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Breaking a taboo

Swiss legislators are currently debating dual-use goods, such as the kitchen knife, the perfect example of a product that is both utensil and weapon. They're trying to find a solution to the inevitable moral issues that arise out of legislating the arms trade, in particular defining categories of military goods and of authorised export-destination countries.

The issue extends to science too, where research into encryption, robotics and even virology may be deemed as having a military application. Unfortunately, Swiss institutions are reluctant to tackle this. It's not our concern, say some, who then admit researching into fields subject to export control by the State Secretariat for Economic Affairs (SECO). If politicians, citizens and journalists are to conduct their own analysis and express evidence-based opinions, further transparency will be needed.

In an attempt to break down this taboo, the Swiss Academy of Sciences launched an initiative in spring 2016: the Forum for Genetic Research. The Forum has opened the discussion among biologists on issues arising from the potential for dual-use stemming from their work, such as in the case of biological weapons.

Academia quite rightly fights for research freedom. But everything in moderation: finance, ethics and the law all have their limits. "There are many things that technology should never be allowed to do. The way you do not allow it, is to not create it", were the words of the Apple CEO Tim Cook earlier this year in response to an FBI request to unlock a terrorist smartphone. Already in Germany, some universities have introduced blanket bans (known as 'civil clauses') on any research not exclusively intended for civilian purposes. Swiss academics will now have to hold an open debate on the management of arms-related research and conclude whether or not to support the adoption of similar measures. At any rate, the end result will either be tough rules imposed by the authorities or difficult questions posed by civil society.

Daniel Saraga, chief editor

FNSNF
Swiss National Science Foundation

swiss academies
of arts and sciences

horizons


MP7A1
Papafoxtrot
Parts: F01, F02, F03, H01, H02, H04, H05, H06, H07, H08, M02, M03, M04, M05, M06, M07, T01
M02
M03
M04
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G05
G08
T02
G07
MP7A1
Papafoxtrot
Parts: B03, G03, G05, G07, G09, M01, M08, S02, S03, T02

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Concept: Max Brück/Photo: Janine Bächle

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Weapons harm and protect

In Switzerland, arms are made, traded, carried – and used. We take a closer look at a highly ambivalent relationship.

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2. stock süd

Knowledge and politics

◂ Cover: A paper model of the MP7A1 assault rifle that's in use all over the world. The real rifle, made by Heckler and Koch, weighs 1.9 kilos and fires up to 950 rounds a minute. Photo: Stöh Grünig

◂ Inside cover: The handicraft kit by Papafoxtrott comprises seven A3 sheets, each 0.5 mm thick. Estimated time for completion: 16 hours. Photo: Stöh Grünig

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Valérie Chételat

Culture and society

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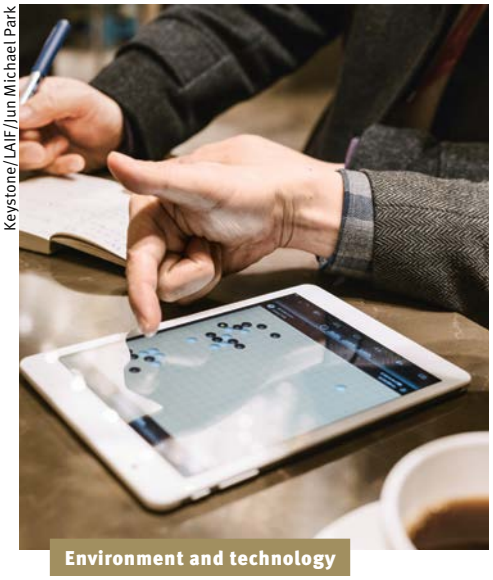
Keystone/LAIF/Jun Michael Park



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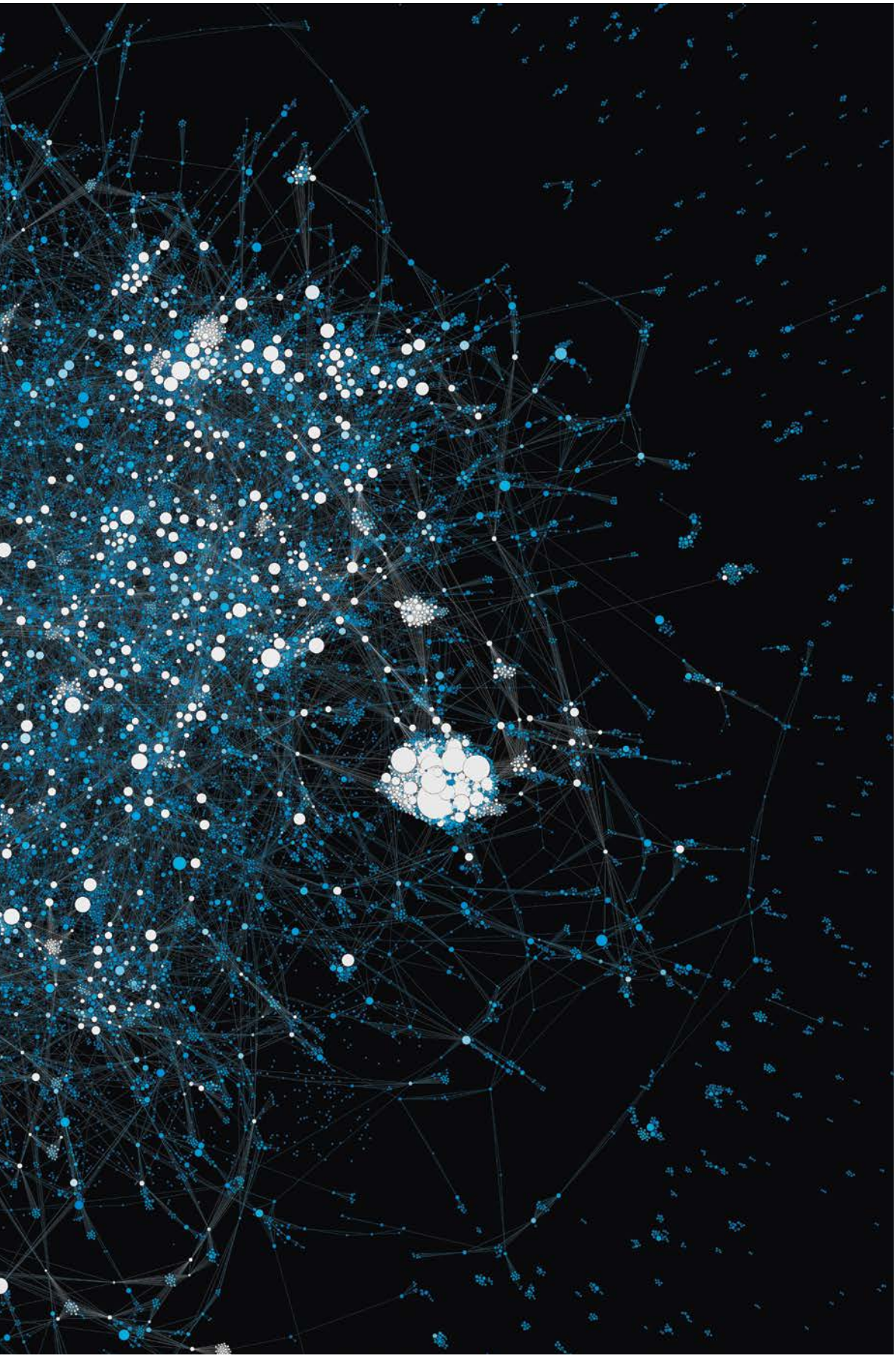
Wikimedia Commons

Biology and medicine



The Swiss research galaxy

Every research project financed by the SNSF between 2006 and 2015 has been compiled into an infographic. In total it contains 355,000 collaborations, 45,000 researchers and 25,000 projects. It is the brainchild of Martin Grandjean of the University of Lausanne (UNIL) and appeared within a few days of the publication of the People, Projects and Publications, or P3 database, at p3.snf.ch.

The nodes represent researchers, and their size depicts the total number of projects in which they were involved. The darker to lighter shading is used to represent the number of collaborations, which themselves are described by the lines.

One can make out individual communities in the central network, but the centre is no denser than its periphery. In fact, there are far-reaching satellites made up of scientists whose names appear on only a small number of research projects or whose work stems from very small teams composed of relatively secluded researchers.

The various domains of research can be seen in the structure of the network. Medical and computing sciences are concentrated on the left, whereas chemistry and biology are at the top, earth and physical sciences on the right, and human and social sciences on the left.

"It's basically a structural analysis", says Grandjean. "We need to add qualitative layers systematically, such as the domains, institutions and even the mobility of researchers, so as to bring out the full meaning of the visualisation. The data will be linked to a database containing every scholar in Switzerland, allowing a more detailed analysis. This will be done in collaboration with Pierre Benz and Thierry Rossier of the Swiss Elite Observatory at UNIL". *dsa*

Image: Martin Grandjean

Should we believe in parallel universes?

According to many theories, our universe is just one amongst many. But should we take them seriously without any experimental evidence? Two experts speak up.

Martin Rees/© Keith Mindham; Carlo Rovelli/© Grégory Scicluna (photomontage)

Yes,

keep an open mind, says the astrophysicist Martin Rees.

How large is physical reality? We can only see a finite volume out to the horizon – a shell around us, delineating the distance light can have travelled since the big bang. But that shell has no more physical significance than the circle that delineates your horizon if you're in the middle of the ocean. We'd expect far more galaxies beyond the horizon, and we are surely comfortable that those galaxies exist even though we can't see them.

However, even this extended reality might not be the end of the story. While space and time could be limited to the aftermath of 'our' big bang, some theories suggest that our big bang is in fact one of many. In other words, what we've traditionally called 'the universe' may be just one island in a perhaps-infinite archipelago of space-time. That prompts the question: why should these domains have a different epistemological status to the galaxies beyond our visible horizon?

Some claim that unobservable entities aren't part of science. But I think that's the wrong way to look at things. We can't look inside black holes, but we believe what relativity says about their interiors because this theory correctly describes the phenomena that we can observe. Likewise, if we had a model that described the universe in its earliest moments and that model were based on physics that was corroborated in other ways, we should take the model seriously if it predicted multiple big bangs.

> "Our preferences are irrelevant to the way physical reality actually is".
>
> Martin Rees

Another bone of contention is the idea (part of string theory) that each universe within the multiverse could be governed by its own set of physical laws. Were this the case, there would then be nothing surprising about the fact that we observe the fundamental constants – the numbers that determine the kind of universe we live in – as being tuned to permit the emergence of life. We would of course live in one of the universes where an observer could evolve.

This would mean that the fundamental constants are mere environmental accidents – secondary consequences of some deeper theory. That naturally disappoints ambitious theorists, who desire deep explanations for the world around us. But our preferences are irrelevant to the way physical reality actually is. We should surely be open-minded about the possibility of many universes.

Sir Martin Rees is a professor at Cambridge University. He is Astronomer Royal and a former president of the Royal Society.

No,

evidence is insufficient, says the theoretical physicist Carlo Rovelli.

The world could be vaster than the region we have mapped out so far. In the past we repeatedly discovered it to be larger than we had thought. But at each step, it was evidence that convinced us. Seventeenth-century scientist Johannes Kepler showed that a Sun-centred model of the universe better predicted planetary motion than did an Earth-centred one, while at the beginning of the twentieth century the astronomer Henrietta Leavitt developed a new technique that revealed nebulae to be distant galaxies.

The multiverse has no such empirical basis. In fact, there are numerous, quite different, versions of the idea: a zoology of multiverse types, each with its own theoretical motivation. For example, some cosmologists posit many distinct big bangs, each generating a universe. Some physicists, meanwhile, try to make sense of quantum mechanics' strangeness by imagining that our universe continually branches out into multiple parallel universes.

An early version of the idea was put forward in the 1990s by the theoretical physicist Lee Smolin, who suggested that universes reproduce via black holes: each black hole giving rise to a new child universe. This mechanism implied a Darwinian evolution that selected the universes that generate more black holes – a fascinating extension of biological concepts to the cosmos. Indeed, Smolin, unlike many proponents of the multiverse, at least tried hard to deduce observational consequences.

> "It would be like saying that we have evidence for angelic choirs".
>
> Carlo Rovelli

A common argument offered to justify the multiverse is that it could 'explain' why the constants of nature appear to be fine-tuned to our existence. But this argument is upside down. The fundamental constants determine the way nature works and therefore what exists, not the other way around. If the constants were different, the universe would just be different – perhaps much richer and more complex, we don't yet know enough to say.

I hope it is clear that I respect colleagues who speculate. Maybe the multiverse idea will one day give us a serious testable prediction. But until then physicists should be cautious in selling their speculations as knowledge. It is easy for scientists to get carried away by their imagination, and the history of science is full of fascinating ideas that turned out to be useless. Claiming that we know what lies outside the presently observable universe is like saying that we have evidence for angelic choirs outside the fixed stars.

Carlo Rovelli is a professor at Aix-Marseille University in France. He co-founded the theory of loop quantum gravity.

Arms research: defence or offence?

Ever since humans began using tools, they have been using weapons too. But trying to talk openly about weapons is tricky – not least when dealing with universities.

■ **Toy gun, 2014. Made by a visitor to Max Brück's workshop at the Offenbach University of Art and Design. The topic: replicating toy weapons from childhood. The response to the workshop was similar to the reactions provoked by the weapons themselves: a mixture of fascination and repulsion**

Photo: Janine Bächle

The dual-use joker card

Swiss universities don't like to talk about weapons research. They argue that even research intended for civil purposes could always be put to military use.
By Roland Fischer.

Should a university be allowed to develop weapons and acquire knowledge that might be used for the purposes of war? This is a complex question, and a political minefield – as becomes obvious when you try and ask Swiss universities to respond to it.

Many are of the opinion that asking about military research is something purely hypothetical. For example, ETH Zurich explains its stance as follows: "ETH Zurich does not carry out any weapons research – projects that are exclusively and explicitly designed to develop or improve weapons. That is why there is no register of any such projects". The University of Basel clearly assigns even less significance to the question of militarily useful research (in fact, it assigns it no significance at all): "The University of Basel focuses on the life sciences and the humanities. In these disciplines we primarily carry out basic research. Whether or not the results of this basic research might be used for military purposes in the near or distant future is at present impossible to tell. This is why weapons research is not a topic here".

An unwelcome question ...

EPFL is more explicit. It, too, insists that it carries out basic research with a primarily civilian focus, and that it always makes its results public – which, it points out, is not really compatible with military research projects. But when asked, it admits to holding occasional consultations with the State Secretariat for Economic Affairs (SECO) regarding export licences for dual-use goods (products that may be used for both civilian and military purposes) and for 'special military goods', in other words products that may not be employed directly in battle. EPFL keeps strictly to the guidelines, it says.

> "Weapons research is not a topic here".
>
> University of Basel

What is certain is that armaments money does flow into research in Switzerland. The Federal Office for Defence Procurement (Armasuisse) paid some CHF 3.4 million to Swiss universities in 2015, as Armasuisse itself confirmed when asked. If we exclude the universities of applied sciences, the sum is CHF 2.7 million. But again, no information is given on concrete projects. Nevertheless, there is a list of all the institutions with which Armasuisse has research partnerships. These include the Universities of Bern and Zurich, ETH Zurich and EPFL, a whole series of universities of applied sciences, EMPA and

Agroscope. Foreign partners include the University of Oxford and the Technical University of Kaiserslautern. When asked about its current collaboration with Armasuisse, the University of Bern replied that this is for two projects run by the Institute for Infectious Diseases together with the Spiez Laboratory of the Swiss Federal Office for Civil Protection. "Both projects were developed by the Department of Biology and are intended to improve or enable proofs of the existence of microorganisms (in other words, newly emergent, hitherto unknown viruses) and their toxins (botulinum neurotoxin, a nerve poison)". Initially, the University had also stated that "no weapons research projects are being carried out at the University of Bern".

Three years ago, the Sonntagszeitung in Switzerland also revealed that the Pentagon's 'Darpa Program' supported roughly a dozen research projects between 2011 and 2013, to the tune of more than a million dollars. These American armaments monies were paid to institutions including ETH Zurich and the Universities of Zurich, Bern and Neuchâtel. They primarily financed basic research such as quantum information processing and microelectronics. Some of the work was more applied in nature, such as the development of a portable telescopic contact lens or acquiring new knowledge about the evolution of flu viruses.

. . . leads to slippery answers

But why are the universities so cagey when asked about research that is fit for military purposes? One possible explanation lies in the concept of 'dual use' and the fact that the boundary between the civilian and military use of research results is a porous one. This becomes all the more evident, the closer you get to basic research. The University of Zurich refers directly to this: "The University of Zurich weighs up the implications of research proposals with dual-use potential. Such research projects have to be approved by the University's management and the scientific results must be made generally available".

At our universities, many of the research projects that are funded by the military fall under this category. And many who carry out research in this field justify being open to such financing by saying that the civilian use is given priority. A good example is a project at the University of Bern to track down space junk. It is being financed by the US Air Force, but is indisputably useful for the general population, since debris circling in orbit above us can also endanger civilian satellites.

Setting up commissions

It is rarely easy to decide whether to steer clear of certain research projects. However, clear guidelines are provided by those universities with a 'civilian clause', such as the Technical University of Berlin (TU Berlin). Their clause states that "no arms research may be carried out. Furthermore … neither TU Berlin nor its research institutions may accept commissions or donations for arms-related research". The TU Berlin decided on this civil clause in 1991, shortly after having jettisoned the strict regulations on research in the natural sciences put in place just after the Second World War. Since 1946 the Allied Control Council Act No. 25 had forbidden all military research in Germany along with applied research in a series of fields that had both a civil and a military use. These included nuclear physics, aircraft construction, ship building, radar and sonar technology and cryptography. Basic research was exempted from this regulation, but was still strictly controlled.

> "If a binding declaration is not made that research goals are exclusively for civilian purposes, the project is not accepted".
>
> Technical University of Berlin

> The boundary between the civil and military use of research results is a porous one.

The civil clause is more than just a declaration of intent. It is a self-imposed declaration of 'unfreedom' in research. At TU Berlin, a commission decides in a 'civil clause procedure' whether a project may be approved. Last year, however, only one project was held back, even though the university, by its own admission, is very explicit in its dealings with this clause. "Every research project has to be displayed in the TU Berlin Research Department and a binding declaration must be made to assure the University that its research goals are exclusively for civilian purposes. If this declaration is not made, then the project is not accepted. With industrial projects, the contractual partner has to confirm in writing, in the actual contract, that the research results will be exclusively used for civilian purposes". The commission decides in individual cases whether all doubts have been unambiguously dispelled. If they remain, however, then the project is rejected.

This procedure is reminiscent of projects with animal experiments and medical studies, where ethics commissions are involved in the development process. In such cases, a commission is powerful enough to halt a project if needs be. This ethical safeguard is not an exercise in tokenism. There is a series of laws that places boundaries on research. In this sense, any assumption that research is not free is not quite correct. However, there is no similarly restrictive law against potential weapons research – not even in Japan, where there is a strong peace movement that is also active at the universities.

Achieving greater transparency

Often, researchers and universities argue that military research would take place anyway – if not at universities, then behind closed doors in specialised research laboratories. In Switzerland, for example, this would happen at Ruag. By its own admission, this company invested CHF 140 million in research and development in 2014 – and it also invested in various research partnerships with industry and universities. But Ruag also stops short of providing greater detail.

In Germany, several universities have followed the example of TU Berlin and have introduced a civil clause. In Switzerland, however, there are no such clauses. What is less surprising is that the 'Group for a Switzerland without an army' (GSOA) regularly campaigns for restrictions on arms research. And the GSOA also knows about the crucial issue of dual use. Thomas Leibundgut is responsible for this topic

Swiss researchers didn't find any close entanglement between universities and the military.

at GSOA, though he believes that a civil clause would affect only very few projects in Switzerland: "Explicit weapons research plays a marginal role at Swiss universities". He believes that "even just talking about civilian clauses means we've already made a lot of progress".

The GSOA is trying to get students to exert political pressure on university management – such as in Bern, for example. The committee of the student body of the University of Bern is busy acquiring information from the University's management and faculties about the arms research being carried out there. "Our goal is prevention. It's not necessarily about stopping concrete projects", says Corina Liebi, a history student who initiated the process in collaboration with the GSOA.

> "It would be important just to know exactly what is being researched".
>
> Corina Liebi

This situates the question about arms research in a much bigger, political and research context, as it touches on the often-criticised lack of transparency in research funding from third parties. Liebi is hoping to change this: "It would be important just to know exactly what is being researched, and what the deals are".

Not much weapons research

However, Swiss universities are not profiting much from armaments funding. The technology historian David Gugerli was part of a team tasked with writing the history of ETH Zurich, and he had expected to come across a 'military pedagogical complex' in the course of their work. Because at least until the Industrial Revolution, scientists were mostly employed by the military. They had to be able to construct fortifications and had to know about ballistics, and this knowledge was acquired at specialised educational institutions.

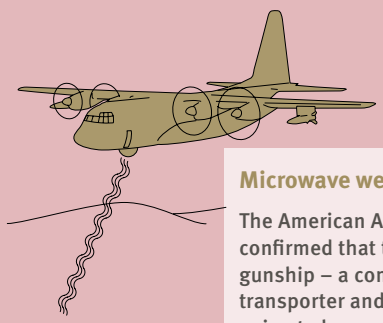
But the Swiss researchers were surprised: they did not find any such close entanglement between the universities and the military in Switzerland. Gugerli believes that the reasons for this lie in the founding of ETH Zurich, when a conscious decision was made to set itself apart from the French engineering tradition. The Swiss did not want to build palaces and fortresses and produce armaments, but instead were concentrating primarily on the construction industry and mechanical engineering. In this sense, Switzerland could well be a special case in weapons research, says Gugerli. However, this does not mean that Swiss industry has simply steered clear of arms projects. Gugerli mentions Bührle as a case in point, adding that the really interesting question is whether or not this company actually needed the help of the federal government in order to achieve its success: "In other European countries, technology polices have a distinctly national slant, such as is the case in France. In Switzerland, however, when similar policies were tried out, they had little success".

But whoever looks beyond the boundaries of Switzerland to consider the broader history of science has to admit: without large-scale projects during and after the Second World War, basic research would not be where it is today. The Manhattan Project, in which some 150,000 researchers and technicians worked on the atom bomb from 1942 onwards, set new standards in this regard. As a result, atomic research became a prime example of dual-use technology – and remains so to this day.

Roland Fischer is a science journalist in Bern.

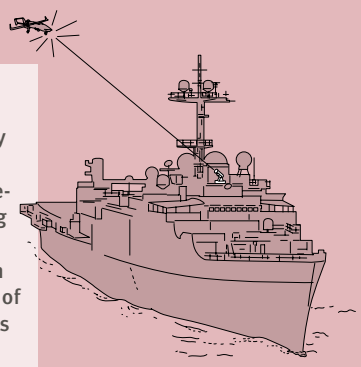
Weapons of the (near) future

What weapons will be used to fight the wars of the future and to defend our borders? A glance at some of the latest technology and developments shows that science fiction is already becoming science fact.
By Roland Fischer, illustrations by 1kilo



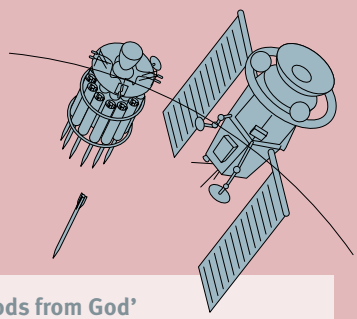
Microwave weapons

The American Air Force recently confirmed that the Lockheed AC-130 gunship – a combination of troop transporter and combat aircraft – is going to be equipped with microwave weapons. Such 'active denial systems' have been undergoing tests for several years, including for use against violent crowds. They are intended to incapacitate people temporarily: the microwaves heat the surface of the skin, creating intense pain. It is still being debated whether or not these microwaves are truly harmless to humans. Experts believe that such systems have not yet entered into widespread use because the political will is absent – not because of any technological considerations.



Lasers

Laser weapons that cut and destroy reached a point of technical readiness a few years ago. The US battleship USS Ponce has been patrolling the Persian Gulf since 2014 with a laser canon as its standard weapon system. The precise technical data of the canon is still secret. But experts assume that this weapon, which is supposedly based on a standard, 30 kilowatt, commercial cutting laser, has a range of one kilometre for thin-walled targets. A whole series of other directed-energy weapons are currently also being tested.

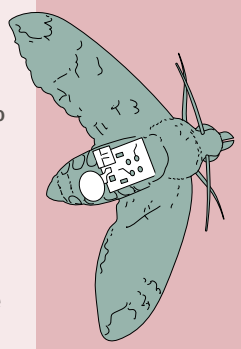


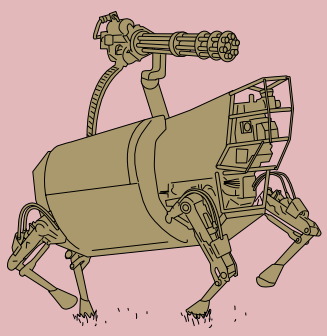
'Rods from God'

The 1979 SALT II Treaty forbids the deployment of weapons of mass destruction in orbit. Conventional weapon systems are nevertheless being developed, including an idea that the science fiction author Jerry Pournelle came up with in the 1950s and that he called the 'Thor project'. This involved metal objects being dropped by satellites with pinpoint accuracy. A few years ago, the US Air Force presented a system that featured tungsten rods ten metres in length that would be able to withstand the heat of re-entry into the atmosphere and would reach speeds of over 3,000 metres per second, thus allowing them to penetrate even the thickest concrete bunkers. But all this is presumably still tomorrow's world: the enormous costs involved mean that these 'hypervelocity rod bundles' are likely to remain mere science fiction.

Remote-controlled insects

Nature is superior to our technology in many ways. So why not bring together biology and technological progress? One of the most surprising research programmes of the Defense Advanced Research Projects Agency (DARPA), a branch of the US Defense Department, is called 'Hybrid Insect Micro-Electro-Mechanical Systems'. It is trying to breed crawling and flying insects into which microcontrollers have already been inserted at the larval stage, and which then develop into remote-controlled, hybrid beings. These could be used primarily in the areas of surveillance and espionage. The researchers have also been investigating biological weapons. But very little has emerged as yet about any concrete research successes.





Autonomous war machines

On the battlefields of the future, machines engage in mighty conflict with each other – at least, that's how science fiction sees it. But sci-fi aficionados also know that combat robots can be used against people. The four-legged robot made by Boston Dynamics – bought up by Google in 2013 – was developed as an automated packhorse for the military. These machines are decked out with heat sensors and always run to heel. But they also demonstrate how technology will soon advance far enough for robots to hunt down enemy soldiers. Algorithms that make autonomous decisions about life and death pose new ethical questions. It's not just the United Nations that follows this question, two thousand experts including Stephen Hawking, Steve Wozniak and Noam Chomsky spoke out against the use of autonomous weapon systems last year.

■ A water pistol (yellow) and a Colt 3 cap gun, probably from the late 1970s. Capacity and rounds per minute not specified. Produced in the GDR by VEB Plastspielwaren Kamenz. Design: Kurt Ali, Baumgarten.
Photo: Keystone/Interfoto/Günter Höhne

■ Softair gun by Wei-ETech. On sale 2009. Technical details unknown. Besides blank pistols and softair guns, imitation guns have also been covered by the new Weapons Act since 2008. Toy guns that mimic real guns may only be sold if the vendor possesses a "weapons licence for the sale of non-firearms".

Photo: Keystone/Urs Jaudas

Weapons, tanks and laws

Swiss military hardware is in demand, but exports are controversial.

By Marcel Hänggi, infographic: 1kilo

Switzerland wants to export war materials without encouraging existing conflicts or human rights abuses. The principle sounds simple, but in practice it's complicated.

Two laws and several international agreements regulate the export of war-related materials from Switzerland. The War Material Act forbids without exception the export of atomic, biological and chemical weapons, anti-personnel mines and cluster ammunition, and also forbids financing them. Other war materials may be exported to countries that are not at war.

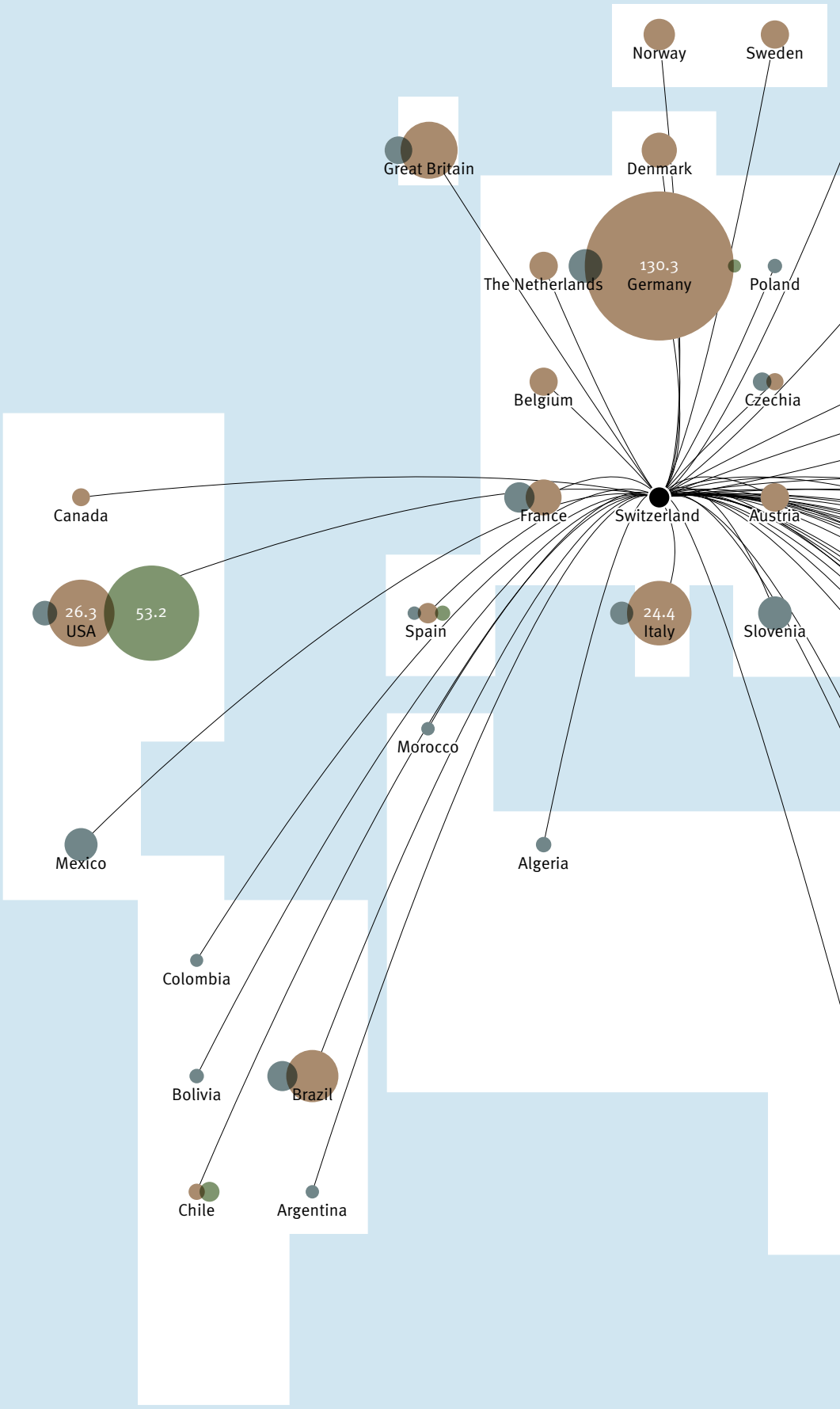
The Goods Control Act also controls the export of 'special military materials' (which may not be used directly in battle) and 'dual-use materials' (i.e. those that may be used for both civilian and military purposes). These may be exported to countries at war unless it is forbidden by international treaties or embargoes, would endanger regional or global stability, or if there is reason to assume the materials might be used for terrorist purposes. Export licences for military grade materials are granted by the Swiss State Secretariat for Economic Affairs (SECO). In 2015, licenses were issued for goods to a value of CHF 1.7 billion and munitions sales reached CHF 450 million. To put this into context, Swiss export statistics for 2015 list total exports of CHF 203 billion.

There have been two attempts by referendum to institute a complete ban on the export of war materials, but both were unsuccessful. The referendum of 1972 only just failed to pass, while the result of the 2009 referendum was more clear-cut. But the topic remains contentious. Last February, the Neue Zürcher Zeitung reported that the Federal Councillor Johann Schneider-Ammann wanted to allow the export of Piranha military vehicles to countries that are waging war in Yemen. But the Foreign Minister Didier Burkhalter was against it. Also in February, a motion was submitted to the National Council Defence Committee in favour of a moratorium on the export of war materials to those countries, but it had no chance of being accepted.

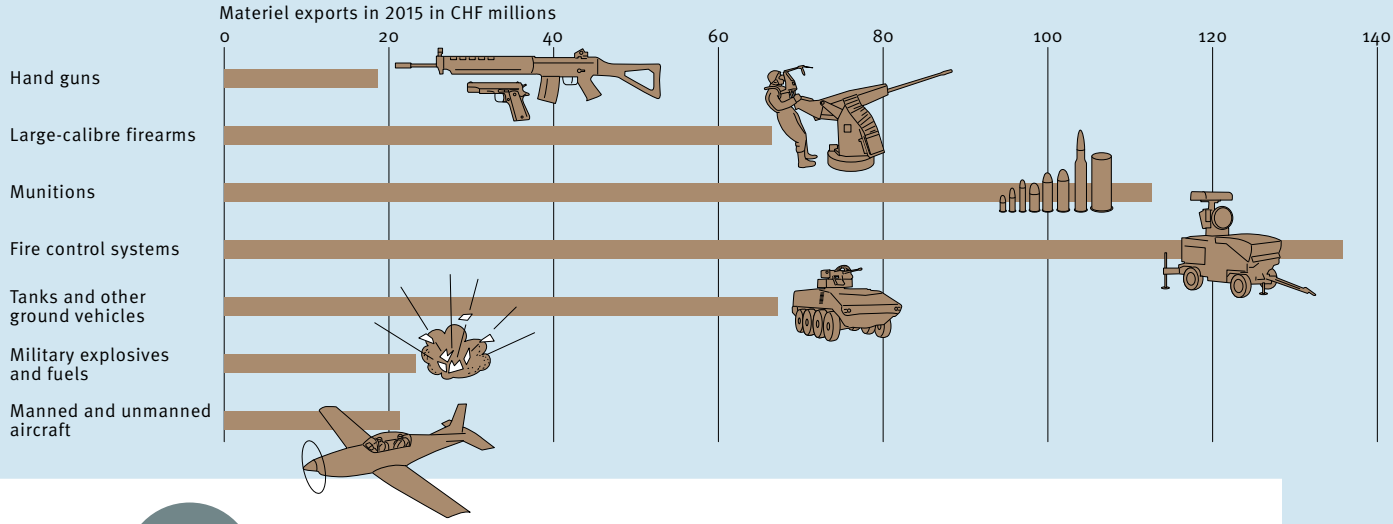
It is also forbidden to export war materials to countries that are not actually engaged in war, but are guilty of 'systematic and grave violations' of human rights. It is, however, permissible to supply replacement parts for materials supplied under an earlier export licence. And since 2014, the above ban may also be circumvented if the danger of Swiss materials being misused is assessed to be 'minor'. This means that even a regime such as that of Saudi Arabia would be able to buy Swiss war materials – or at least it would have been able to do so before its war in Yemen.

Marcel Hänggi is a science journalist in Zürich.

The biggest importers are Saudi Arabia, China, India and Germany



Swiss munitions and fire control systems are in demand



Swiss exports of materiel in 2015 and licensed exports of special military goods and dual-use goods

- Materiel
- Dual-use goods (for civil or military use)
- Special military goods (broad category, goods banned from the battlefield)

Source: SECO

The appeal of arms

In order to keep peace in society, the state controls the ownership of weapons. But that wasn't always the case.
By Urs Hafner

If a man keeps a pistol on his office desk, he's going to have to do some serious explaining to his work colleagues, regardless of whether he bought it legally, and even if it isn't actually loaded. If young men proudly show their illegally acquired butterfly knives to their friends, they hide them under their bomber jackets afterwards. And if children play with toy guns and point them at other kids, we warn them not to do it again.

Weapons are a taboo in civil society. However, this taboo bears a hidden dialectic within it: what's dangerous is admired; what you can't touch seems to possess magical powers. A weapon can kill another human being in the blink of an eye. On the one hand, they are only supposed to be borne in public by state representatives such as the police and soldiers. On the other hand, they are in constant use in society's great space of the imagination: the cinema, where people on screen take great pleasure in shooting and murdering each other. Even pacifists watch thrillers. And weapons are indeed among us: as the Swiss newspaper Tages-Anzeiger reported in December 2015, some two and a half million legal weapons are circulating in Switzerland, almost hidden from sight. Half of these are army weapons.

Arms and the aristocrats

Until the peace movement and pacifism emerged in around 1900, weapons had an exclusively positive connotation and were proudly carried in full view. Weapons today are often barely seen and have a purely functional design, but for centuries they were richly ornamented and were a signifier of high social status. Carrying 'cut-and-thrust' weapons was the preserve of the nobility in the Middle Ages and Early Modern times. They were the group that led the way in everything, and they delighted in parading around on their steeds. Their privilege to bear arms ensured that they had the power. If a serf in bondage fancied rising up, his threshing rod wouldn't have had a chance against the long spears and swords of his masters high on their horses.

In the Middle Ages, aristocratic clans indulged in bloody vendettas that were a burden on both the land and the people. Without bothering about laws or courts, knights laid waste to the farms where their enemies' serfs lived. This brought misery to the peasants, and also made it difficult to secure emerging transport routes. This in turn vexed those citizens who were involved in trade. In everyday life in the

villages and cities, however, people kept a knife handy about their person. If someone uttered the wrong words or made a gesture that was taken as an insult, knives might be drawn quickly. The mediaevalist Arnold Esch gathered together numerous proofs of such behaviour in his book 'True stories from the Middle Ages' (2010).

Phallic swords

The citizens' councils in the emergent cities of the late Middle Ages curbed this kind of violence, says the Bernese historian André Holenstein: "They instituted peace regulations. Not just stabbings were punished – even just drawing a knife and the symbolic threat of violence were made punishable". Also liable to prosecution were those who did not urge two squabbling parties to keep the peace, but simply got out of the way instead. One common punishment comprised breaking the knife or dagger of the offender, says Holenstein: "By destroying the weapon, the authorities took away the offender's manly honour".

> The state determines who is allowed to own a weapon and how it may be used.

One doesn't have to have read Sigmund Freud to see this as a symbolic act of castration. The weapon as phallus had an undisputed symbolic value in the Middle Ages and Early Modern era, one that ennobled its bearer with masculinity. When fitted out with a sword, a man was regarded as powerful, potent and honourable.

Masculinity and weapon ownership are still closely bound up with each other in Switzerland and in the United States. Whereas gun enthusiasts in the USA feel connected to the country's frontier traditions – started by those doughty white settlers who ruthlessly took the land for themselves – many Swiss soldiers and hobby gun owners still cultivate a patriarchal republicanism: brave citizen soldiers guarding the borders of their country and protecting their own homes, within which their wives can safely go about their womanly duties.

The relicts of the old military traditions of the Swiss Confederacy survive with both the Appenzell Cantonal Assembly – where citizens have to turn up wearing their swords – and the notorious assault rifle of the Swiss militia army – kept at home in the proverbial broom cupboard. A man who isn't armed isn't a real man. 'Women's weapons', however, are traditionally regarded as referring solely to their physical charms. Women do carry 'real' weapons, but the most popular among them is the pepper spray, which is not covered by the Swiss Federal Law on Weapons, Weapon Accessories and Munition (unlike in Belgium and the Netherlands, which do proscribe it). And there are not many men who would carry a pepper spray with them. But a women who shoots a gun is still considered a cause for bemusement, at least in Switzerland.

Well-armed Swiss mercenaries

In the Early Modern era, the Swiss Confederacy was the only country in Europe in which farmers and normal citizens were allowed to bear arms. In fact, they were compelled to do so, because military service was regarded as the prime duty of a citizen. The Swiss affinity for weapons resulted in such famous equipment as the 'Swiss degen' sword, the 'Prättigauerknüttel' and the 'Luzernertrüssel' (both are kinds of mace), as is amply documented in the Swiss Historical Dictionary. The European monarchies did not trust their own subjects in times of war, but resorted to mercenaries instead – preferably young Swiss men. And shrewd Swiss businessmen made a lot of money from them. These mercenaries were better armed than the Swiss militias, which towards the end of the Ancien Régime were in a truly pitiful state.

> Until the peace movement emerged, weapons were proudly carried in full view.

Indeed, the first nation to set up an effective people's army – and thus the first to overcome the fear of arming its own citizens – was actually the young revolutionary, republican regime in France. In 1792, the new French democracy mobilised about a million soldiers. They went to battle first to protect their republic, and then to expand it. 'Aux armes, citoyens!' runs the Marseillaise – 'arm yourselves, citizens!'

Thus the state democratised weapons, but at the same time it increased its control of them, thereby making a peaceful society possible. The state determines who is allowed to own a weapon and how he or she may use it. Duelling is forbidden. This remnant of mediaeval feuds was still practised in Germany in the early 20th century. In a duel, the offended party sought to restore his honour by force of arms and without recourse to the state judiciary. But this was an affront to the state's monopoly on the use of force. Today, civilians are allowed to shoot in sports clubs only.

A pacified society

When measured by the number of violent crimes committed, today's society is a peaceful one. In the West, the murder rate has never been as low as it is today. In his book 'On the process of civilisation' of 1939, the sociologist Norbert Elias links this pacification process to the increasing control that humans exercise over their emotions. He finds it was reflected in the sophistication of table manners and in the usurpation of the life-threatening dagger by the dining fork. If someone feels offended by another person, he doesn't just start punching him. And if he does it anyway, then he himself becomes punishable by law.

All the same, weapons are still used repeatedly to commit all kinds of crimes including murder. You can in theory kill someone with a bread knife, but a machine gun is more efficient at it. And a bomb is even more efficient still. In the wake of the terror attacks in Paris in 2015 and in Brussels in 2016, the European Union is planning to tighten up its weapons laws. Similar measures are always demanded in Switzerland whenever a man runs amok with his army gun. The debate about regulation versus self-protection is all about whether or not the state should intensify its weapons controls. It's an age-old story, and it's impossible to know where it's going to end.

Urs Hafner is a science journalist in Bern.

■ An early video game console, Universum Color-Multi-Spiel 4006, Germany, ca 1976. Besides shooting games there was a choice of video games such as squash and pelota.
Photo: Keystone/Interfoto/TV-Yesterday

■ Call of Duty: Black Ops III, 2015, developed by Treyarch and distributed by the American company Activision. This is the twelfth part of the first-person shooter series to have been released since 2003. The game play takes place in the year 2065. Robots are highly developed, and the boundary between man and machine has become fluid. Man fears that robots could take over the world. Up to three people can play together at a time.
Photo: Activision Publishing Inc.

INTERVIEW

Pollinators are in decline

Markus Forte/Ex-Press/BAFU

The first report of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) was published in February 2016. The IPBES member Markus Fischer of the University of Bern talks to us about its main topic, pollination.

What was the basis for producing a report on such a specific question? Isn't it the role of the IPBES to provide general overviews?

The Platform aims to respond to questions that are of interest to governments, be they specific – such as the role of pollination in food production – or more general, such as the role of biodiversity and ecological services on the continental stage. A global report on this second topic is to be published in 2019.

What is the message contained in this year's report?

There are three main messages. First, pollinators such as bees – whether wild or domesticated – are of great importance to global food production. Secondly, wild pollinators are in decline and bees particularly are under pressure. Finally, there are many possible paths to be taken by stakeholders.

Does it set forth any specific recommendations?

No. The IBPES is not a standard-setting organisation; it prefers to propose options. In this example, to reduce the harmful effects of pesticides or to capitalise on the advantages of organic farming.

The IBPES has been compared to the oft-criticised IPCC. What do you do differently?

One difference is that our platform aims to respond to those specific questions raised by government representatives. It is vital that we obtain external legitimacy: not just in academia, but also in politics.

Other critics claim you overlook other agricultural and environmental actors.

Our reports are written not just by researchers but also by people with traditional and local knowledge.

NEWS

UK researchers gagged

On 6 February 2016, the UK government banned the attribution of public money to any "activity intended to influence or attempt to influence Parliament, government or political parties". State-financed researchers are therefore banned from taking any further part in public or media campaigns. In Canada, the ban on researchers at national institutions talking to the media was lifted in the autumn of 2015.

The new pirate of science

Since 2011, the website Sci-hub – launched by the Kazak researcher Alexandra Elbakyan – has made available more than 48 million scientific articles that were downloaded using institutional user accounts. Elsevier brought successful legal action against the site, but the platform is still accessible particularly through the anonymous Tor network. The project is a reminder of the actions taken by the programmer and hacktivist Aaron Swartz, who committed suicide in 2013 following litigation with the US government.

Publications: citations aren't quality control

The impact factor of a journal publishing an article has more influence than its quality on the number of citations the article receives. This has been shown by a study at the Max Planck Society, which analysed almost 10,000 articles published between 2000 and 2004. The authors rated them with a quality score based upon expert opinions taken from F1000, an online recommendation platform. One other factor also rated higher than quality: the number of co-authors. doi.org/bdg4

Blog

Being human

What is man? Who are we? Since January 2016, the philosophical blog 'Alles rund um den Menschen' ('All about Man') has been gathering together texts in which philosophers discuss these questions and others in connection with the state of being human. You can find the complete texts from which the below quotations are taken at blogs.philosophie.ch/mensch.

"Some adherents of neuroscience think their brain is what they are".
Dieter Teichert, University of Lucerne

"Should one be allowed to become an egotist so as to achieve self-realisation? – No".
Satoshi Ishigami, University of Basel

"Don't listen to blasphemers and heretics, they belong to the devil!"
Philipp Bucher, University of Lucerne

"Human beings are primates like chimpanzees, mammals like cows, vertebrates like fish and multicellular organisms like oak trees".
Michael Hampe, ETH Zurich

"What immortal robots would ever be interested in the libraries we've filled to burst?"
Reinhard Schulz, Carl von Ossietzky University of Oldenburg

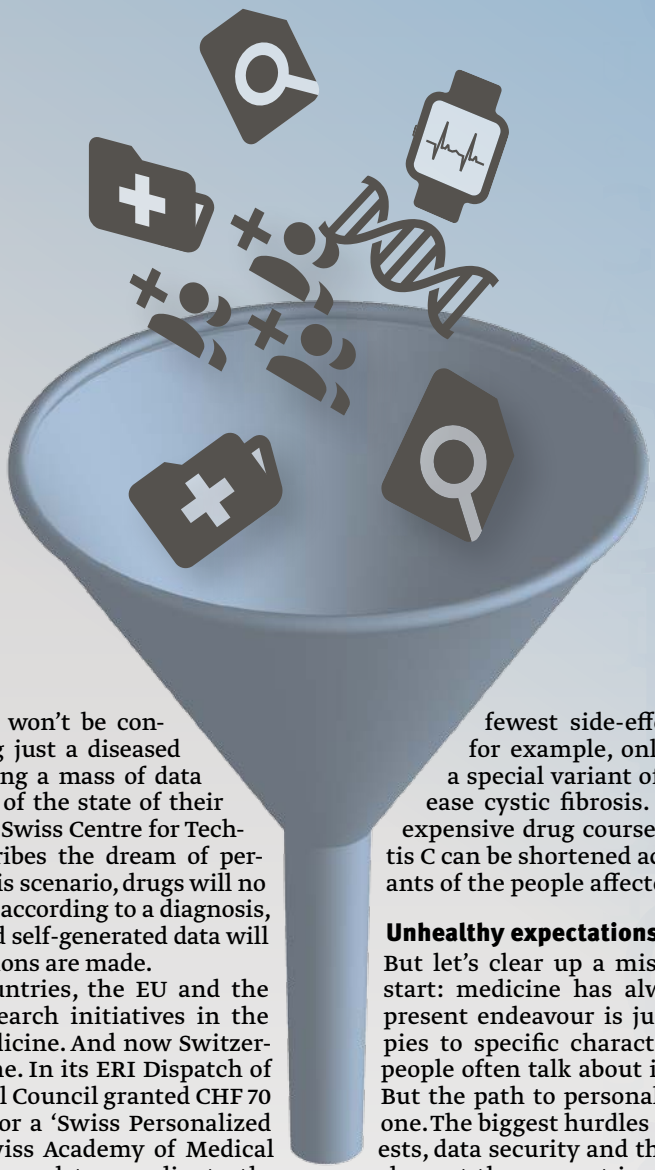
"Man is an animal that can itself answer the question as to what it is".
Christian Steiner, University of Basel

PERSONALISED MEDICINE

Data improves therapy

Swiss universities and hospitals are being given money by the federal government so that they can conduct joint research into the potential offered by their health data. We offer an overview of the pillars on which personalised medicine is constructed, and of the hurdles facing it.

By Florian Fisch



In the future, doctors won't be concerned about treating just a diseased organ – they'll be using a mass of data to get a holistic view of the state of their patients". This is how the Swiss Centre for Technology Assessment describes the dream of personalised medicine. In this scenario, drugs will no longer be prescribed only according to a diagnosis, because gene variants and self-generated data will be consulted before decisions are made.

The Scandinavian countries, the EU and the USA have all set up research initiatives in the field of personalised medicine. And now Switzerland wants to do the same. In its ERI Dispatch of February 2016, the Federal Council granted CHF 70 million over four years for a 'Swiss Personalized Health Network'. The Swiss Academy of Medical Sciences (SAMW) is supposed to coordinate the many current local initiatives at universities and hospitals and enable the exchange of the extant data. "It's only this large network that will enable us to realise the potential of big data in the field of health", says Hermann Amstad, General Secretary of SAMW.

This wealth of information is supposed to enable doctors to find the most effective treatment with the fewest side-effects. The drug ivacaftor, for example, only works for people with a special variant of the hereditary lung disease cystic fibrosis. And the duration of the expensive drug courses needed to treat hepatitis C can be shortened according to the gene variants of the people affected.

Unhealthy expectations

But let's clear up a misunderstanding from the start: medicine has always been personal. The present endeavour is just about adapting therapies to specific characteristics. For this reason, people often talk about it as 'precision medicine'. But the path to personalised medicine is a stony one. The biggest hurdles to it include vested interests, data security and the question of how to implement the concept in a practical context. There are sceptics – such as Timothy Caulfield, a Canadian professor of health law and policy, who warns about raising false hopes: "There is little reason to suspect that the promised cost-saving, life-extending, population-health-improving revolution will unfold as suggested by [its] many vocal advocates".

The four pillars of personalised medicine

New treatments need to integrate genetic information, samples and measurements that were collected by patients themselves. Behind this are efforts to standardise and open access to databanks.

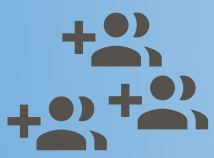
e-PATIENT FILES

Tapping into the knowledge in patient files

Estonia was the first country to do it, back in 2008. And in Switzerland, Geneva was the first canton to allow its citizens electronic access to their patient files, as of May 2013. According to 'Strategie eHealth Schweiz', this should be made possible for everyone in Switzerland in future.

Research can also profit from electronic patient files. Whoever agrees to it can give researchers access to their medical history and their data in biobanks. This can allow retrospective studies into what treatment was the most effective for which group of stroke patients. The British psychiatrist and author Ben Goldacre dreams of large-scale clinical studies in which doctors can try out new therapy variants as a matter of course.

There are all kinds of technical, legal and ethical hurdles to surmount before reaching that point, however. Torsten Schwede of the Swiss Institute of Bioinformatics is in charge of the Swiss data coordination centre, and in his opinion the data still has to be harmonised. "If a file in Basel mentions a 'fever', that might not necessarily correspond exactly to the concept of 'hyperthermie' at the University Hospital in Lausanne. It's difficult to find a common language for internal medicine and ophthalmology even within the same hospital".



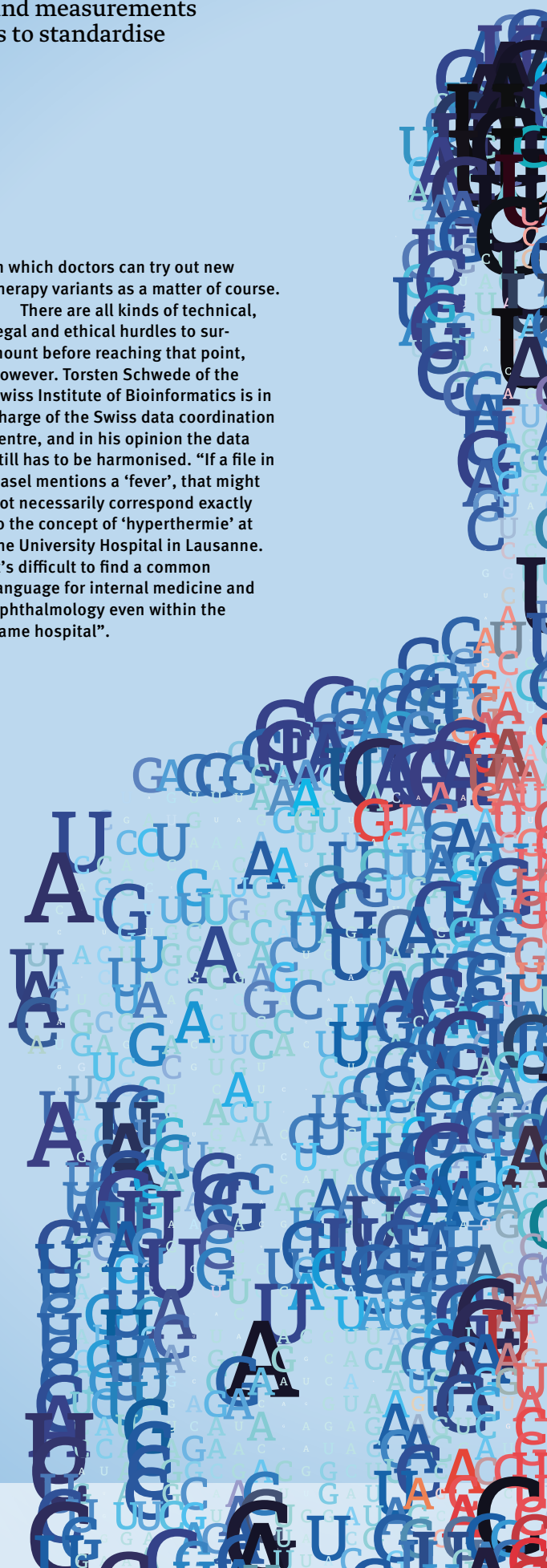
COHORT SURVEYS

Comparing medical histories

HIV-positive people are usually given a combination of three different antiretroviral drugs – and sometimes these can have drastic side effects. For example, the drug abacavir can cause a life-threatening drop in blood pressure and a high fever in very small numbers of patients. If they are tested for the gene variant HLA-B*5701 before being given the drug, such emergencies can be avoided.

This gene variant is a so-called biomarker that allows the HIV therapy to be personalised. Further markers can also provide measurement data or information about a patient's lifestyle. In order to find such biomarkers, cohort surveys are necessary. These are studies that systematically track a large number of patients from different groups over long periods of time.

The Swiss HIV cohort survey has been running for 28 years. Blood samples are taken from 10,000 patients every six months and stored in the survey's own biobank. Huldrych Günthard of the Zurich University Hospital is the head of this survey, and he says such cohorts provide the basic data that is essential for personalised medicine: "Specific diagnoses in hospitals are sometimes distorted by economic factors, such as codifying invoices according to flat-rate payments. In the cohorts we have precise medical histories and a huge amount of laboratory data".



THE QUANTIFIED SELF

Patients monitoring themselves

A smartwatch records your sleep rhythms, while a sensor integrated in an undershirt constantly monitors your blood sugar level. In the evening, all the data is uploaded to a social platform where diabetics can exchange information on their experiences. A tap of the finger on a tablet computer copies the data into your electronic patient file. When you see your doctor, you can discuss this self-generated data along with the treatment options that an algorithm has automatically recommended for you.

This is the vision of Ernst Hafen, a molecular biologist at ETH Zurich who is promoting personalised medicine in Switzerland. “It’s essentially a Google map of health. Instead of having geographical information according to longitude and latitude, the medical data of the individual should be integrated in it”.

Hafen’s vision sounds utopian in several aspects. But initial steps towards it have already been made. There is no lack of self-tracking apps. And sufferers of ALS (Lou Gehrig’s Disease) have come together on the web platform ‘PatientsLikeMe’ and have already published their own study on the non-effects of lithium carbonate. The University of Basel is currently carrying out a study using step counters in order to investigate the influence of movement on cancer therapies.

BIOBANKS

Slumbering samples in biobanks

Research groups and university hospitals have long been collecting and storing samples of DNA, blood and tissue. When linked to a patient’s medical history, these form the backbone of personalised medicine. However, most biobanks are geared to the needs of the individual institutions where they are housed, without anyone having considered how to provide access to other researchers.

Christine Currat estimates that some 300 biobanks, big and small, are currently in existence in Switzerland. Currat is the manager of the ‘Swiss Biobanking Platform’ (SBP) that was founded in April 2016 and is being supported by the SNSF. It is intended to provide researchers with access to all the valuable information that has already been collected across Switzerland. “I would first like to make a list of the extant biobanks”, says Currat. Her main goal is to harmonise procedures so that samples and the information linked to them can be exchanged more easily.

“We need a unified declaration of consent for patients and, above all, we need documentation about how the samples were taken and stored”, says Currat. In the long term, the SBP intends to provide researchers with an entry platform to the different biobanks – not just for medical purposes, but for biological research as a whole.

The problems with new medicine

There are all kinds of stumbling blocks on the way to personalised medicine. Two particularly big obstacles are dealing with confidential data and transferring findings into practice.

DATA SECURITY

Networking personal data is a delicate matter

Genome data doesn't just offer information on personal characteristics and risks. It also allows you to draw conclusions about the situation of relatives. This is why such data is subject to a high degree of legal protection. And the Swiss Centre for Technology Assessment is recommending extending this protection to all personal data. Just how important it is to maintain the trust of the population is proven by the UK programme for linking all clinical data within the National Health Service. After public criticism was aired because of the re-utilisation of data, the programme was halted for a year in 2014.

Ernst Hafen, a molecular biologist at ETH Zurich, has a clear opinion on this: "Only the individual has the right to place his or her data at the disposal of others". His association 'Data and Health' is insisting on digital sovereignty.

However, this does not solve the problem of anonymisation. Even if a single cholesterol measurement cannot be traced back to an individual, when it is linked with lots of other data, that person may still be identifiable. "The only data that may be made available is the data that is necessary for the research project in question and whose use can be agreed with the patient", says Torsten Schwede of the Swiss Institute of Bioinformatics. And the researchers must work within a secure research platform where sensitive data is encrypted. This has already been done for genome research projects.

Brigitte Tag, a professor of law at the University of Zurich, would most of all like to see a secure legal framework on a national level: "Collecting, storing and processing data for human research should be regulated in a uniform manner. The researchers too will profit from this".

SCEPTICISM ABOUT EVIDENCE-BASED MEDICINE

The impenetrable jungle of medical data

When progress was being made in evidence-based medicine, "something of the art of medicine [was] lost", wrote Joseph Fins recently in the specialised journal The Hastings Center Report. Fins is a professor of medical ethics and medicine at Weill Cornell Medical College. His hesitance is also found elsewhere: a survey carried out by Cochrane Switzerland in 2015 found that every fourth general practitioner admitted that evidence-based medicine is of limited use. Gerd Antes, the Director of Cochrane Germany, told the TV channel 3Sat back in 2015 that he wasn't surprised by this: "Researchers are thinking of their careers, companies about their profits, and the doctor stands somewhere between them and is being falsely informed by both sides".

The evidence base in medical research is very confusing. Near-identical clinical studies are being repeated over and again, roughly half of all studies are never published, and the flow of information from research into practice is badly organised. The result is either an excess of medical information or a shortage of it. With personalised medicine, the jungle of data will only become even more impenetrable for doctors.

Bernard Burnand, the Director of Cochrane Switzerland, says: "We need a markedly better information system". In its 2014 report, the Swiss Centre for Technology Assessment also recommended that interpreting data be given greater emphasis when training doctors. Burnand sees a danger for research here: "The regulations for clinical tests are going to get even stricter. What we still lack today is a means of scrutinising therapies in a practical setting".

Florian Fisch is a science editor at the SNSF.

Pooling forces: 'Swiss Personalized Health Network'. SAMWbulletin (1/2016)
Proactive medicine. Short version of the TA-SWISS study (2014)

“Never make unsubstantiated promises”

Patrick Aebischer will step down from the EPFL presidency at the end of 2016. In the space of 16 years, he has completely transformed the Lausanne-based institution, placing it among the world’s best. We take a look back at his achievements. *By Daniel Saraga*

Valérie Chételat

"Working at the interface of different domains requires breaking down institutional limits"

In 2000, the helm of the Ecole polytechnique fédérale de Lausanne (EPFL) was taken up by a complete outsider. Patrick Aebischer was 44 at the time and a professor at the Vaud University Hospital (CHUV). His plan was to introduce life sciences to what is a technical university, to convert it to the American model and to make it more competitive.

This plan quickly ran aground, however. While the faculty, the student body and industry were either rejecting his plans or calling for his departure, Aebischer was being hampered in his attempts to appoint vice-presidents. The ETH Board was against it, and Aebischer had to hold his ground firmly, refusing to start work until the Board gave in at the end of a two-week deadlock.

Some 16 years later he has reached his objectives, and even surpassed them. Today, EPFL is one of the best European research institutions and has a portfolio of high profile projects, ranging from the Human Brain Project and Solar Impulse to the Rolex Learning Center. But Aebischer's style – visionary and proactive – was not free from criticism. Horizons met him this spring to listen to the defence of his vision for academia and leadership.

You started your presidency with an uphill struggle. Were you bluffing?

I wasn't allowed to select my own management team. It was double or quits. I'd have returned to the US if it hadn't worked. I was very clear about my intentions. It's possible the Board thought I'd come around once in office … but I needed my team to succeed with my plans.

Did this victory provide you with leeway later on?

Yes, obviously. It wasn't an easy conflict to live with, however. There were blows coming from every side, a bit like taking a tumble in a washing machine. It wasn't even the easiest way forward for me either, as I was quite happy with my research position. I'm sure youthful folly also played its part.

You came from another institution and brought with you a background in medicine. Does Switzerland need this kind of concoction?

Yes, it's too scarce. It can bring freedom with it. There comes a time in the life of an institution when serious reform becomes necessary and new lifeblood helps. That said, there are political imperatives for an EPFL president. You have to know the country. As I stood before the parliament, I was told, "You're a Fribourger!" And there I was, returning from the US, thinking I was European if anything, maybe Swiss, but a Fribourger! [laughter]

"I was strongly influenced by the American model"

Your successor, Martin Vetterli, is somewhat more traditional. He's 58 years old and has spent 21 years at EPFL. Is that a problem?

No. There's no reason to change everything every time. At any rate, EPFL is going though a period of consolidation, although I'm not a fan of that word. I hold Martin in very high regard. Next time around, however, the younger generation should take the reins.

What were your three greatest achievements at EPFL?

The tenure track for young assistant professors, the doctoral school and the faculties.

The tenure track means academic independence for young researchers. It gives them the chance to carry out their own research projects and to open new paths. It has completely transformed EPFL.

In the doctoral school, we receive candidacies and shortlist the best. We also ensure competition among the professors by allowing the successful candidates to choose which group they wish to join.

Then there's the faculties. When I arrived there were 12 departments, each with a two-year management rotation. We regrouped them into five faculties and created four-year, renewable deanships. The deans take on great responsibility, including hiring the best teaching researchers.

Despite resistance, you managed to have a large impact. How?

For the first two years, I hardly left campus. I practised walk-around management. I met and personally won over every EPFL professor. I received a great deal of support from those researchers who were familiar with the American system and who understood my plan.

Your revolution at EPFL in 2000 was a success, but Ernst Hafen's at ETH Zurich wasn't. Why was that?

I think all his efforts were correct. What's different is the culture, added to which, our Zurich-based twin has relatively fewer researchers with experience of the US model. It's also a much older institution, making reform considerably harder.

Once again, the American model.

Yes, I was strongly influenced by the culture there. It's a meritocratic system that encourages innovation. There are swathes of Swiss and European researchers working there, many of whom would prefer to be closer to their families, but what they would also prefer is to return to an environment that meets US standards. This is what we have tried to create at EPFL.

In the US, people are very proud to bear the name of their university – we wanted to develop the EPFL brand. When taxi drivers in Lausanne claim to be proud of EPFL, it's a measure of success.

Many industry representatives sit on the EPFL Strategic Advisory Board.

Besides teaching and research, our mission also includes the transfer of knowledge. Our students need to find jobs, and we need to understand the profiles sought by the private sector. Many members of the Board are also financial sponsors of major EPFL projects.

To give you an example, the Innovation Park brings together more than 100 startups and industry mammoths, such as Nestlé, Intel, Peugeot and Logitech.

Our research excellence has to contribute to the economic development of French-speaking Switzerland. I'm happy to note there's been a significant increase in the number of our students launching startups.

Your presidency is associated with private money.

Everybody thought it was impossible to fundraise in Switzerland, but really no one had ever really tried. I spent a great deal of time creating a network. Having been

raised in an artistic environment was a great help, as it means I'm at ease with all layers of society.

The idea of sponsored chairs received criticism. Why is there a blocking vote for the chair?

It's natural to grant the company paying for the chair the right to know who's being appointed. If it doesn't agree with the choice, it can withdraw its financing, but it cannot stop the person from being hired. Privately sponsored chairs have the same academic freedom as publically sponsored chairs.

But this is an issue that should first be addressed in the chair's job description.

That's why it's never happened.

You transferred intellectual property rights from joint research to Rolex. Isn't that controversial?

Usually, royalties are negotiated on the basis of granting licences. With Rolex, we transferred them in return for the large sums it was offering to build the Learning Center. They were far greater than anything we could have ever hoped for from royalties. Rolex made it possible to create an indispensable element of today's EPFL.

> "Having been raised in an artistic environment was a great help"

Switzerland stands above the crowd when it comes to support for basic research. That could be undermined by being too close to industry.

It's vital support. Without basic research, there's no creation of value. Almost a third of our professors have received ERC grants and we're regularly published in the best scientific journals. That's all basic research! Our researchers aren't manipulated by industry; it's the other way around. Companies sidle up to us precisely to avoid the risk of missing the next technological breakthrough.

The growth of EPFL has been built on the success of others, for example, the integration of the Institute of Microengineering (IMT) in Neuchâtel and of ISREC. Isn't it demotivating for other institutions to lose research quality?

We felt a responsibility to take up IMT, because its rate of growth outstripped the financial capabilities of the University of Neuchâtel. The University was later able to reallocate that money to strategic areas. IMT only had four chairs back then, now it has 12. Everybody came out on top. The same can be said for ISREC, whose research was also growing at an unsustainable rate – we must remember that cancer research is expensive.

EPFL is known for trumpeting its flagship projects before having achieved any results, as was the case with the Human Brain Project (HBP) and the Venice Time Machine. Aren't you worried about the backlash that may come if they fall flat?

The HBP was the follow-on from EPFL's Blue Brain, which had already produced enough results to be able to take on board one of the two FET-Flagship Projects financed by the European Union to the tune of a billion euros over a period of 10 years. Two years into the HBP, a major article has already been published in Cell. But you're right on one thing, however. It's difficult for science to predict results along a 10-year timeline. For example, when the Human Genome Project was launched, it promised great things. It actually took longer than expected for its impact to be felt by doctors. Today, not a soul would argue against the need for such a project. I hope it will be the same for the HBP.

Don't you think there are limits to what researchers can promise?

One should never make unsubstantiated promises, particularly in medicine.

Are you sad to leave?

I'll be happy to be a free man. I loved this job, but it's also a never-ending battle against inertia, reticence and litigiousness.

What are your plans?

What I'd love to do is bring together the worlds of science, technology, entrepreneurship and art. The noteworthy projects will be interdisciplinary and inclusive. Working at the interface of different domains requires breaking down institutional limits, freeing oneself from superfluous administrative restrictions and creating the necessary zones of freedom.

What's the first thing you'll do when you leave your office in December?

We're planning a big Christmas party for everyone at EPFL, during which I will invite Martin [Vetterli, Ed.] to speak. Then I'm headed to Cape Town, South Africa, where I'll embark on a polar expedition organised by the Swiss Polar Institute, a new EPFL project.

Daniel Saraga is Head of Science Communication at the SNSF.

From art to science

Patrick Aebischer was born into a family of artists in Fribourg. He later studied medicine and neuroscience in Geneva and Fribourg before an eight-year stay at Brown University, USA. In 1992, he returned to Switzerland as a professor at the Lausanne University Hospital. In 2000, he took the reins of EPFL, without forfeiting his research, spending one morning a week at the Brain Mind Institute in his laboratory (he actually published 126 articles during his presidency, the latest proposing an implant to fight Alzheimer's disease). He has also founded three startups.

The Aebischer era

EPFL has become one of the world's top research institutions. Almost a third of the faculty, including tenured professors, are recipients of ERC grants, a hallmark of quality in academia.

EPFL has been accumulating prestige in the worlds of research (e.g. Human Brain Project, Venice Time Machine), partnerships (e.g. Alinghi, Solar Impulse, Nestlé Health Institute, Biotech Campus) and even architecture (e.g. Rolex Learning Center, Swiss Tech Center). It has also been working on its academic profile, in particular by leading the way in Europe in MOOCs (mass online open courses), committing to French-speaking Africa and creating chairs in emerging and interdisciplinary fields (e.g. digital humanities, neuroprosthetics, etc.).

In figures

	2000	2015
Number of students	4,899	10,124
Doctoral students	702	2,077
Postdocs	100	825
Professors	180	380
Ranking (Shanghai/QS)	177/32[a]	126/14
Startups created (5 years)	52[b]	81[c]
Funds raised by startups (5 years; CHF)	100 m[b]	700 m[c]

[a] 2004
[b] 2000–2004
[c] 2011–2015


Valérie Chételat

A heart for the Ancients

Patchwork families and single-parent households in Classical Rome: Sabine Huebner, an assistant professor in Ancient History in Basel, has been investigating everyday life in the ancient world.
By Pascale Hofmeier

It happened one spring day on the Via Appia. Sabine Huebner was 12 years old when she went walking with her parents along the cobblestones of this old Roman highway. "The history of the place so gripped me that from this moment on I wanted to study the ancient Romans". Her childhood enthusiasm led to studies of Ancient Greek, Latin and ancient history – and a smooth career trajectory. After studying in Münster and Rome she took her doctorate in Jena. She also spent five years researching in the USA, including time spent at the University of California, Berkeley and at the Institute for Advanced Study in Princeton. After taking her postdoctoral habilitation in Ancient History at the Free University of Berlin, she was appointed a Heisenberg Fellow of the German Research Foundation in Paris and Rome. She's 39 years old now. "I never doubted wanting to stay in academia", she says. The University of Basel is her "dream destination".

Family and career

Huebner sits, relaxed, in her well-organised office. There's a computer, a table and two full bookshelves, one of which is full of historical reference works including the great texts of the Ancients. However, it's not Cicero, Homer or the life of the emperors that are the focus of Huebner's academic work. Instead, she's interested in the lives of 'normal' people.

Huebner's comprehensive list of publications and editions also makes it evident that she's most passionate about the everyday life of ancient times. Many of her works are on the social, economic and religious history of the 'little people' and their family lives. "A considerable number of children in the ancient world grew up without a father". Men married later than women and often died before their children had grown up. "In times of high mortality and divorce rates, patchwork families and single-parent households were normal", says Huebner, who draws a comparison with our own times: "When we talk about families we often mean what was considered ideal in the 1950s – but that state of affairs had never existed at any other time".

Huebner is both an academic and a mother of two children – soon to be three – and she herself brings up her own family situation. She's always being asked how she manages to combine an academic career with having a family. This pressure to justify herself sometimes gets on her nerves. "I always just ask in return: 'Would you ask the same of a man who is a professor and a father?'". When Huebner had to move from one country to another because of her academic career, her family always went with her. "The mobility demanded of young academics is something I have always seen as a great opportunity, not a burden". She also finds the time to go jogging every day and it doesn't stress her out when she has to reply to e-mails at weekends. "I think I'm just very efficient".

Her doctoral supervisor Walter Ameling can attest to that. These days he's a professor of Ancient History in Cologne. "Yes, that's the best description for her", he says. She had a doctoral scholarship in Jena that lasted for three years. "But unlike many other scholarship holders, she kept to her schedule". And another characteristic of hers became evident during her doctoral studies: independence. "Right from the start she wanted to stay in academia. She chose her topics herself and sorted out how to finance her work".

Everyday matters and fish sauce

It would be easy to confuse her determination with the somewhat proverbial, ruthless German trait of efficiency. But this is not how Sabine Huebner comes across, nor is it how others experience her. "She's not the pushy type. Her door is always open

"I think I'm just very efficient".

and working with her is a real act of collaboration", says one of her colleagues on her current project, which aims to make the Basel papyrus collection accessible to the public. Papyri are important sources for the social history of the ancient world. "They offer us insights into the lives and everyday concerns of normal people, and the direct, personal information they offer makes them an especially fascinating type of text", explains Huebner. Simple farmers, artisans, shepherds, their wives and children and other socially weak groups speak to each other and to us through these papyri - groups of people that we would otherwise never encounter in the literature of the ancient world.

This collection lay forgotten in Basel for 100 years. It had been bought by the University in the late 19th century, when international research institutes were competing for the best items on offer.

Until now, there was only an old-fashioned, incomplete edition of the roughly 65 texts in the collection. The greater number of them are everyday documents such as contracts, letters and receipts, written in Ancient Greek, Latin, Coptic and Hieratic. But there is also a copy of Homer's Iliad among them. And then there is a private letter from the early third century AD in which a man called Arrian and his brother Paul exchange everyday pleasantries, including a discussion of fish sauce. The letter is a minor sensation because the two men were Christians. "It was only recently that we were able to prove that this is the oldest surviving private correspondence on papyrus between Christians, dating back to the first half of the third century". That's more than 50 years earlier than all other extant documents of a comparable nature. Huebner believes that this can provide us with new information about the Christianisation of Egypt - and thus also new information about processes of societal change.

The planned edition of the Basel papyrus collection is also intended to be shown to the Basel public in an exhibition in early 2017. Huebner is convinced that "the dialogue between academia and the public is important - new findings about the ancient world can still fascinate a broad spectrum of people today". She regrets that ancient history is slowly disappearing from our schoolrooms: "History doesn't just begin in the mediaeval period", says Huebner, and offers compelling examples as to why ancient history is still important in our own times: "Greek philosophy, the Athenian concept of democracy, Roman law and the ancient ideal of beauty are all things that still have a major impact on European culture to the present day".

Pascale Hofmeier is a science editor at the SNSF.

Single minded

Sabine Huebner (39) grew up near Münster in Germany, the eldest of three daughters to parents who were both teachers. She lives today in a house in Alsace in France together with her husband, the French writer Stéphane Piatzszek, and their two children aged five and two (with a third on the way). She studied Ancient Greek, Latin and ancient history in Münster, Berlin and Rome. In 2005 she completed her doctorate in ancient history in Jena with a thesis on the organisation of the church in late antiquity. In 2010 she completed her postdoctoral habilitation at the Free University of Berlin with the thesis 'The Family in Roman Egypt'. Since 2014 she has been an assistant professor in Basel, where she heads the Department of Ancient History.

Safiental's landscape is dotted with hundreds of little barns. Modern agriculture doesn't need them, but they're being kept until a new use is found for them.

No fond farewells to growth

An ordered retreat could solve the problems faced by remote mountain regions. But the political and social resistance to the idea is great. *By Atlant Bieri*

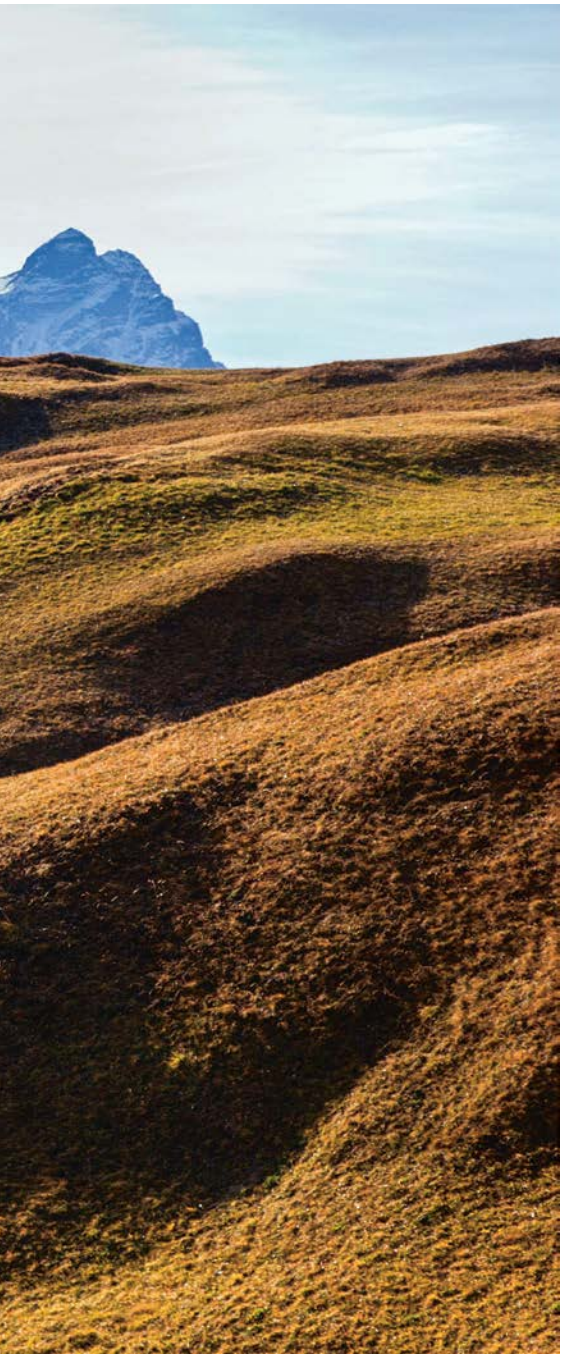


Photo: Keystone/Arno Balzarini

Times are hard for the Swiss mountain regions. The economy is stagnating and people are migrating elsewhere. Various strategies for the future are being considered. But one of them has already been rejected several times: contraction. In other words, the planned downsizing of villages and regions. Early this year, scientists of the Interacademic Commission on Alpine Studies met in Bern to develop procedures for an ordered plan of contraction that would be fair to those affected. They want to put this particular approach back on the agenda. But it's a tricky business.

Replacing growth with contraction is a taboo topic, both among the population and among politicians. This is probably because the Alps were traditionally a profitable region, says Jon Mathieu from the Department of History at the University of Lucerne. He is engaged in intensive research into the history of the Alpine region. "For centuries, the Alps were situated between several highly developed European centres such as Venice, Milan, Munich and Lyon". This has been a huge boost to tourism, right up to the present. "Today, however, the Alps have lost their monopoly", says Mathieu. Travelling has become cheap. "This means that the Alps are now in competition with many different regions of the world". The income from tourism is also threatened by climate change – at least in the winter.

> "Downsizing isn't on the political agenda".
>
> Stefan Forster, ZHAW

Agriculture is also under pressure. In Switzerland, three businesses a day close down, one of which is situated in the Alps. And there's one other branch of the economy that towns such as Andermatt could rely upon until the 1980s, but can do so no longer: the army. The Swiss Army is now closing down an armoury in Andermatt that used to provide an income to half the town's population.

Healthy contraction is expensive

It's migration that hits hardest in the villages. "Young people want leisure, culture, cinemas and entertainment. The countryside can't offer as much as the towns can", says Dieter Rink, a sociologist at the Helmholtz Centre of the University of Leipzig. The process that is taking place in the mountain regions is essentially the same as took place in the former GDR. After the Wall came down, many people left and moved to what was West Germany.

There were veritable ghost towns back then. Finally, the state stepped in and offered money to tear down empty houses on the periphery and to renovate old buildings in the inner cities. Since 2002, the federal government in Berlin has provided some three billion euros to offset the negative growth of towns in eastern Germany.

It would also be sensible for the Swiss state to fund the planned downsizing of villages in the Swiss mountains. But at present there is no means of enabling this. "No region at present has the option of calling a halt", says Stefan Forster, the head of the Research Division for the Countryside and Tourism at the Zurich University of Applied Sciences: "The regional policy of the federal government is based on growth, not on contraction. There's simply no discussion about that".

Terminologically challenged

The Office for Economy and Tourism of the canton of Graubünden has at least been trying. In 2009 it published a report entitled 'Strategies for dealing with spaces with little potential'. "They really just wanted to take a look at where the problem of downsizing was most urgent", says Forster. The result was a map on which these 'spaces with little potential' were marked in red. These included the regions Hinterrhein, Val Müstair and Schanfigg between Chur and Arosa.

"It was a fiasco", says Forster. "There was an outcry in the media. Local mayors were shocked". As a result, the project was shelved just after it saw the light of day.

The reason was that the concept of regional downsizing is not tolerated in Switzerland, unlike in Germany. Other places are also trying desperately to find the right terminology for the concept. In Germany, the term 'lean city' was invented. "But it hasn't caught on", says Rink. The EU also has a term for it in English, though it is somewhat cumbersome: 'Cities regrowing smaller'.

The USA is the only country that has up to now been successful in inventing

The ruins of a prefab building in Leipzig. Here, removing empty apartment blocks has been the object of targeted investment.
Photo: Keystone/Caro/Hechtenberg

palatable names for the process in question. Cities such as Detroit used to be thriving but are now in a process of decay. Local mayors there have come up with the label 'legacy city', which seems to hold on to what is good about a place, while at the same time ignoring what is negative.

Switzerland is still far from finding a term as positive as this. It's not surprising. The federal government, the cantons and the municipalities are all doing their best to counter the process of contraction in every way possible. "There is a constant pressure to innovate. People are holding meetings and brainstorming sessions", says Forster. "It means lots of money is being spent on new development projects that ultimately won't work anyway".

Growth at any cost

Andermatt is a good example. For six years, the Egyptian investor Samih Sawiris has been trying to build a luxury resort on its former military compound. He is planning several hotels, dozens of apartment buildings, several hundred holiday apartments and a golf course. But only one hotel has been built up to now, out of six that are planned. And the number of tourists visiting is very low. Forster doubts whether everything that has been planned on paper will be realised.

The biggest grand project in the Alps is the 'Heidi world experience' at Flumserberg – another region that is struggling with sinking numbers of tourists. A 'Heidi village' is planned, along with an alpine dairy, holiday homes, a restaurant and a playground. Also on the drawing board are two new hotels with some 180 rooms and an adjoining parking garage with 400 spaces. The canton of St. Gallen hopes that this project will entice more tourists to this peripheral region, but the investment costs are currently running at CHF 100 million.

> "Other countries manage this".
>
> Dieter Rink, sociologist, Leipzig

When referenda are held for such projects, they are usually accepted, even when agricultural land has to be sacrificed in favour of a golf course or a hotel. "These regions have a particular interest in getting people to come who might hold back the process of contraction. And the population is prepared to make all kinds of concessions in return", says Rink.

Small is beautiful

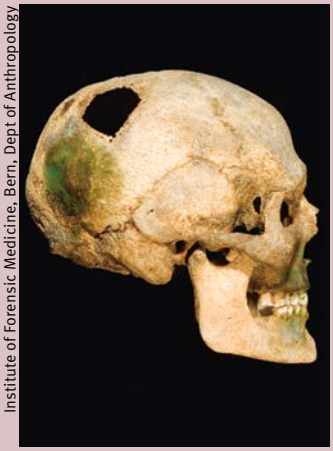
Often it would be better if the monies in question were invested in an ordered process of economic retreat. Because however negative the concept of contraction sounds, it also has a positive side. If the number of school pupils in a village dwindles because people are moving into the towns, the children who remain get more out of their teacher. This improves their quality of education. "Of course, this means that the canton has to maintain more schools, and this too costs money", says Rink. "But other countries also manage this. In Finland there are many sparsely populated areas where the state runs small schools".

Outlying villages also have a charm of their own as alternatives that are far away from the rat race of the hectic, overpopulated cities where we live and work. "There are people who choose to go and live in these peripheral regions. They are young, highly qualified groups who can work from their laptops", says Colette Peter, the sociologist who runs the Institute for Sociocultural Development at the University of Lucerne.

Despite these advantages, to this day there is no village that has consciously chosen the path of downsizing. There have been tentative forays, however, such as in Safiental in the canton of Graubünden. Safiental is characterised by hundreds of little barns in which the farmers used to store hay in years gone by. "The population doesn't yet know what to do with these historical buildings", says Forster. "But perhaps the next generation will have an idea as to what to do with them". This is why money is now being gathered to renovate them. In this way, the barns can take a break and wait until a new use is found for them.

This example also demonstrates what Mathieu thinks is crucial for the future of the Alpine communities, namely involving the local population in finding a solution, not forcing them to act. "That's the most important consideration of all".

Atlant Bieri is a science journalist.



Institute of Forensic Medicine, Bern, Dept of Anthropology

This man was operated on twice. He survived the first trepanation, seen here.

Ice Age boring

As early as the late Ice Age, medical practitioners were opening up the skulls of their patients – presumably in cases of headaches or to treat injuries. They mastered various techniques of the procedure we call trepanning. And the survival rate could be high in some places. In Great Britain during the Ice Age, some 25 percent of patients survived trepanning, but the skulls hitherto investigated in Switzerland show an overall survival rate of 78 percent. These statistics are the result of research carried out by members of the Department of Anthropology at the Institute of Forensic Medicine at the University of Bern, led by Sandra Lösch.

Lösch's team has been examining the bones from the Celtic burial ground in Münsingen that was discovered back in 1906. Two of the 77 well-preserved skulls have the lesions typical of trepanning. Both were adult males and had undergone an operation on the site of a previous injury on the left side of their cranium that was presumably the result of fighting.

The younger of the two died during the operation, which consisted of scraping back the skin of the parietal bone before drilling a hole into the skull. The older man was operated on twice. "New bone tissue has grown on the edges of his bones, which means that healing had taken place. So he clearly survived the first trepanning", the researchers explain. In their current study, they have demonstrated a survival rate of 33 percent at the excavation site in Münsingen.

It's difficult to determine just how these surgical interventions were carried out, as there are almost no written sources. The researchers believe that the patients were probably first given medicinal plants to make them drowsy, then were given herbs afterwards that had an antibacterial effect. *Anne-Careen Stoltze*

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N. Moghaddam et al.: Survival after trepanation – Early cranial surgery from late Iron Age Switzerland. International Journal of Paleopathology (2015)

Well-behaved foot soldiers

Since 2014, the members of the Swiss Council of States have been voting electronically, not with a show of hands. This has had consequences: the number of dissenters within the political parties has actually sunk from roughly ten percent to less than six percent. The reduction was particularly noticeable in the big parties SVP and SP (the Swiss People's Party and the Socialist Party, respectively). Furthermore, the voting behaviour of the National Council and the Council of States has become almost identical. These are the findings of a research group from the University of St. Gallen. "There seems to be latent pressure and an awareness that voting behaviour can be checked", says Katharina Hofer from the Swiss Institute for Empirical Economic Research. As a rule, Swiss parliamentarians don't have to fear any long-term disciplinary measures such as exclusion from their party. The research group now wants to look closer at the factors that lead politicians to make their decisions.

The results of a study carried out by a team from the universities of Basel and Zurich can perhaps offer information in this regard. They have been investigating loyalty to the party line, independent of voting procedures. "The biggest groupings in the National Council today vote more as a bloc than was the case twenty years ago. In the SVP, unity rose from 80.5 percent in 1995 to over 89 percent in 2015", write Stefanie Bailer and Sarah Bütikofer in a study published in 2015. The reason for this lies in the "increasing professionalism of the party members and in the firmer leadership in the party". In this regard, the Swiss parliament is moving closer to the norms of other European parliaments. *Astrid Tomczak-Plekawa*

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Ch. Benesch, M. Bütler, K. Hofer: Transparency in Parliamentary Voting. CESifo Working Paper No. 5682, 2015

S. Bailer und S. Bütikofer: From loose alliances to professional political players: how Swiss party groups changed, in Swiss Political Science Review, 2015

Dominik Feusi

Electronic voting makes it possible to find out exactly how everyone votes.

Western Cape Archives and Records Service

Mary Elizabeth Barber's findings made an indirect feminist statement.

Learning equal opportunity ornithologically

When scientists investigate something, their own values and convictions always play a role. One such example is the work of Mary Elizabeth Barber, who was born in England in 1818 but emigrated at an early age with her parents to the Cape Colony in South Africa, where she remained for the rest of her long life.

Barber was the first botanist, entomologist, archaeologist and ornithologist of South Africa. When researching birds she specialised in the social behaviour of both the indigenous and the European species that winter in South Africa. "It is striking that it was through observing birds that Barber found a counter-model to the predominant Victorian model of the family", says Tanja Hammel, a historian at the University of Basel. She is writing her doctoral thesis on this important scientist, who has been almost completely forgotten until now. Barber highlighted the fact that female and male birds are equally responsible for building nests and rearing chicks, and hardly display any gender-specific differences. Hammel explains: "Her work implicitly laid claim to a social equality of the sexes, criticising the institution of marriage and demonstrating the possibility of alternative relationship models". With her scientific feminism, Mary Elizabeth Barber drew attention to discrimination against women, long before the women's rights movement got off the ground in South Africa. *Urs Hafner*

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T. Hammel: Thinking with birds: Mary Elizabeth Barber's advocacy for gender equality in ornithology, in: Southern African Histories, Kronos, 2015

Into the high-risk zone

On 1 June 2016, the Gotthard Base Tunnel opened after just under 20 years of building work. Peter Guntli was involved in the construction of what is the world's longest railway tunnel, working as chief geologist of the Sedrun section. He looks back on the project for us.

"My daughter was four years old when she asked my sister: 'When will Daddy be finished with the tunnel?' She answered: 'When you get your driving licence'. So in this sense, we finished earlier than we expected back then. My daughter is 23 years old today and she still doesn't have her driving licence. But the tunnel will open on 1 June this year. For a long time I was unable to contemplate that this day would actually arrive. But now it's here. After working for 20 years on this project!

I came to the Gotthard Tunnel by chance, really. At the beginning, I had absolutely no experience. In a normal geology degree course, you don't learn how to build shafts or tunnels. We Swiss just stood in front of the huge black hole that was the Sedrun shaft, and we looked down and marvelled at what the South African shaft builders were doing down there. Over the years I acquired experience in tunnel building. I took courses, but most of it was learning by doing. And so I became the head geologist of the Sedrun section of the Tunnel.

Building a tunnel with gut feeling

Our main task is to assess the rock in front of us so that we can advise the engineers and tunnel constructors as they advance: are they going to be confronted with an unproblematic zone made of hard gneiss, where they can make progress without undue danger? And will they be able to secure the tunnel with just five centimetres of sprayed concrete and a few braces? Or is it going to be a high-risk zone with soft, squeezing rock and a heavy water flow where they will have to carry out advance drilling and institute comprehensive sealing and support measures?

You usually don't have much time to make elaborate tests in a laboratory. It's just not possible to stop construction for several days at a time. There are objective criteria that have been catalogued systematically and in detail. But in the end, you're left with your gut feeling. Or, to put it in more professional language, it's down to your experience and good teamwork. Luckily, nothing serious happened in my section in terms of the geology. But the 'normal' accident risk is still high on such a construction site. If a tool falls 800 metres down a vertical shaft despite all safety measures, it's best not to be standing under it. At the beginning in particular, I had a lot of respect for the tunnel – more than respect. Even if you get used to the atmosphere over time, it remains something special. It's not suited to everyone. It's odd to feel that there are thousands of metres of rock above you, not to mention

the many kilometres you have to travel in the dark, the constant artificial light and the noise of the hammer drills. In the tunnel you have to work meticulously and carefully. It's not a place for fooling around. Though on one occasion my young colleagues did allow themselves an April Fool's joke: they wrote in the official survey report that they'd struck gold and were shutting the tunnel down over Easter in order to go prospecting. One of the people higher up who read it actually got angry and informed us that the gold belonged to the building contractors, not to the geologists!

Always on call

But as a rule, we're very serious about the job. We recently had a really strenuous day at the site, in a zone where there are many water-carrying layers that we had to investigate by drilling into them. We commissioned a specialised company to enter there with borehole cameras – and the water flow was ten litres per second. That wasn't easy. But we got a grip on the problem in the end. I was able to go home towards midnight.

I still enjoy my work. The tunnel is fascinating – but tiring. Basically, I've spent the last two decades on constant call, because we're building round the clock. On 1 June I will be very happy and very proud, but also very relieved.

As told to Christian Weber.

Top: A specialised, four-armed drill rig bores holes for explosive charges in the rock of the Gotthard massif below Sedrun.
Bottom: Peter Guntli (with the white helmet) leads geology students through his section of the tunnel.
Photos: AlpTransit Gotthard AG (top) and Christian Schlüechter, Uni Bern (bottom)

Imitation neurones, genuine potential

It's already been 50 years since we first created algorithms to mimic the working of the human brain. But only recently have they gained any traction. Using these artificial neural networks, artificial intelligence is now making great strides forward. *By Fabien Goubet*

In March 2016, the world Go champion Lee Sedol lost 1-4 against AlphaGo. For many, this was yet another defeat for humanity at the hands of the machines. Indeed, the success of the AlphaGo software was forged in an area of artificial intelligence that has seen huge progress over the last decade. Deep learning, as it's called, uses artificial neural networks to process algorithmic calculations. This software architecture therefore mimics biological neural networks.

Much of the progress in deep learning is thanks to the work of Jürgen Schmidhuber, director of the IDSIA (Istituto Dalle Molle di Studi sull'Intelligenza Artificiale) which is located in the suburbs of Lugano. The IDSIA doctoral student Shane Legg and a group of former colleagues went on to found DeepMind, the startup acquired by Google in early 2014 for USD 500 million. The DeepMind algorithms eventually wound up in AlphaGo.

"Schmidhuber is one of the best at deep learning", says Boi Faltings of the EPFL Artificial Intelligence Lab. "He never let go of the need to keep working at it". According to Stéphane Marchand-Maillet of the University of Geneva computing department, "he's been in the race since the very beginning".

Cat photos, thousands of cat photos

The real strength of deep learning is structural recognition, and winning at Go is just an illustration of this, albeit a rather resounding one. Elsewhere, and for some years now, we have seen it applied to an entire spectrum of areas, such as visual and vocal recognition, online translation tools and smartphone personal assistants. One underlying principle of machine learning is that algorithms must first be trained using copious examples. Naturally, this has been helped by the deluge of user-generated content spawned by smartphones and web 2.0, stretching from Facebook photo comments to official translations published on the Internet. By feeding a machine thousands of accurately tagged images of cats, for example, it learns first to recognise those cats and later any image of a cat, including those it hasn't been fed.

> Deep learning is still alive thanks to video games.

Deep learning isn't new; it just needed modern computers to come of age. As far back as the early 1950s, biologists tried to lay out formal principles to explain the working of the brain's cells. In 1956, the psychologist Frank Rosenblatt of the New York State Aeronautical Laboratory published a numerical model based on these concepts, thereby creating the very first artificial neural network. Once integrated into a calculator, it learned to recognise rudimentary images.

"This network only contained eight neurones organised in a single layer. It could only recognise simple characters", says Claude Touzet of the Adaptive and Integrative Neuroscience Laboratory of Aix-Marseille University. "It wasn't until 1985 that we saw the second generation of artificial neural networks featuring multiple layers and much greater performance". This breakthrough was made simultaneously by three researchers: Yann LeCun in Paris, Geoffrey Hinton in Toronto and Terrence Sejnowski in Baltimore.

Byte-size learning

In multilayer networks, each layer learns to recognise the precise visual characteristics of a shape. The deeper the layer, the more abstract the characteristics. With cat photos, the first layer analyses pixel colour, and the following layer recognises the general form of the cat. This structural design can support calculations being made upon

Lee Sedol lost four out of five Go games against the machine. The machine learned this complex game – which has 2.08×10^{170} possible playing positions – with a software architecture that mimics neural networks. Photo: EPA/Jeon Heon-Kyun

thousands of layers, and it was this aspect of the architecture that gave rise to the name 'deep learning'.

Marchand-Maillet explains: "Each artificial neurone is assigned an input value, which it computes using a mathematical function, only firing if the output exceeds a pre-defined threshold". In this way, it reproduces the behaviour of real neurones, which only fire and transmit information when the input signal (the potential difference across the entire neural circuit) reaches a certain level. In the artificial model, the results of a single layer are weighted, added up and then sent as the input signal to the following layer, which processes that input using different functions, and so on and so forth.

> "Real artificial intelligence will lead to the most important change in the history of our civilisation".
>
> Jürgen Schmidhuber

For example, if a system is trained with great quantities of photos of apples and watermelons, it will progressively learn to distinguish them on the basis of diameter, says Marchand-Maillet. If it cannot decide (e.g., when processing a picture of a tiny watermelon), the subsequent layers take over by analysing the colours or textures of the fruit in the photo, and so on. In this way, every step in the process further refines the assessment.

Video games to the rescue

For decades, the frontier of computing held back more complex applications, even at the cutting edge. Industry walked away, and deep learning only survived thanks to the video games sector, which eventually began producing graphics chips, or GPUs, with an unprecedented power at accessible prices: up to 6 teraflops (i.e., 6 trillion calculations per second) for a few hundred dollars. "There's no doubt that it was this calculating power that laid the ground for the quantum leap in deep learning", says Touzet. GPUs are also very good at parallel calculations, a useful function for executing the innumerable simultaneous operations required by neural networks.

Although image analysis is getting great results, things are more complicated for sequential data objects such as natural spoken language and video footage. This has formed part of Schmidhuber's work since 1989, and his response has been to develop recurrent neural networks in which neurones communicate with each other in loops, feeding processed data back into the initial layers.

Such sequential data analysis is highly dependent on context and precursory data. In Lugano, networks have been instructed to memorise the order of a chain of events. Long Short Term Memory (LSTM) networks can distinguish 'boat' from 'float' by recalling the sound that preceded 'oat' (i.e., either 'b' or 'fl'). "Recurrent neural networks are more powerful than other approaches such as the Hidden Markov models", says Schmidhuber, who also notes that Google Voice integrated LSTMs in 2015. "With looped networks, the number of layers is potentially infinite", says Faltings.

For Schmidhuber, deep learning is just one aspect of artificial intelligence; the real thing will lead to "the most important change in the history of our civilisation". But Marchand-Maillet sees deep learning as "a bit of hype, leading us to believe that artificial intelligence can learn anything provided there's data. But it's still an open question as to whether deep learning can really be applied to every last domain".

Fabien Goubet is a science journalist for Le Temps.

The Mozart of mathematics

After more than a hundred years, the publication of the collected works of Leonhard Euler is finally nearing completion. But the archives of this great mathematician from Basel still have much more to offer.
By Mathias Plüss

It took longer to edit Leonhard Euler's works than it took him to write them (he lived to the age of 76). Photo: Keystone/Heritage Images/Fine Art Images

"It's simply a huge amount of material", says Martin Mattmüller. On the bookshelf behind him stand the 75 volumes of the Euler Complete Edition published thus far. "It's barely possible for a single human being to get to grips with all of it". And even more astonishing that a single man was able to write it all.

Mattmüller is himself also a mathematician from Basel, and he's the Secretary of the Euler Commission. This Commission works under the auspices of the Swiss Academy of Natural Sciences (SCNAT) and is responsible for publishing the collected works of Euler. "Two volumes about astronomy are still to appear", he says. He's 58 now, and the edition should be finished by the time he's 60. "In two years they should be done". This means that all of Euler's publications will have appeared in a modern edition. The edition of his letters should also be finished in the foreseeable future – the last four volumes are currently being edited.

Originals in Saint Petersburg

Leonhard Euler (1707–1783) is regarded as the most prolific mathematician ever to have lived. He wrote two dozen books and almost 900 essays. He was born and educated in Basel, but spent the rest of his life at the Russian Academy of Sciences in Saint Petersburg and in Berlin. Besides making a major contribution to the whole field of mathematics and to physics, he also engaged with technological problems – such as trying to improve turbines and telescopes. His famous formula $e^{i\pi}=-1$ has been chosen by his fellow mathematicians as the most beautiful equation of all time. And he even invented a precursor of Sudoku.

At the time of the celebrations for Euler's 200th birthday in 1907, the Swiss Society of the Natural Sciences (today's SCNAT) founded the Euler Commission and gave it the task of publishing the complete works. This project, 'Opera omnia', began with a lot of enthusiasm, and the first volumes were published in rapid succession from 1911 onwards.

But the project came to a halt several times. The Commission lost some of its assets in the 1930s when a bank went bust. And Euler's manuscripts, which had been lent to Basel from St. Petersburg, had to be sent back to their permanent home. The Commission would gladly have kept them for good in Switzerland, but the Soviet Union even refused an exchange deal that would have involved Swiss archives giving up letters by Lenin in return. Since then, the researchers in Basel have worked with photos and copies wherever necessary.

Unrecognised genius

After the Second World War, the project started up again. But it began to drag once more in recent years. The editors were often retired professors. So whenever one died, the project slowed down again. And the manner of working has also changed over the decades. The first volumes were edited by physicists and mathematicians and had few footnotes and only brief introductions. But since the publication of Euler's correspondence began, his material has been edited with a greater attention to historical, critical principles. Euler's original works had ceased to be available in print, so the aim of the earlier editors was simply to make them accessible once again to mathematicians and to historical researchers. This problem doesn't exist today because most of his publications can be found on the Internet.

However, there are still many letters, notebooks and other unpublished manuscripts that have not found a place in the Opera omnia. "From today's perspective, we would probably give priority to editing this material, some of which has never been analysed at all", says Martin Mattmüller. There are plans to publish all of it after the printed volumes have appeared. This would again be a mammoth project – only this time it would be digital.

It would be worthwhile in any case because Euler was a truly unique figure, believes Mattmüller. "Switzerland didn't have a Goethe or a Mozart. But we had Euler – a man of absolute global significance. People here are far too little aware of this".

Matthias Plüss is a science journalist who writes chiefly for Das Magazin.

Even tiny transistors feel the heat

The layperson might not know much about how computers are actually constructed, but many have still heard of Moore's law, according to which the number of transistors in an integrated circuit will double every two years. Physical boundaries would seem to mean that this trend must end. The smallest possible transistors are already under development, and they have a gate length of just five nanometres.

Until now, researchers have assumed that such small transistors would have an advantage, namely that electrons could flow through them without coming into conflict with the atomic lattice of the transistors themselves. That would save electricity.

But the advantages hoped for would seem to be illusory. This has now been shown by Reto Rhyner and Mathieu Luisier of ETH Zurich, using atomistic computer simulations of transistors comprising wires three nanometres in length. These simulations have shown that interactions with the atomic lattice do indeed take place: "These interactions inhibit the mobility of the electrons and the holes – and this means that the transistors heat up and energy is lost", says Luisier. In nanowires made of silicon, the flow of electricity was 30 to 50 percent less than expected.

Rhyner and Luisier also investigated how this energy loss might be minimised. Germanium is clearly better suited than silicon, and the organisation of the lattice also has an impact on the flow. The surface of the nanowires is similarly important, say the two electrical engineers, because the thermic conductibility of the lattice depends to a large degree on its roughness. With these tips, other researchers can now pursue new solutions – and in perhaps five to ten years, highly efficient nanowire transistors with ultrashort channel lengths will be manufactured. *Sven Titz*

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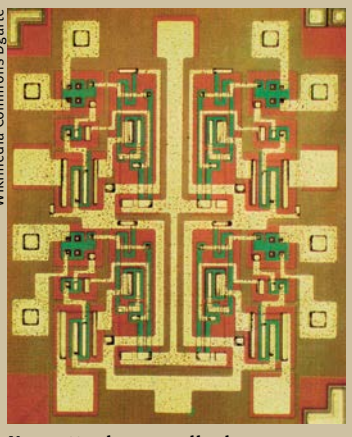
R. Rhyner and M. Luisier: Minimizing Self-Heating and Heat Dissipation in Ultrascaled Nanowire Transistors. Nano Letters 16, 2016

Wikimedia Commons Dgarte



No matter how small – here we see a fourfold NAND gate – the transistor still gets hot.

colourbox.com

Cirrus clouds look like fine brush strokes. But they have a major impact on our climate.

Ice crystal clouds warm the Earth

Cirrus clouds – clouds of ice crystals between eight and ten kilometres above the ground – are one of the greatest uncertainty factors in the models that climate researchers use to forecast global warming. For her doctorate at ETH Zurich, Erika Kienast (currently of MeteoSwiss) analysed 13,000 hours of measurement data from lidars – instruments similar to radars, but which use laser beams. She developed an algorithm that allowed her to track cirrus clouds and evaluate their characteristics and their influence on the Earth's climate. "Because of their positive radiative forcing, cirrus clouds act as a kind of blanket, keeping the Earth warm", she explains. Clouds of ice crystals let the rays of the sun through, but they reflect the Earth's radiation, and this has a warming effect on the climate. Lower-lying clouds, on the other hand, reflect sunlight; this cools down the Earth beneath them.

This study also found that there are invisible cirrus clouds that had not been recognised until now, and which also have a warming effect on the climate. This effect is only equivalent to five percent of the impact of the visible cirrus clouds, and so is only minor in impact. "Although we've been researching into clouds for over 100 years, we still know little about them" says Ulrike Lohmann, a professor of experimental atmospheric physics at ETH Zurich. And indeed, there is no global historical measurement data available. "The existing data is just a series of snapshots that you have to try and assemble into an overall picture", says Kienast. But even if such large-scale data existed, there is still a problem: "Climate models are too complex for computers to be able to calculate clouds precisely, even with today's increases in computing power". *Sergio Caré*

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E. Kienast-Sjögren et al.: Radiative properties of mid-latitude cirrus clouds derived by automatic evaluation of lidar measurements. Atmospheric Chemistry and Physics Discussions (2016)

Climate: increased forest growth at altitude

In his doctoral research, Nicolas Bircher of ETH Zurich has been looking at the effects of climate change on Swiss forests. This is a topic of concern for both the authorities and the forestry industry.

His work involved simulating the growth of 71 populations of common Swiss forests for the coming 100 years and using a range of scenarios relating to climate change and land use (with or without human intervention). Overall, the tests looked at 11 possible changes in the climate, including a general rise in temperatures and reduced summer rainfall. The result is that we should be expecting to see changes in the structure and composition of Swiss forests as of the second half of the twenty-first century.

"These models allow us to establish a number of trends, but not to make any accurate predictions", says Bircher. "We've looked at the basal area, an index that estimates a forest's productivity, and noted a reduction for the low-altitude forests on the Swiss Plateau and in the Jura. At higher altitudes, however, we noted an increase in the basal area, particularly in the Alpine foothills, including an increase in deciduous trees". Another conclusion of the study is that efforts made to plan forests may reduce the negative impact of climate change. "Forest development is strongly tied to the characteristics of each site, for example, to the soil type. Any strategies must therefore take into account the local specificities". *Sophie Gaitzsch*

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N. Bircher: To die or not to die: Forest dynamics in Switzerland under climate change. Ph.D. Thesis, ETH Zurich (2015)

Alison Pouliot

The composition of our forests – such as this beech grove – will change with the climate.

Medicine's awkward relationship with death

Palliative care eases the suffering of the terminally ill, but many doctors neglect it. Why? *By Susanne Wenger*

Mr Lazaroff was in his mid-60s and suffering from metastatic prostate cancer. He had no hope of a cure, but was nevertheless subjected to two operations. Two weeks after the second, he died in intensive care. "If he was pursuing a delusion, so were we", writes the American surgeon Atul Gawande self-critically in his book 'Being mortal'. "We could never bring ourselves to discuss the larger truth about his condition or the ultimate limits of our capabilities, let alone what might matter most to him as he neared the end of his life".

Relief – the primary concern

This is where the concept of palliative care comes in. Instead of trying to extend life at any cost, its main therapeutic goal is different: giving the terminally ill the best possible life in the time they have left.

In Switzerland, the federal government and the cantons only set up a national palliative care strategy in 2015. Terminal care is still a young academic discipline here. The first chair in palliative medicine was only created in 2011, at the University of Lausanne. Since then, five further chairs have been created: two in Lausanne and one each in Geneva, Bern and Zurich - the last of these being at the Theological Faculty.

> "It's about a lot more than just morphine and holding hands".
>
> Gian Domenico Borasio

Things are changing, and yet until now supporting the terminally ill seems to have been neglected, even stigmatised in the medical world. It has been a separate field, only brought into play when a patient is deemed to have exhausted all other possible therapies. "Our field is the enemy of curative medicine: dying", explains Stefan Eychmüller, a professor of palliative care at the University of Bern. In the highly specialised field of medicine, healing is the only goal, and death is often regarded as mere failure, a defeat.

Countering fantasies of omnipotence

It's thanks to the impressive progress made by curative medicine that our life expectancy has almost doubled. But medicine sometimes seems to imagine itself to be omnipotent, says Gian Domenico Borasio, a professor of palliative care at the University of Lausanne.

By contrast, palliative medicine accepts that medicine can't heal every disease. It asks uncomfortable questions: is everything meaningful just because it's possible? "Too much treatment at the close of a life is a huge problem in our health system", says Borasio. Not just ethically, but also financially. It's not just doctors who are responsible for this, but society as a whole. It's a fact that excessive treatment allows a lot of money to be made. The Swiss health system "is organised on a business model", confirms Eychmüller. A dying person who refuses expensive medical procedures soon becomes a negative cost factor.

Spiritual care is needed

It was only recently that palliative care was established as part of a doctor's general training programme. Often it's equated with mere pain therapies in the dying phase. According to Borasio, however, it's about "a lot more than just morphine and holding hands". The control of physical symptoms, such as pain and shortness of breath, is only half the story when it comes to the clinical reality. The other half is just as important: psychosocial and spiritual care.

Doctors are afraid of accelerating death by prescribing morphine. But the life-shortening effect of it "is generally overestimated", as the Swiss Academy of Medical Sciences notes in its guidelines on palliative medicine. There are other interventions that also require doctors to weigh up different factors, adds Eychmüller. "The

Palliative care according to the WHO

"Palliative care is an approach that improves the quality of life of patients and their families facing the problem associated with life-threatening illness, through the prevention and relief of suffering by means of early identification and impeccable assessment and treatment of pain and other problems, physical, psychosocial and spiritual".

Even Ferdinand Hodler's lover, depicted here in his 'The dying girl', would have wanted palliative care in the final phase of her terminal cancer.

Photo: Kunstmuseum Basel/Martin P. Bühler

seriously ill can also die from an emergency operation or from an experimental chemotherapy that was intended to alleviate their suffering".

At the end of a life, collegial teamwork is needed that goes beyond the usual hierarchies. Doctors work with experts in the fields of nursing, psychology, social work and pastoral care. Research, too, has to cross disciplinary boundaries. However, because medicine is oriented on principles from the natural and technological sciences, anything that doesn't fit the usual course design runs the risk of being ignored as 'soft data'.

> "Dying is the enemy of curative medicine".
>
> Steffen Eychmüller

"We still have to develop a common language in palliative research", says the theologian Simon Peng-Keller, a professor of spiritual care at the University of Zurich. As part of the National Research Programme 'End of life' (NRP 67), he investigated the strong images experienced by people close to death. Fear is a topic here, but so is trust. Spiritual care is especially important in the case of limiting illnesses: "Questions of meaning arise. People want to be perceived as a whole person, also by their doctor". Peng-Keller has discovered "a gratifying openness" among his students, both those in medicine and those in theology.

Life-extending care

In recent years, two studies from the USA and Japan have shown that the terminally ill who are given palliative care live just as long as those who are given the usual chemotherapies – and in some cases even longer. And they enjoy a better quality of life, too.

Such findings, says Borasio, help to bring palliative care from the margins into the centre, and allow medicine as a whole to be designed in a more patient-centred, communicative fashion. This would seem to be becoming ever more important, given that people in Switzerland often refuse life-extending measures. But not all doctors include their patients and their environment in their decisions, as shown recently by a study that was conducted as part of NRP 67. According to its co-author Georg Bosshard, a geriatrician at the Zurich University Hospital, we have to expand this comprehensive concept to encompass the growing number of chronically ill people.

To be sure, even palliative medicine doesn't have any generally valid criteria for a 'good death'. Dying is as individual as living, says Gian Domenico Borasio: "The goal is to allow every person to die their own death". Some decide in favour of assisted suicide because it is the right way for them. "But when people are given expert palliative care, only few of them choose that way out".

Susanne Wenger is a freelance journalist in Bern.

The green, green grass of home

Plant growers brought about the so-called green revolution by creating more productive varieties of wheat, maize and rice. Will this revolution soon be reaching the grass on our meadows and pastures? *By Ori Schipper*

The grass might be greener on the other side, but otherwise people don't pay much attention to how it grows. And yet some two thirds of Switzerland's agricultural land comprises meadows and pastures. So at least in economic terms, grass growth is a factor that we have to bear in mind, and that should be optimised where possible.

Just under a fifth of our grasslands is made up of so-called artificial pasture. Unlike permanent pasture, this is integrated into arable crop rotation and is regularly seeded with forage grass. The seeds of the most important varieties of grass are subject to constant development through cultivation. But whereas our success in cultivating varieties of grain such as wheat, maize or rice has led to spectacular increases in yield and entered into the public consciousness as the 'green revolution', little attention has been paid to the progress made in cultivating forage grasses.

Yet surely forage grass would respond to the same factors that increase the yield of grain crops. The main role is played by so-called hybrid cultivation, though we are still only beginning to understand why hybrid plants grow better and stronger than non-hybrids. Scientists speak of the 'heterosis effect'.

Genes discovered against inbreeding grasses

Bruno Studer is an SNSF Professor at the Institute of Agricultural Sciences at ETH Zurich. He too can only speculate as to what causes this effect. Hybrids are descended from genetically different parents. This is why they display a maximum degree of different gene variants. "This gives them much plasticity, meaning they can adapt optimally to many different environmental conditions", he suggests.

Studer and his team have recently taken a big step towards cultivating hybrid forage grasses. They have found a gene that ensures that the pollen of so-called self-incompatible grasses does not form any pollen tubes when it lands on the stigma of a female flower of the same plant. This gene, called the S-locus gene, is an important component of a biological mechanism that hinders self-fertilisation, thereby preventing inbreeding.

> "Carefully steering natural processes could offer a significant increase in yield".
>
> Bruno Studer

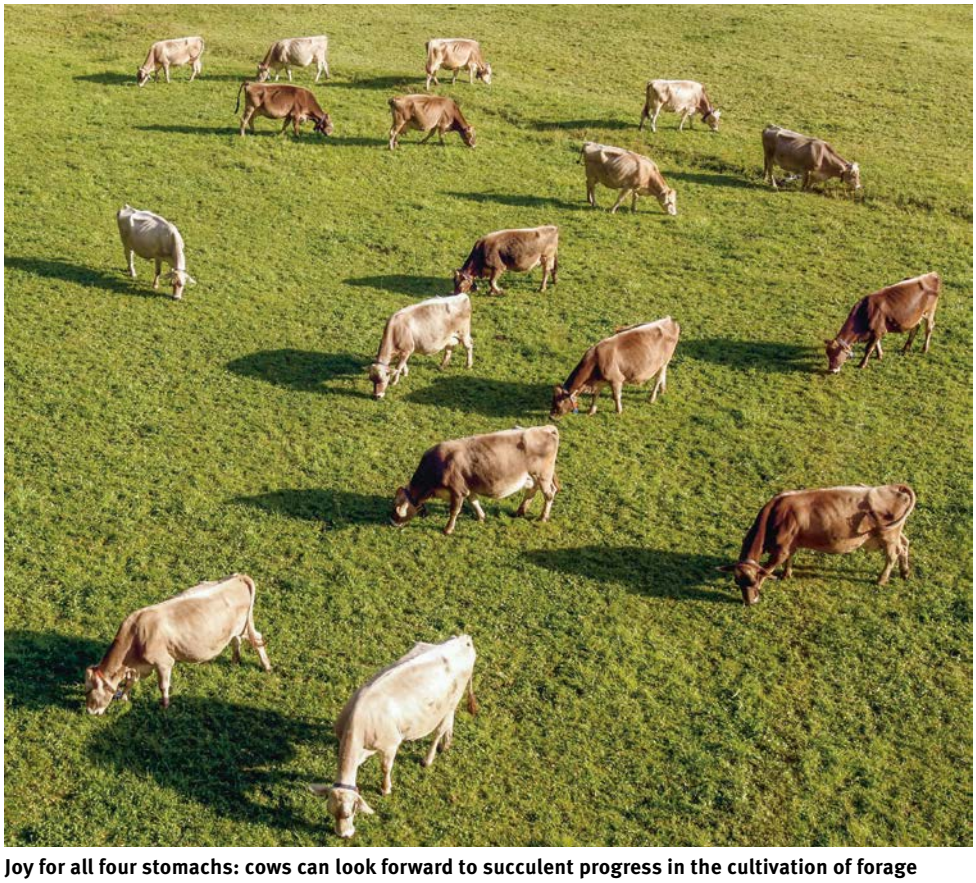
For his work on self-incompatibility, Studer was awarded the Wricke Prize at this year's conference of the German Society for Plant Breeding. The discovery of the S-locus in English rye-grass (*Lolium perenne*) marks a milestone in the cultivation of forage grasses. "Only with this knowledge can we take cultivation concepts that were imagined decades ago, and implement them in the real world", says Studer.

In his mind, one possibility is to use genetic markers to inform the growers of which plants can be crossed with each other. "If we can steer pollination within breeding populations, then we can use the heterosis effect to increase the yield of forage grasses significantly – but by natural means, and without losing any genetic diversity".

Beat Reidy, a fodder crop expert at the School of Agricultural, Forest and Food Sciences in Zollikofen, also sees great potential in this new finding. However, he believes that only the coming decades will show whether the hoped-for progress has been realised.

Ori Schipper is a science editor in Bern.

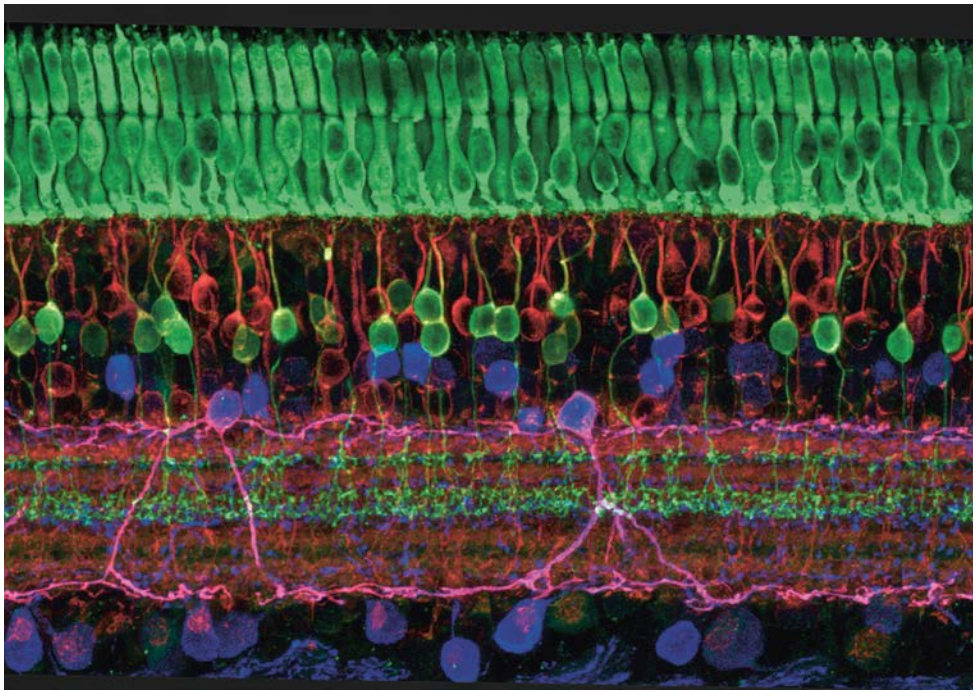
C. Manzanares et al.: A Gene Encoding a DUF247 Domain Protein Cosegregates with the S Self-Incompatibility Locus in Perennial Ryegrass. Molecular Biology and Evolution (2015)



Joy for all four stomachs: cows can look forward to succulent progress in the cultivation of forage grasses. Photo: Keystone/Urs Flüeler

Cracking the brain's code

Researchers have linked a rabbit retina to a chip in vitro. It connected to thousands of transistors and helps us to understand how neurones process information. *By Martin Angler*



In human retinas, the light stimuli are received by photoreceptors (green, top) and processed first by nerve cells (bottom, brightly coloured). Photo: Keystone/NIH

Nystagmus is a genetically transmitted disease that causes an uncontrolled, back-and-forth twitching of the eyeball. Roughly one in every 1,500 men suffer from it. But before now, we did not know that this twitching is caused by retinal neurones making miscalculations when converting visual stimuli into electrical signals.

How does the brain – to which the retina also belongs – understand what information is contained in a stimulus? Until now, it was known that neurones answer stimuli by firing off salvos of electrical signals that are transmitted via synapses to other nerve cells. The information about the stimulus is actually contained in the number of impulses and in the time intervals between them. But just how these codes are read and written is still a subject of debate among neuroscientists.

Useful noise

Felix Franke from the Bioengineering Laboratory of ETH Zurich has come one step closer to understanding this process – at least as far as the retina is concerned. In a recently published study in the specialist journal Neuron, Franke's team investigates whether it is more useful for the brain to 'hear' a whole orchestra of neurones at the same time, or only individual nerve cells. They found that if the brain hears them all, then it can learn more about the stimulus that caused the impulses – such as a picture that the eye has just seen.

> "We could predict epileptic fits and suppress the abnormal pattern".
>
> Felipe Gerhard

In their experiment, Franke's team linked the retinas of rabbits, laid out flat, with a computer chip containing 11,000 densely packed electrodes. They then moved a bright bar past the retinas. The neuroscientists were able to record the signals in the photoreceptors as data, via the electrodes.

The problem is that the nerve cells often answer differently to the same stimulus, which makes it difficult to form conclusions about the original stimulus. Franke explains this so-called 'signal noise' by using a dice metaphor: "If the stimulus is the number three, then one neurone will perhaps give us a two, and the neurone next to it a four. If we take the average of them both, the answer is correct. Viewed individually, each answer would be incorrect". The 'orchestra' is thus more precise than individual neurones.

This has been confirmed by the neuroscientist Felipe Gerhard, who completed his doctorate at EPFL and is currently involved in research at Brown University in Providence, USA. The experiments with the rabbit retinas help him to process patterns in this signal noise, enabling him to recognise visual stimuli better. These findings should be a solid basis for future research on the neural code.

But this random signal noise in the brain can sometimes also hinder communication between neurones, says Gerhard: "Evolution has found ways of dealing with this noise, and even of using it". It's especially useful for creative thinking, he maintains.

Prostheses with a tactile sense

Franke believes that these findings might in future be employed for therapeutic purposes. "If we can understand how neural networks function, then we can also better understand the diseases that are connected with them". Such as the nystagmus mentioned above.

Franke was involved in a study published in early 2016 that for the first-ever time found a connection between nystagmus in a human eye and a malformation of the retina in mice. It was the first time, says Franke, that a neural calculation was recognised as a factor in a human disease.

At Brown University, Gerhard also sees the possibility of therapeutic applications – such as prostheses controlled by thoughts. Arm prostheses could possibly even 'write' in the neural network of the brain and thereby recreate a sense of touch.

Currently, Gerhard is working with epilepsy patients measuring and analysing their neural activity during epileptic fits. Here, too, patterns in the signal noise play a role: "This could allow us to predict epileptic fits. As soon as the fit begins, we could attempt to stimulate these neurones actively, and thereby suppress the abnormal pattern".

Martin Angler is a freelance journalist in Bolzano.

F. Franke et al.: Structures of Neural Correlation and How They Favor Coding. Neuron (2016)

Pavel Krasensky/Shutterstock

Uncomfortable bedfellows: these blood suckers are increasingly resistant to insecticides.

Decoding the bedbug

We've never been able to prove that bedbugs transmit disease to humans, despite knowing that their bites can cause skin reactions and phobias. Over the last 20 years, these blood-sucking beasts have made a comeback in mattresses across the world and have become resistant to traditional insecticides. An international team of researchers has finally sequenced the bedbug's genes and identified the components that may explain this adaptation.

"By comparing bedbug DNA against an enormous library of genes from other insects, we have identified its unique genes, including some that may be involved in the resistance to insecticides", says Robert Waterhouse, a geneticist at the Swiss Institute of Bioinformatics in Geneva. For example, the researchers have described genes that neutralise the toxicity of insecticides and others that have thickened the cuticle of the bedbug (their external shell) compared to that of their ancestors of 60 years ago.

The researchers also discovered the genes of bacteria, the origin of which remains unclear. "If we find them among the natural flora of all bedbugs and can establish their role in the bedbug's survival, then we can treat infected locations with specific antibiotics", says Waterhouse. He hopes the functional analysis of all these genes will allow him to understand the biology of bedbugs and improve the options to fight them. "Until we know more about the precise molecular effects, we're just using insecticides blindly", he says. *Aurélie Coulon*

J. B. Benoit et al.: Unique features of a global human ectoparasite identified through sequencing of the bed bug genome. Nature Communications (2016)

Will pigs become organ donors?

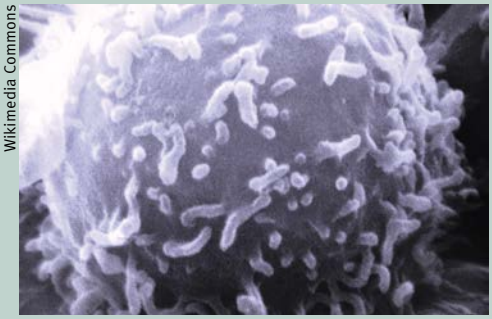
Pigs could solve the current lack of donor organs, but the human immune system rejects foreign organs. Now, however, a research group from the Geneva University Hospital (HUG) might have come one step closer to achieving so-called xenotransplantation.

We know from transplant attempts with apes that organs from genetically modified pigs can to some extent avoid being regarded as a foreign body by the recipient's immune system. It is also known that human immune cells (T regulatory cells or 'treg cells'), which protect the body from its own immune system, can suppress the defence reaction against transplants. Researchers led by Jörg Seebach have succeeded in using signalling substances from porcine tissue to attract treg cells in cell cultures.

The problem, however, is that other human immune cells could also be attracted by these signalling substances from the porcine tissue. "But it could be possible to reproduce treg calls in the laboratory and to give them to organ recipients", says Seebach. "Another possibility that we're looking at is to produce transgenic human signalling substances in the pig's organs that would attract treg cells". Seebach hopes this could help to suppress the immune reaction. In any case, the procedure would first have to be subjected to animal testing.

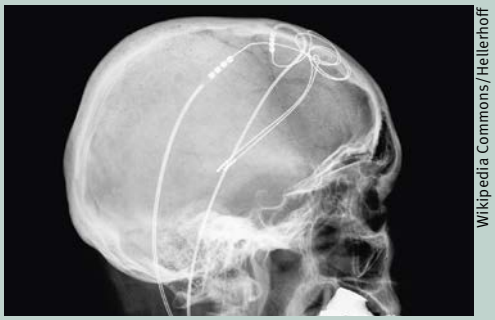
Dan Salomon, an immunologist at the Scripps Research Institute in La Jolla, raises doubts, however: "In my opinion, it's highly unlikely that tolerance for xenotransplantation could be increased by activating and administering treg cells in this manner". *Stéphane Hess*

D. Ehirchiou et al.: Chemoattractant Signals and Adhesion Molecules Promoting Human Regulatory T Cell Recruitment to Porcine Endothelium. Transplantation (2016)



Wikimedia Commons

Immune cells could protect donor organs from the rest of the immune system.



Wikipedia Commons/Hellerhoff

Electrodes stimulate deep-lying regions of the brain, thereby easing symptoms.

Battling depression with brain pacemakers

For years so-called deep brain stimulation has been used successfully to treat diseases such as Parkinson's. It involves implanting two electrodes in the brain that fire off 150 three-millivolt electrical impulses every second. This treatment allows patients to cut up to 70 percent of their drugs, and can largely compensate for the negative consequences of the disease. Now researchers at the Universities of Lausanne and Berlin have tested the procedure for the first-ever time on five patients suffering from severe depression. One of the patients thereafter underwent a major improvement.

Together with a team of neurosurgeons, the neurologist Bogdan Draganski from the University Hospital of Lausanne implanted the electrodes in a part of the brain called the subgenual grey matter. It is found in the frontal lobes and is known to be connected to depression. The neurosurgeon carrying out the procedure made an error with one patient, however. He placed her electrodes slightly too deep, meaning that they reached the gyrus rectus – an area about which we still know little.

It was this patient who experienced a dramatic improvement in her condition. "After the intervention, she had a feeling of lightness of being", says Draganski. The operation had been a last, desperate measure after many failed therapies. The result shows that the gyrus rectus could be a target for deep brain stimulation in the future. "Our work has been an accidental discovery. Now we have to carry out further tests to confirm the result", says Draganski. *Atlant Bieri*

E. A. Accolla et al.: Deep brain stimulation of the posterior gyrus rectus region for treatment resistant depression. Journal of Affective Disorders (2016)

Drone software, Swiss made

The PX4 operating system has been widely adopted by open source-based drones. Next step: incorporating vision.

Journalist: Daniel Saraga
Infografic: ikonaut

The brain
Developed at ETH Zurich, the open-source platform PX4 works like the operating system of a smartphone. It controls the propellers, feeds off information from the sensors and allows for the integration of additional modules. An autopilot enables the drone to reach a destination automatically or hover steadily on the spot.

The limbs
Apps can also be added – third-party software designed for a specific task. A 'follow-me' app developed in Latvia instructs the drone to hover at a certain distance above a GPS receiver worn by the user. This service was offered to skiers in Swiss resorts last winter. Other researchers have used PX4 to control juggling drones or vertical landing planes.

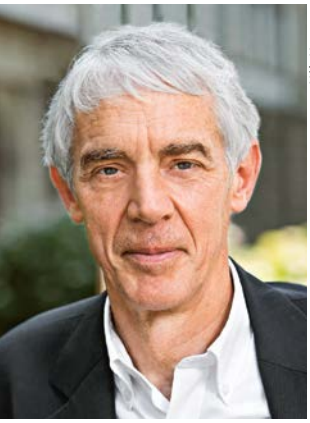
The ears
A drone uses a variety of devices to calculate its position and direction. The GPS gets signals from satellites; they are robust but not very precise or fast. The inertial sensors measure the accumulated movements after take-off. Laser or ultrasound altimeters give the elevation. In special indoor settings, fixed external infrared cameras triangulate the position of markers on the drone.

The eyes
Computer vision is not yet widely used on commercial drones. Aerial robots from labs at ETH Zurich were the first to fly using on-board cameras only. They can reconstruct the shape and dimensions of objects. "Vision allows the drone to recognise obstacles and avoid them. It's necessary for safety", says Lorenz Meier, a PhD student and the author of the PX4 operating system. "We will incorporate computer vision in 2016 by default in PX4-driven drones". He has also developed Pixhawk, a hardware autopilot running PX4.

Languages are a natural resource

By Martin Vetterli

Languages are useful when you have to make yourself understood. But they're a lot more than that. Languages – especially foreign languages – also serve as an archive of important information. This was the case in the Middle Ages, for example, when most Ancient Greek texts were unreadable and had to be retranslated into Latin from the Arabic at a time when Arabic scholarship was highly advanced.


Nik Hunger

But languages also expand the way we think. This is because certain concepts only occur in specific languages and can only be understood through them. A nice example is the German word *Weltanschauung*, which is written thus, even when it's being used in English. And it's also often the case that physical things only exist in our perception when they're given their own word in our own language. Here, I'm thinking of the many types of bird that European naturalists discovered and named in America in the 18th century (though the birds themselves naturally existed before the Europeans and had been given local names by the local population).

Neuroscientists tell us that mother tongues and foreign languages are not processed in the same regions of the brain. The brain treats early language acquisition in a manner different from learning a language later in life. So it's no surprise that children who grow up in a bilingual environment seem to be better able to understand foreign concepts, things and even people.

Switzerland possesses four official languages. They are joined here by many other languages such as English, Serbo-Croat and Portuguese. This country has a long tradition of dealing with different languages and has found an artful manner of doing so, even on the level of federal politics, where every politician speaks his or her own language. This cosmopolitan language policy has resulted in Switzerland producing many diplomats who are respected all over the world. Languages are a kind of natural resource in Switzerland. Other countries may laboriously try to construct themselves as rainbow nations, but the Swiss are already living it.

I am firmly convinced that Switzerland should use this unique fact as an opportunity. To be sure, learning several languages is not everyone's cup of tea. Furthermore, English is becoming increasingly dominant in the world of science. But the opportunity to learn several languages exists in our country, and we should further it via inter-cantonal exchange programmes (and, later on, through international exchanges). We should also make active use of the languages of immigrants that are spoken here. Switzerland should open itself up, because its wealth of languages makes it well-nigh predestined to engage with the diverse world of ideas and languages and thereby surprise us with new theories, innovations and technological progress. In other words: linguistic diversity is part of our national DNA. And, just like in biology, a diversity of ideas can in the long term enable our country to develop a higher degree of resilience.

Martin Vetterli is President of the National Research Council and a computer scientist at EPFL.

18 and 19 June 2016

Algae, fish and the physics of the lake

The Centre for Ecology, Evolution and Biogeochemistry looks back on 100 years of research into lakes
EAWAG Kastanienbaum, Lucerne

27 to 29 June 2016

Personalised medicine

At the Lastis Symposium, the opportunities and challenges of personalised medicine will be discussed
ETH Zurich

1 and 2 July 2016

Making digital heritage visible

At the second Swiss Open Cultural Hackathon, participants will be developing ideas for presenting cultural data in digital form
University Library, Basel

Until 14 August 2016

In the abyss of the sea

This exhibition brings the nocturnal life of the oceans to the surface
Museum of Natural History, Neuchâtel

Until 11 September 2016

The first animal encyclopaedia

To commemorate the 500th birthday of the polymath Conrad Gessner, the exhibition 'Animals from A to Z' is dedicated to his animal books
Zoological Museum, University of Zurich

22 and 23 September 2016

ScienceComm 2016

Swiss science communicators reflect on their relationship to politics and digitisation
Yverdon-les-Bains

Letter to the editor

International ethics
I was drawn to the subtitle "Liberties without ethical concerns" in the article on China (Beijing's research gambit, Horizons, March 2016, p. 20). What recommendations are given by the SNSF to researchers involved in joint work with China? How do you ensure that money from the SNSF is not funding projects that would not be authorised in Switzerland?

Marcel Gyger, President of the Vaud Animal Experimentation Commission

SNSF response: All research supported by the SNSF must meet Swiss ethical standards. This applies equally to experiments conducted abroad. The researcher concerned must obtain a certificate from the relevant authority in Switzerland – such as an ethics commission or an animal experimentation commission – stating that the planned experiments comply with Swiss legislation.

Some doubt
Not only is there no credibility to the position expressed by Jose Tarazona of the European Food Safety Authority (EFSA) on the toxicity of glyphosate (Horizons March 2016, p. 9), but it also raises doubt about the seriousness of work at EFSA. Just as with tobacco and diesel, it seems scientists are protecting the interests of the planet's major polluters through a lack of curiosity and with a calm reassurance.

Jean-Pierre Papis, Geneva

Martin Vetterli steps down

Martin Vetterli, the President of the National Research Council of the SNSF, will step down after finishing his four-year mandate at the end of 2016 to become the President of EPFL. A nomination commission led by Gabriele Gendotti will be in charge of appointing his successor.

English specialist awarded the Marie Heim-Vögtlin Prize


SNSF/Mauro Mellone

The literary scholar Zoë Lehmann Imfeld is being awarded this year's Marie Heim-Vögtlin Prize for her exceptional doctoral thesis. She is a postdoc at the University of Bern and her interdisciplinary work, taking in English literature, theology and philosophy, has made a big impact. Family commitments have occasionally compelled her to reduce her scholarly activities. The Prize will be awarded on 21 June 2016.

Concerns about federal cuts

The cuts announced in research funding in the Dispatch on the Promotion of Education, Research and Innovation (ERI) 2017–2020 are worrying higher education and research institutions, including the SNSF. While the Federal Council has confirmed core projects, it also sets out an intention to allocate a significantly lower amount to the ERI sector. In a joint statement, the institutions have expressed their fear that the budget cuts will jeopardise Switzerland's leading position in education, research and innovation.

New NRP approved: 'Sustainable economy'

The SNSF has been mandated by the Federal Council to conduct the National Research Programme 'Sustainable economy: resource-friendly, future-oriented, innovative' (NRP 73). Its aim is to contribute to a more sustainable economy in which resources are used more efficiently and supply is more reliable. The budget for the five-year programme is CHF 20 million. A call for proposals will be launched in June 2016.

Only few women scientists make a career for themselves

Although more women than men study at Swiss universities, the proportion of women in professorships is just under 20 percent. The Swiss Academies have been investigating the reasons behind this. They have now presented their findings on the career situations of young women scientists in the report 'Einschätzung der Karrieresituation von Nachwuchswissenschaftlerinnen in der Schweiz'. It offers concrete recommendations as to how gender-equitable academic career paths ought to be constructed, such as by having mixed teams, transparent appointment procedures and flexible working-time models.

The energy revolution makes you healthy

The energy revolution isn't just good for the environment. It can also improve your health. These are the words of the Swiss Academies of Arts and Sciences in a new fact sheet 'Energiewende und Gesundheit'. For example, there is less air pollution due to traffic and heating. Conversely, the energy revolution also brings certain health risks with it. Wood burning furnaces can send a lot of fine dust into the atmosphere. The report notes that realising the energy revolution always has to take health issues into consideration.


Valérie Chételat

Bulgaria and Romania: 39 completed projects

Over CHF 14 million were awarded to new EU member states under an EU enlargement contribution programme set up by SECO and the SDC. This money contributed to research on cancer, solar cells, river pollution, inter-ethnic relations and education policy. Joint projects were conducted between Swiss, Bulgarian and Romanian teams between 2012 and 2016.

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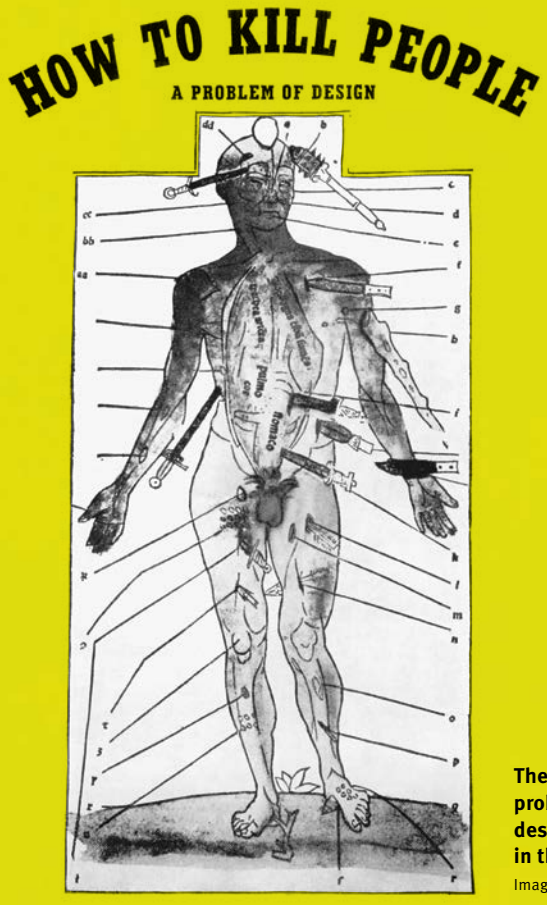
The SNSF
The SNSF is the principal body for the promotion of scientific research in Switzerland. It is mandated by the Confederation to promote basic research in all fields and disciplines and each year distributes some 755 million Swiss francs amongst more than 3,500 projects involving about 8,750 scholars.

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.

“I think I’m just very efficient”.
Sabine Huebner page 32



“The tunnel isn’t a place for fooling around”.
Peter Guntli page 38

The designer’s dual-use problem: even an object designed for everyday use in the kitchen can kill.
Image: Vitra Design Museum

“It’s about a lot more than morphine and holding hands”.
Gian Domenico Borasio page 44