix up letters, make innumerable spelling errors and can only read hesitantly. Between 5 and 15 percent of the population suffer from such a reading and writing disability, which is generally known as dyslexia. New findings from brain research might offer them help.

Trouble with syllables

Researchers have long been investigating just what goes wrong in a case of dyslexia. What is certain is that it's got nothing to do with intelligence or a lack of it. Instead, neuroscientists have discovered a deficit in the brain's interface where it processes spoken and written language. "The problem is not primarily to do with hearing or seeing, but lies on a higher level where auditory and visual linguistic processing come together and are concentrated",

the subject alert. Image: Nicolas Righetti/Lundi13

explains Daniel Brandeis, a professor of neurophysiology at the University of Zurich. "At this interface, spoken language is dismantled into its individual elements and linked to visual patterns of written characters that can be recognised by specialised regions of the brain".

> "For those who are badly affected, reading usually remains difficult despite successful treatment".
>
> Daniel Brandeis

This corresponds to the experience of those who teach children with special needs. Children with dyslexia find it difficult to break down language into its smallest units – phonemes. For example, they find it difficult to clap to syllables and to differentiate between similar sounds such as 't' and 'd'. This is why therapies for dyslexia often concentrate on these deficits. "Purely visual training without language has no positive effect on reading and writing", says Anke Sodogé, a professor at the University of Applied Sciences of Special Needs Education in Zurich. "On the other hand, exercises for differentiating and processing sounds have been proven to be effective". But she also warns about expectations being too high with this therapy because the progress attained is often only minor, regardless of the effort involved.

Correcting brain oscillations

A new neurological approach to treating dyslexia could improve the success of these therapies. It is based on the finding that specific brain waves are out of step in people with dyslexia. With the aid of electrical brain stimulation, the Swiss psychologist Katharina Rufener at the Otto-von-Guericke University of Magdeburg aims to bring these oscillations back into synch. "The idea is to normalise the initial physiological activity of the brain so that the therapy has a better impact".

> "In dyslexia, these oscillations are too slow or too quick".
>
> Katharina Rufener

In the brain, neurons fire synchronously to create different types of oscillations that fulfil different functions, according to their frequency. The gamma oscillations that are disturbed in cases of dyslexia have a frequency of between 25 and 40 hertz and are involved in processing auditory language: "The brain has about 25 milliseconds to recognise individual phonemes. This sampling rate corresponds roughly to the period of a gamma oscillation", says Rufener. "In dyslexia, these oscillations are too slow or too quick, which means that the sampling rate of the acoustic language signal is disturbed. This is why the brain cannot distinguish between different phonemes".

In order to make these altered oscillations synchronous again, Rufener stimulates the brain of her test subjects by means of two electrodes attached to their heads. The desired frequency is transmitted to the brain by a weak alternating electric current. It is known that nerve cells in the regions stimulated will take up oscillations transmitted from outside.

Rufener stimulated her test subjects with these oscillations and at the same time had them carry out tasks to differentiate phonemes. Children and young people with dyslexia were able to carry out these tasks better with this stimulation than without; the frequencies used were in the gamma range. In a second series of tests, Rufener now wants to find out the effect of other oscillations that are also impaired in the majority of dyslexia patients, and which are linked to cognitive ability.

It is still unclear whether or not this method can lead to a long-term improvement, because after a single phase of stimulation, the brain falls back into its incorrect rhythm almost immediately. But there are signs that the effect lasts longer when the brain receives this stimulation several times over a longer period.

Testing the approach

Anne-Lise Giraud, a professor in neuroscience at the University of Geneva, believes that it is too soon for a therapeutic use of this approach. "Actually, we don't really know yet what happens when the brain is stimulated". She is carrying out similar tests in collaboration with the Wyss Center for Bio and Neuro-engineering – though initially only on adults without dyslexia. "When we stimulate them, we see an improvement in their ability to recognise phonemes. But we also get many contradictory results".

This is why Giraud first wants to carry out more basic research. For example, it still has not been definitively explained whether or not gamma oscillations are constantly present. "We believe that the brain itself only gives out a weak oscillation, which is then strengthened through the act of hearing". Her investigations also show that the gamma oscillations are coupled with other waves in the brain that quite possibly control adjustments to different speaking rates. In order to test her hypotheses, Giraud has developed a computer simulation: "The model depicts a network of neurons that produces gamma oscillations, and with this we can run through all these processes".

Even if these connections have not yet been explored in detail, Daniel Brandeis finds the application of electrical brain stimulation a highly promising approach: "I can well imagine that this procedure can decisively increase the efficacy of existing therapies, and thereby achieve quicker, longer-lasting changes". All the same, we should not expect to achieve a complete cure. "For those who are badly affected, reading usually remains difficult despite successful treatment. Only in rare cases will they be able to read with the same ease as people without dyslexia".

Yvonne Vahlensieck is a freelance science journalist who lives near Basel.

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Rufener K. S. et al.: Transcranial Alternating Current Stimulation (tACS) differentially modulates speech perception in young and older adults. Brain Stimulation (2016)

Remote-action bacteria

In the first weeks of life, the immune system of mammals isn't yet fully developed. This is why mothers provide their young with antibodies to protect them against dangerous pathogens. They do this through the placenta and in their milk.

But maternal support goes beyond this, as Andrew Macpherson and his research group at the University Hospital of Bern have discovered. Intestinal bacteria are known for their positive effect both on digestion and on the immune system; when Macpherson placed these microbes in the gut of pregnant mice, it improved the intestinal flora and the immune system of their unborn young. This effect was even observed when the young mice later had no direct contact with the bacteria at all.

In these tests, the intestinal flora of the mothers had a particular influence on the cells of the innate immune system that are most active in the intestinal mucosa. These so-called lymphoid cells multiplied more in young mice whose mothers had been specifically provided with bacteria, than was the case in control mice without this flora. For these tests, all the mothers were raised under sterile conditions.

"The innate immune system of young mice is clearly prepared to react to colonisation by the maternal bacteria", explains Macpherson. "We were also able to show that the propagation of the lymphoid cells was boosted by antibodies that the mother gives her offspring".

Now Macpherson and his team want to find out whether the intestinal flora of the mothers also influences the further development of their young. *Karin Hollricher*

S. C. Ganal-Vonarburg et al.: Maternal microbiota and antibodies as advocates of neonatal health. Gut Microbes (2017)

srisakorn wonglakorn/Shutterstock

The immune system of a young mouse is already trained in its mother's womb.

Loïc Costeur

The inner ear of a cow foetus (reconstruction) tells us much about the evolution of ruminants.

Of cows and men

The inner ear contains our organs of balance and hearing, and lies firmly enclosed within our skull. In the course of our prenatal development, soft cartilage cells turn into the cover of the cochlea and our balance organ, before ossifying. For biologists, the solidification of this labyrinth is an interesting indicator of evolutionary change.

Loïc Costeur from the Natural History Museum in Basel has now tracked the prenatal growth of the inner ear of cow foetuses for the first time, and has come upon a surprising congruity: "The labyrinth ossifies after about five months of pregnancy in cows, which is at roughly the same time as in humans".

For his study, Costeur and his colleagues at the Basel University Hospital made CT scans of different stages of skull development in cow foetuses and of a fully-grown bone from the museum collection. According to their analyses, the labyrinth in the inner ear grows quickly and ossifies in the early phases of its development. By contrast, the massive petrosal bone, in which the inner ear lies, continues to grow after birth, along with the other cranial bones.

"Such development features are important in order to understand better the evolutionary connections between species", says Costeur. Studying these ossicles in cattle has provided results that offer an initial step towards a more comprehensive analysis of ruminants. If we consider that the phylogeny of the ruminants can be traced back 45 million years, then it is astonishing that the inner ear of humans undergoes a similar development. *Stefan Stöcklin*

L. Costeur et al.: Prenatal growth stages show the development of the ruminant bony labyrinth and petrosal bone. Journal of Anatomy (2016)

Doubly useful fungi

The larvae of the cockchafer beetle live in the soil and eat the roots of plants. This means that they aggravate the erosion of fertile soils in alpine valleys and are a problem for farmers. But in Switzerland, no one is allowed to kill the larvae with synthetic insecticides – nor is this desirable. This is why Jürg Enkerli of the research institute Agroscope in Reckenholz is looking for biological means of combatting these pests. He is now investigating the potential of the fungus *Beauveria brongniartii*, which attacks the cockchafer and its larvae.

Fungi that attack insects can be found mostly in the ground. Some of them, however, can also live in plants. In such cases, experts speak of endophytic colonisation. Together with a colleague in Jordan, Enkerli has recently discovered that *B. brongniartii* too can live in plants. In their tests, the researchers sprayed the leaves of broad beans with spores from this fungus. Astonishingly, the broad beans do not initiate any defence or stress reactions while the fungus spreads amongst them. On the contrary, they grew on average even quicker than the control plants that weren't sprayed.

The cause of this increase in growth remains unclear. It also remains unexplained whether the plants are actually protected from the cockchafer larvae. If this is proven during further tests, it would provide a highly promising opportunity for an organic means of combatting the cockchafer. *Ori Schipper*

L. R. Jaber and J. Enkerli: Fungal entomopathogens as endophytes: can they promote plant growth? Biocontrol Science and Technology (2017)

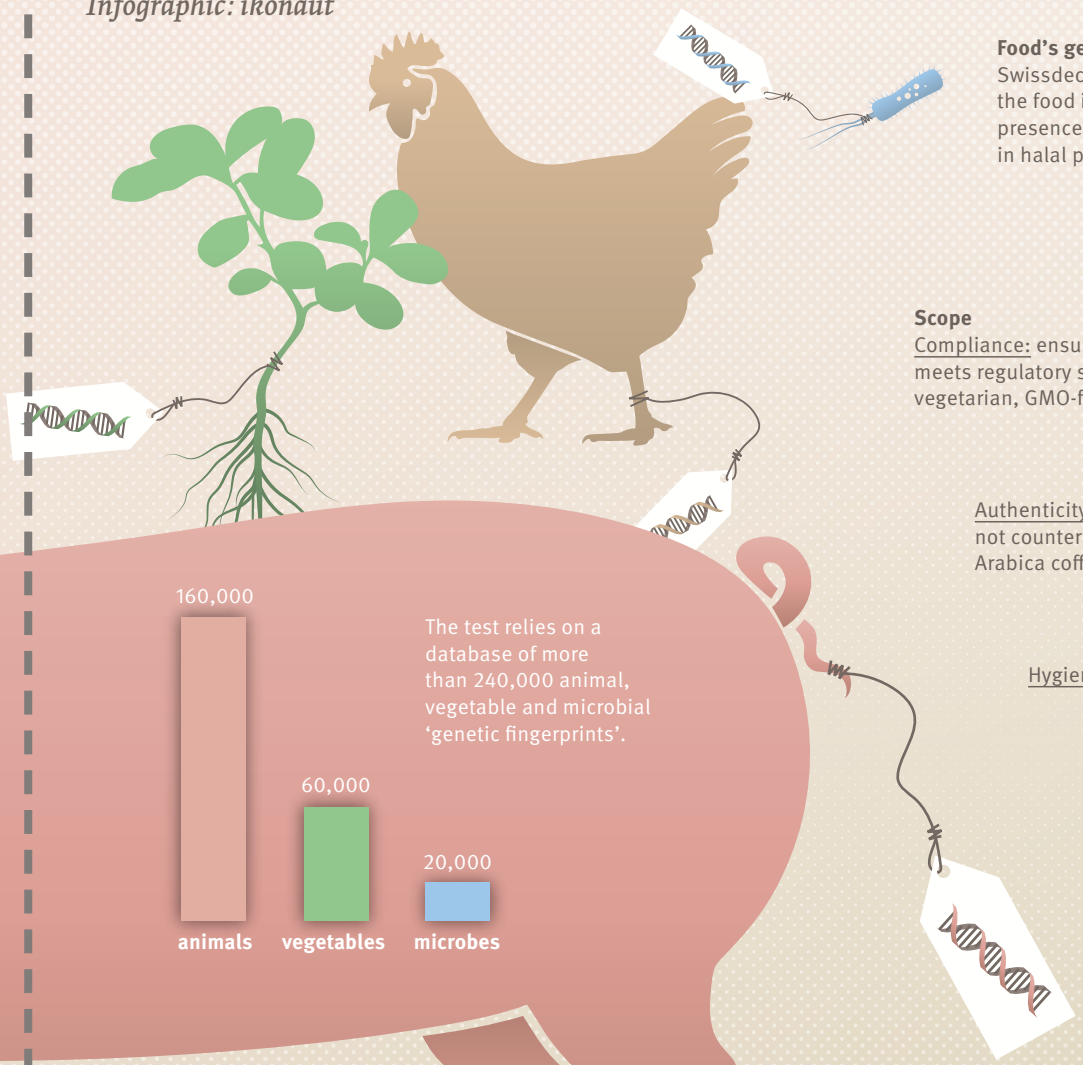
Jürg Enkerli, Agroscope

A fungus infests the stalks of broad beans and promotes their growth at the same time.

DNA: You are what you eat

A start-up in Lausanne is taking genetic testing out of the laboratory. It aims to speed up verification checks in the food chain.

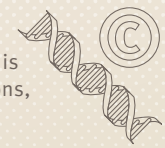
Text: Daniel Saraga
Infographic: ikonaut



Food's genetic fingerprint
Swissdecode has developed an on-the-spot DNA test for the food industry. A sample of food can be checked for the presence of specific genetic sequences, such as porcine meat in halal products or fungus in cereals.

Scope
Compliance: ensuring that a foodstuff meets regulatory standards (kosher, vegetarian, GMO-free, etc.)

Authenticity: guaranteeing a foodstuff is not counterfeit (geographical indications, Arabica coffee, Chinook salmon, etc.)



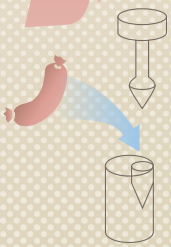
Hygiene: detecting fungus in shipments.

The test relies on a database of more than 240,000 animal, vegetable and microbial 'genetic fingerprints'.

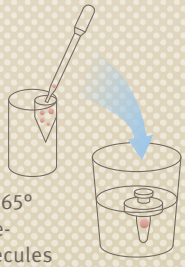
First steps
In mid-2017 a test for porcine meat will be placed on the market by this spin-off, which started out at the University of Geneva. "The companies we're working with are regularly having to wait two days for the results of each and every lab test", says co-founder Gianpaolo Rando. In the pipeline are three other tests to detect probiotic bacteria protected under intellectual property law.

A genetic test in 30 minutes

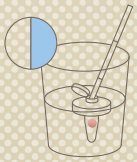
1 Mix hot and cold water.



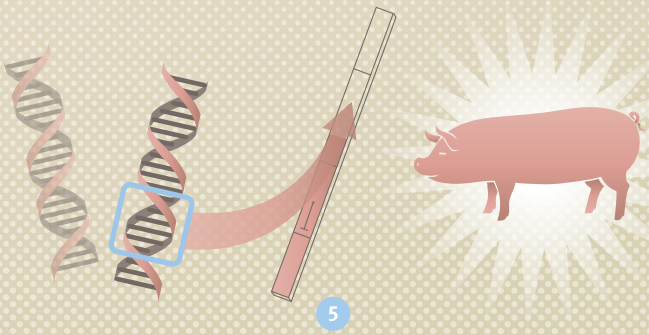
2 Crush the sample to condense the genetic material.



3 Place the sample in a bain-marie (55–65° C), along with freeze-dried chemical molecules and enzymes.



4 Wait 30 minutes before inserting the test strip.



5 The test recognises the genetic material of the sample molecule and produces a synthetic DNA molecule. By capillary action, it then moves up the test strip setting off a colour chemical reaction.

Fake news: Sherlock among the tulips

By Matthias Egger

The camera roams over the picturesque Prinsengracht in Amsterdam, but the horror is just around the corner. The bloated corpse of a young man is being recovered from the Bouwersgracht. The dead man is a Russian cancer researcher who has made millions of scientific articles freely accessible online via an Internet platform, and thereby made himself liable to prosecution. In his pocket he has a receipt from a taxi ride to Sonarweg 31, the headquarters of the Greed Elsegier Concern, the most powerful scientific publishing company in the world. A few days later, its CEO is found dead in his office chair.

Manu Friederich

With its exciting plot, this imaginary episode of a successful TV thriller series would lay bare the scandalous monopolistic misuse of power by scientific publishers. Their business model is ingenious: they take knowledge financed by tax monies and privatise it. They publish the results of this research in journals to which the universities have to subscribe at inflated prices – again paid for with tax money. The market is dominated by just a few publishers who exercise their power ruthlessly. With their ever-rising prices they have long reached profit margins of over 30 percent. The salary of the CEO of Reed Elsevier was GBP 16 million in 2015.

> "We have the power to change the rules of the game. We simply have to stop funding this business with public money".

If only such a thriller could really be made, then awareness might be raised, among both the public and our politicians, of the importance of the Open Access movement, whose aim is simply to prevent the general public from having to buy back knowledge from academic publishers that their tax dollars have already paid for.

But we don't have to wait for TV to tell the world about it. We ourselves have the power to change the rules of the game. We simply have to stop funding this all-too-profitable business with public money.

Matthias Egger has been the President of the National Research Council since January 2017.

Letter to the editor

Selenium does come from meat

Your article about selenium (Horizons 112, p. 47) made a lot of things comprehensible to me with regard to the selenium cycle across the world. I will use the map in my teaching, because I am trying to show my students more than just the basics of nutritional sciences.

However, the following statement was regrettably assigned a prominent place and irritated me: "Humans absorb selenium primarily through plant-based foodstuffs". That would be true if the feed we give our livestock were not enriched with selenium. The most recent study on the selenium supply in Switzerland (Burri et al., 2010) reached this conclusion: "Meat remained one of the most important Se sources in Switzerland. According to the first dietary intake estimation, at least 20 percent is covered by this food group".

Stephanie Baumgartner, lecturer in nutrition and dietetics, FFHS

23 and 24 June 2017

The future of developed tourist regions

What are the opportunities and development models for Alpine tourism in Switzerland?
Congress and Culture Centre, Pontresina

16 June to 17 July

'The last of their kind'

The summer programme of botanical gardens across all of Switzerland.
Across Switzerland

until 6 August 2017

'Schnuppernase', an exhibition in 100 odours

Museum of Mankind, Zurich

17 and 18 August 2017

Meat in all its forms

This congress of the Swiss Society for Food Chemistry thematises the risks and analyses the challenges of meat production.
University of Neuchâtel

29 August 2017

ETH Industry Day

Companies get a peek at current research highlights and spin-offs, and can make contact with researchers.
ETH Zurich

until 10 September 2017

The imagination of the sciences

This exhibition shows how Friedrich Dürrenmatt was inspired to his literary and visual works by the scientific discoveries of his time.
Centre Dürrenmatt, Neuchâtel

21 and 22 September 2017

Show me science!

ScienceComm, the annual congress for science communication, brings together people in the fields of science and communication.
Landhaus, Solothurn

until 26 November 2017

The mechanics of the stomach

From foodstuff choices via the sounds of digestion to the microbiome: this exhibition deals with all aspects of eating.
Natural History Museum, Neuchâtel

Open access to research data

123dartist/Shutterstock

From October 2017 the SNSF is requiring researchers to include a data management plan (DMP) as an integral part of their research applications. This DMP may be adjusted in the course of their project, but the definitive version must be ready by the time the project is complete. The DMP is an important step on the path to open research data. It will encourage researchers to think about the life cycle of their data before they even start their research.

Nanomaterials: Opportunity or challenge?

Twenty-three projects are investigating nanomaterials in different stages of their life cycle. This spring, the researchers in charge of Opportunities and Risks of Nanomaterials (NRP 64) delivered their final report. Most of their projects were focussed on the environment and biomedicine.

Sustainable universities

The funding programme 'Sustainable Development at Universities', run by the Swiss federal government, has now come to an end. Its CHF 4 million played a fundamental role in entrenching sustainability in research and teaching. The programme was coordinated by the Swiss Academies of Arts and Sciences over four years, and supported 54 projects.

Evaluating selection procedures

External reviewers from the Nordic Institute for Studies in Innovation, Research and Education (NIFU) and a group of scientific experts were commissioned by the SNSF to evaluate the selection procedures for the National Centres of Competence in Research (NCCR). They have given them a good overall report, but have identified possibilities for improvement in the expertise of their reviewers, the transparency and clarity of the basis for review, and the length of the selection process. Their recommendations will be integrated in the next NCCR call for applications.

International collaboration

'Scientific exchanges' is the name of the instrument for supporting international conferences and research exchanges. The old funding instruments 'Scientific conferences', 'International exploratory workshops' and 'International short visits' have been merged. Researchers can now view all the different funding offers in one place.

Supporting women in academia

Colourbox.com

Women professors are very under-represented at Swiss universities. In order to promote more appointments, the SNSF is creating the 'Prima' programme (Promoting Women in Academia). Prima is open to women researchers at postdoc level from all disciplines who aspire to an academic career at a Swiss university. Prima will be launched on 1 August 2017. The 10 to 12 most promising projects will be financed, with an overall budget of CHF 15 million.

Funding innovation

There is a lot of interest in 'Bridge', the new joint funding programme of the SNSF and the Commission for Innovation and Technology (CTI). In response to the first call for proposals for 'Proof of Concept', 102 applications have been received. Of these, eleven ideas are going to be funded with up to CHF 130,000 each. The programme is designed for young researchers who want to develop an application. The second funding programme, 'Discovery', is aimed at experienced individual researchers and consortia of up to three participants, who would like to realise a technologically innovative project with a high degree of societal or economic impact.

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The SNSF
The SNSF is the principal body for the promotion of scientific research in Switzerland. It is mandated by the Confederation to promote basic research in all fields and disciplines and each year distributes some 755 million Swiss francs amongst more than 3,500 projects involving about 8,750 scholars.

The Swiss Academies
Also mandated by the Confederation, the Swiss Academies of Arts and Sciences are committed to an open dialogue between science and society. They are on the side of science, each specialising in a respective domain, yet also acting in an interdisciplinary way. Being anchored to the scientific community rewards them with access to the expertise of around 100,000 researchers.

"It's really, really important to have broad interests".
Kevin Schawinski page 31

"Semi-autonomous cars should know the emotional state of the person behind the wheel".
Jean-Philippe Thiran page 40

"Solely monolingual teaching is no longer sustainable".
Rita Franceschini page 23

He's your wide-eyed, cute best friend: the smart teddy bear Musio X. He can chat with children and adults, and teach them English at the same time.
Image: AKA, LLC