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Who are the best pacemakers?

There's no secrecy surrounding science's handicaps. The system encourages researchers to conduct myriad studies - swiftly and simultaneously - but not to verify the work of others; to stock-pile ideas and techniques so as to be the first published but not to disclose inconclusive results; and to overlook one's errors but not to point out minor deviations from guidelines.

The open science movement aims to resolve these issues by allowing access to publications, results, raw data, lab books, methods and instruments. It aims to involve everyone: researchers, enthusiasts, manufacturers and activists. Most of the necessary tools are even already there online, it's just behavioural change that's lagging. While the Internet has changed the face of employment, trade, music and travel, science sits stolidly. Ironically, it was the desire to share CERN's particle-accelerator results that led to the development of the world wide web. Yet three decades later, this landmark example of open data remains the exception not the rule.

In spite of its freedom, science grows slowly. The economist Sascha Friesike points not only to its decentralised structure but also to the absence of a real market for discoveries. Value is set internally by eminent parties whose interests are vested in the status quo. Companies, on the other hand, are true independent actors. They can overhaul practices and invest in new technology at the drop of a hat, and indeed must, if they are to keep up with the whims of their clients.

The public and forward-looking side to science shouldn't be overlooked, however. This is the role of academia. Yet, wasn't it researchers from the pharmaceutical company Amgen who renewed the debate on reproducibility in 2014 after unsuccessfully attempting to verify published results? And didn't the private foundation Wellcome Trust set up its own journal to ensure that the results of the studies it finances are accessible? From that perspective, shouldn't it be the private sector that marks the pace for academics: in terms not of long-term vision but of quickly achieving reliable results and meeting mutable needs?



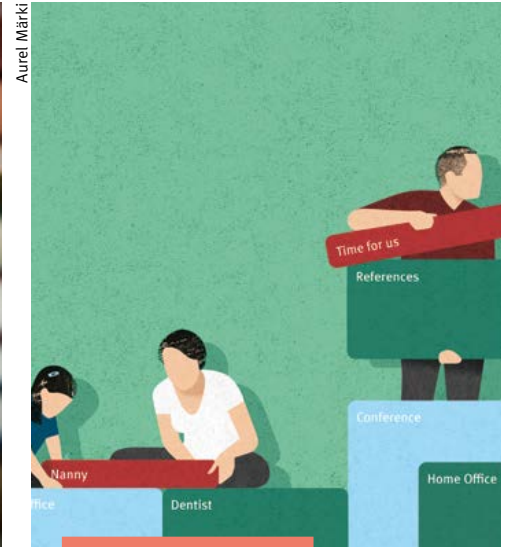
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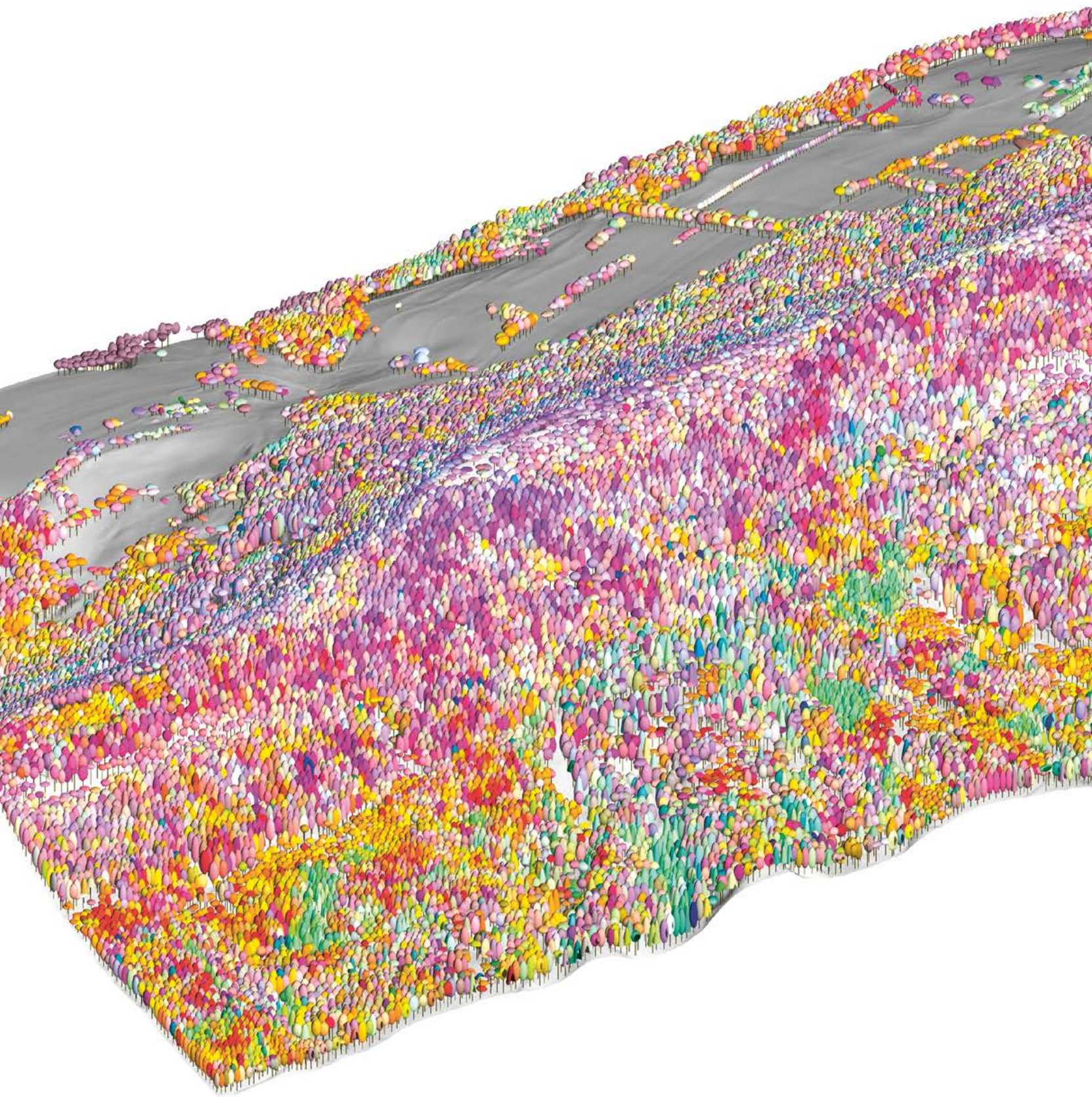
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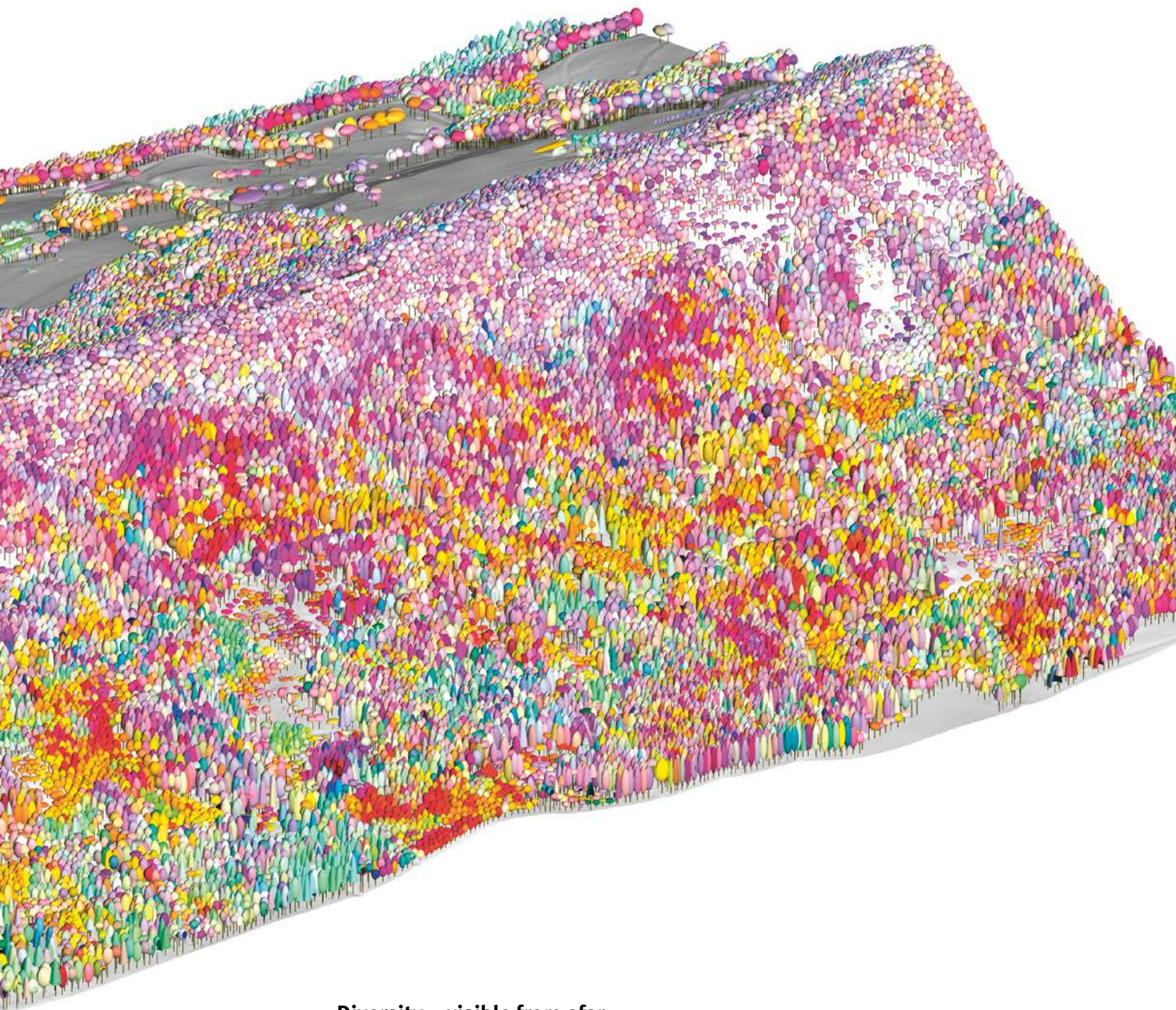
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Diversity – visible from afar

What looks at first like an abstract pointillist painting in fact shows the forest in Lägern near Baden, comprising 44,000 treetops. This picture illustrates the relatively high degree of diversity of biological activity in this area in July 2015. The rose-red dots, for example, signify trees with a high chlorophyll content. A team from the University of Zurich, led by the geographer Michael Schaeppman, is using two highly sensitive measuring devices in an aircraft to measure the diversity of the vegetation.

A laser scanner (lidar) scans the surface and determines the height,

density and form of all the trees in this area of 1.5 × 3 kilometres. An imaging spectrometer – rather like a camera – measures visible and invisible colours on 500 different channels at the same time. In this manner, for every two-metre-long image element, the researchers are able to investigate the trees' content of chlorophyll and 15 further substances such as cellulose, water and nitrogen.

In total, six people have been working on this for three years, bringing datasets together and comparing them with information gathered on the ground. Lägern is

one of the test areas where highly precise methods for remote sensing are being developed. They will then be applied over larger areas in order to monitor changes in biodiversity systematically. "It means we are in a position to measure the diversity of biological functions to a very precise degree", says Schaeppman. They are planning to expand their project to cover grasslands, the rain forests and arctic tundra. "Our distant goal is to equip satellites with measuring devices". *ff*

Image: UZH: Fabian Schneider, Reik Leiterer, Felix Morsdorf, Michael Schaeppman

Are generalist universities still relevant today?

With the exception of ETH Zurich and EPFL, most Swiss universities offer the full spectrum of arts and sciences. Do they have a future?

Valérie Chételat (photomontage)



Yes, says Astrid Epiney, the Rector of the University of Fribourg

The generalist university is neither obsolete, unnecessary nor inefficient. In fact, it fulfils a very specific role as the cantonal university in the Swiss tertiary education system. On the one hand it makes a contribution to educating future academics, but on the other hand it also helps to promote scholarly engagement with the great societal questions. Thus the universities allow students to acquire a broad spectrum of both general and specialised knowledge in all fields, with due regard to appropriate methods and scientific practice in each case, while still maintaining the unity of teaching and research.

Generalist universities promote the development of independent, critical thought, which in turn enables us to delve deeper into abstract issues and to further the emergence of new knowledge. They also make a contribution to professional and scientific activity. This all implies a degree of collaboration in teaching and research that stretches across the disciplines. Ultimately, it's about ensuring that both teachers and students cultivate more than just their own, more or less narrow branch of scholarship. Instead, they can appreciate the perspectives offered by other sciences, and engage with different approaches.

In this manner, the truly significant challenges that we face today - whether migration, digitisation or climate change - can be analysed with input from different fields of scholarship. And we hope that this will help us to find solutions to them.

“The concept of the generalist university is more relevant than ever today”.

Astrid Epiney

The task of the university in this regard is twofold: to nurture interdisciplinary relationships (at the very least, an awareness of that should be encouraged among the students); and to promote interdisciplinary collaboration in research. The generalist university creates the best conditions for training young, talented minds for business, science and society - producing people who are not just specialists but who have a multidisciplinary perspective when they approach their given tasks. This does not mean, however, that a university should not set particular emphases to com-

plement the activities of other universities. And quite apart from this, there is no empirical evidence that 'specialised' universities produce fundamentally better 'results'.

The concept of the generalist university is more relevant than ever today. Our prime task should be to use to the full the opportunities offered by the generalist university, and thereby enable it to play its role in the service of society to the best of its ability.

Astrid Epiney is the Rector of the University of Fribourg and a professor of European and international law.



No, says Patrik Schellenbauer
of Avenir Suisse

In the global context, Switzerland is a small, economically very successful country. It also owes this prosperity to the fact that it is an extraordinarily successful centre of knowledge and research, when we take its size into consideration. Some of our universities achieve exceptional results that have a worldwide impact. Switzerland's workplaces, its export industry, its financial centre and its service industries are all dependent on cross-fertilisation with its knowledge centres and the ideas they generate.

“Switzerland should see itself as a single, national tertiary education area”.

Patrik Schellenbauer

But there is no guarantee of future success. Global competition is increasing as the most sought-after minds become increasingly mobile. In many fields, cutting-edge research is becoming more demanding and more expensive, and the critical mass of resources needed is getting

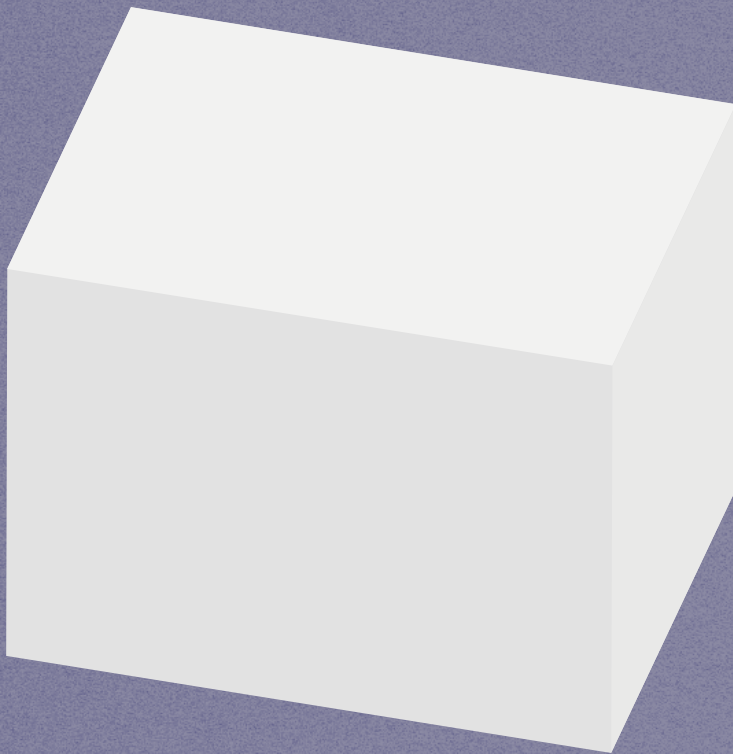
bigger. At the same time, the money being spent on education and research is in competition with other state expenditure. If Switzerland wants to maintain its position or expand it, then it has to bundle the resources of its knowledge base more than has been the case until now.

The contrast to the reality of Swiss university policy is stark. Here, it's not efficiency or excellence that is the prime concern, but all too often a mesh-work of regional political concerns. Instead of asking whether Switzerland really needs seven faculties of the human sciences or another business school, energies are being invested in getting the biggest possible slice of the public cake for education, and then distributing it among the players involved. Universities are seen as a kind of 'public service' that should maintain the broadest possible spectrum of educational offerings all over the country. The Federal Act for the Support and Coordination of Higher Education Institutions is an expression of this federalist, corporatist premise that affords the distribution of monies greater importance than efficiency.

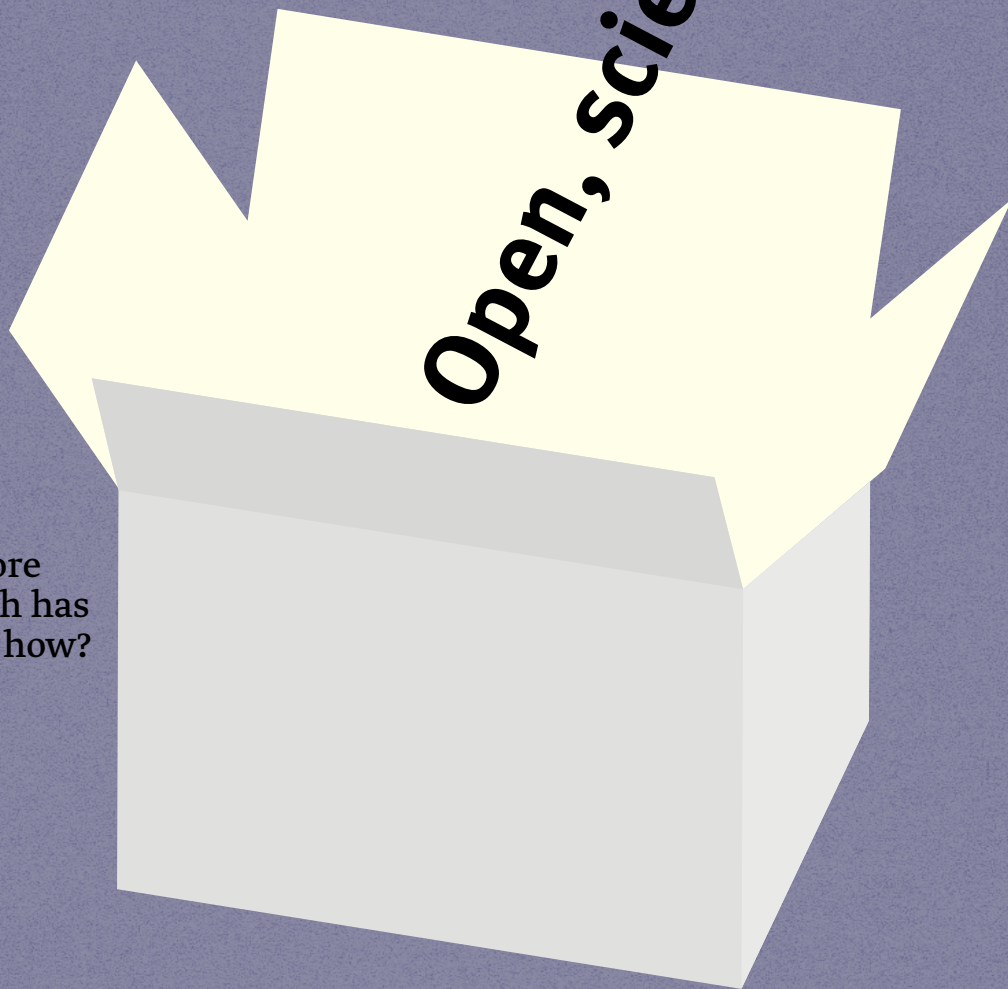
Switzerland should rather see itself as a single, national tertiary education area that plays a part in the global concert of

knowledge centres. We don't need some bureaucratic master plan that assigns different roles to different universities, but more freedom of design for individual institutions. To this end, they should be removed as far as possible from political influence. One possible way of depoliticising the debate would be to move from today's model of provider-financing to one of user-financing. This could be done via a state-financed education account from which students pay for their studies. This would create competition and force the universities to contemplate which courses they want to offer themselves, and which should be offered in collaboration with other institutions. The result would be more specialisation, and we would achieve the greater concentration of resources that is necessary today. Perhaps generalist universities would continue to exist, because the breadth of disciplines they offer naturally has a value of its own. But if not, it wouldn't be a misfortune for the students, because the Swiss university towns are all within commuting distance.

Patrik Schellenbauer is Deputy Director of Avenir Suisse and its Chief Economist.



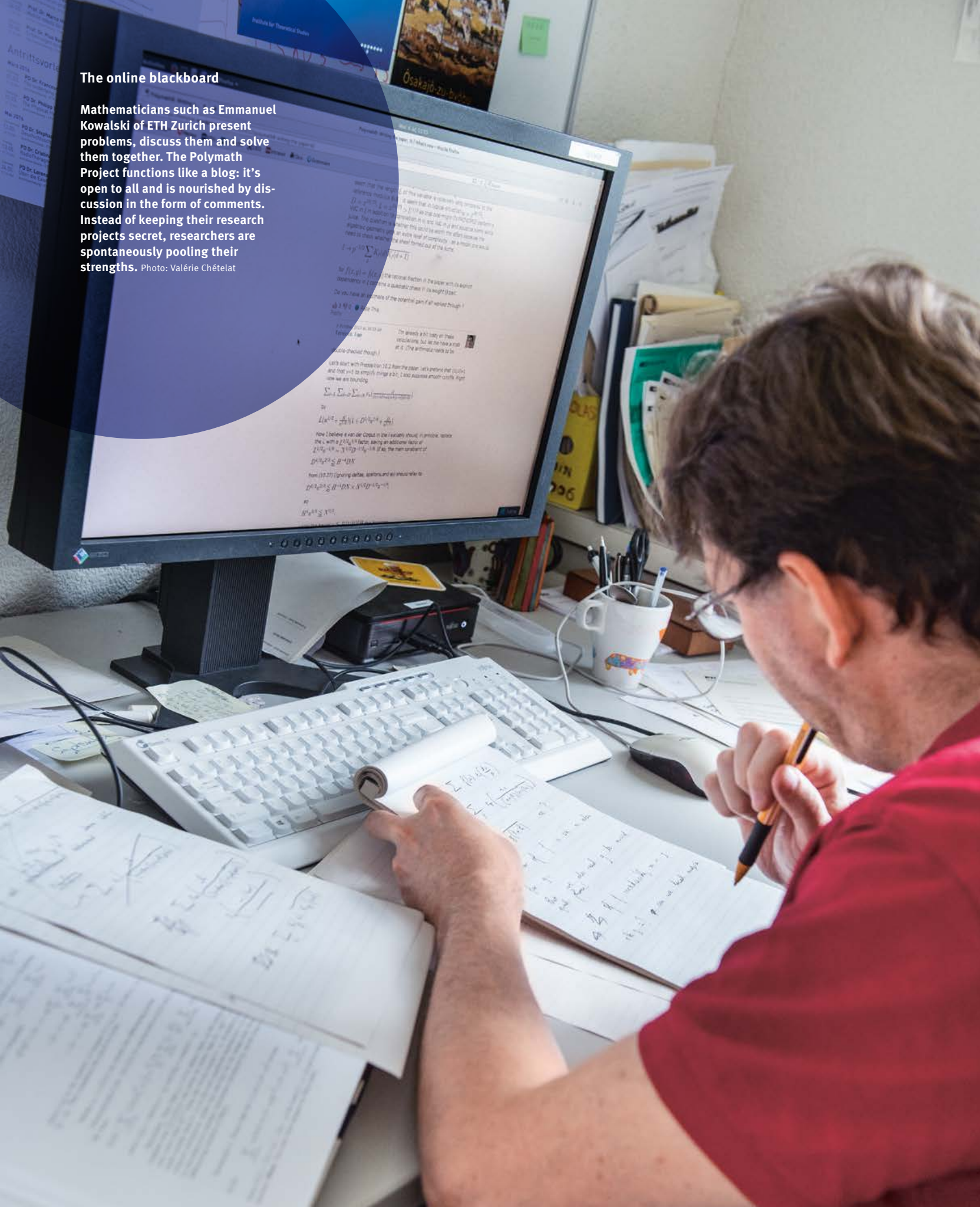
Open, science!



More transparent, more collaborative: research has to reinvent itself. But how?

The online blackboard

Mathematicians such as Emmanuel Kowalski of ETH Zurich present problems, discuss them and solve them together. The Polymath Project functions like a blog: it's open to all and is nourished by discussion in the form of comments. Instead of keeping their research projects secret, researchers are spontaneously pooling their strengths. Photo: Valérie Chételat



Unleashing science

The open science movement is encouraging researchers to redouble their efforts to share results and data. Its aim is to make science more effective, useful and reliable.

By *Daniel Saraga*

Research creates its own problems. Articles may be withdrawn because of irregularities, results can be impossible to reproduce, methods are often non-standardised, and publications may not be accessible (See 'Fixing science', *Horizons* September 2015). The search is now on for solutions.

Many observers consider that overcoming these issues will require a new paradigm: open science. The idea is to break the shackles that fetter the individual elements of the scientific production process - from the formation of hypotheses to the publication of results (See infographic, 'The elements of open science', p. 13). The watchwords are: sharing and inclusion, collaboration and decentralisation, and transparency. By fully opening research work, it can be made useful to everyone: to scientists, industry, and members of civil society. Even computer programs will be able to draw new conclusions from old results.

Knowledge for everyone

The first pillar is open access, the aim of which is to ensure all scientific publications are accessible free of charge. "Even if people are a little impatient, we are clearly on the right track", says Daniël Lakens, a psychology researcher and practitioner of open science at Eindhoven University of Technology. According to a European study published in 2014, more than half of all the articles published since 2007 are open access. Nevertheless, the question of cost remains: even if an open-access journal can be consulted free of charge, the average cost of publishing each article is EUR 3,000. Also to be factored in are prepublication archives, such as Arxiv and SSRN, that offer free access to manuscripts submitted to journals. Tariffs for publishing articles are continually increasing, and this is a bone

of contention. Science publishing has to react, as it is now also confronted by piracy: some websites make millions of articles available, and not all of them illegally.

"Open data today has only a minimal impact on a researcher's reputation".

Sascha Friesike

The second pillar, open research data, involves a radical change in the attitude of scientists with regard to their raw data. "Most of them consider that it belongs to them", says Lakens. Their work revolves around the interpretation of their results and the formulation of clear and concise conclusions, not around the disclosure of primary data. This approach renders it impossible to make comparisons or to question their choice of interpretation, such as the type of statistical analysis employed. "For me, publication bias - that is, the general practice of only publishing positive results - is the biggest problem in today's science. Fixing it will require access to all data, particularly those not included in a publication", says Lakens.

Creating interest

For most scientists, there is no individual or direct interest in sharing raw data, particularly in light of the burdens of time, cost and, in some cases, the development of computer skills. Open research data therefore often continues to rely on individual initiative or top-down provisos of certain research programmes. "What's needed is new incentives, because open data today has only a minimal impact on a researcher's reputation", says Sascha Friesike of the

Alexander von Humboldt Institute for Internet and Society (HIIG) in Berlin and a former doctoral student in the management of innovation at the University of St.Gallen. Things are changing, however, "particularly because a number of public and private financing bodies are introducing a requirement to share the data stemming from the research they pay for", she adds.

Greater transparency

Data is not enough on its own, however; there also needs to be precise disclosure of the methodology used in acquiring it, such as laboratory methods or adjustments made to instrumentation. Only then will it be possible for other research groups to reproduce the results and subsequently either validate or refute them.

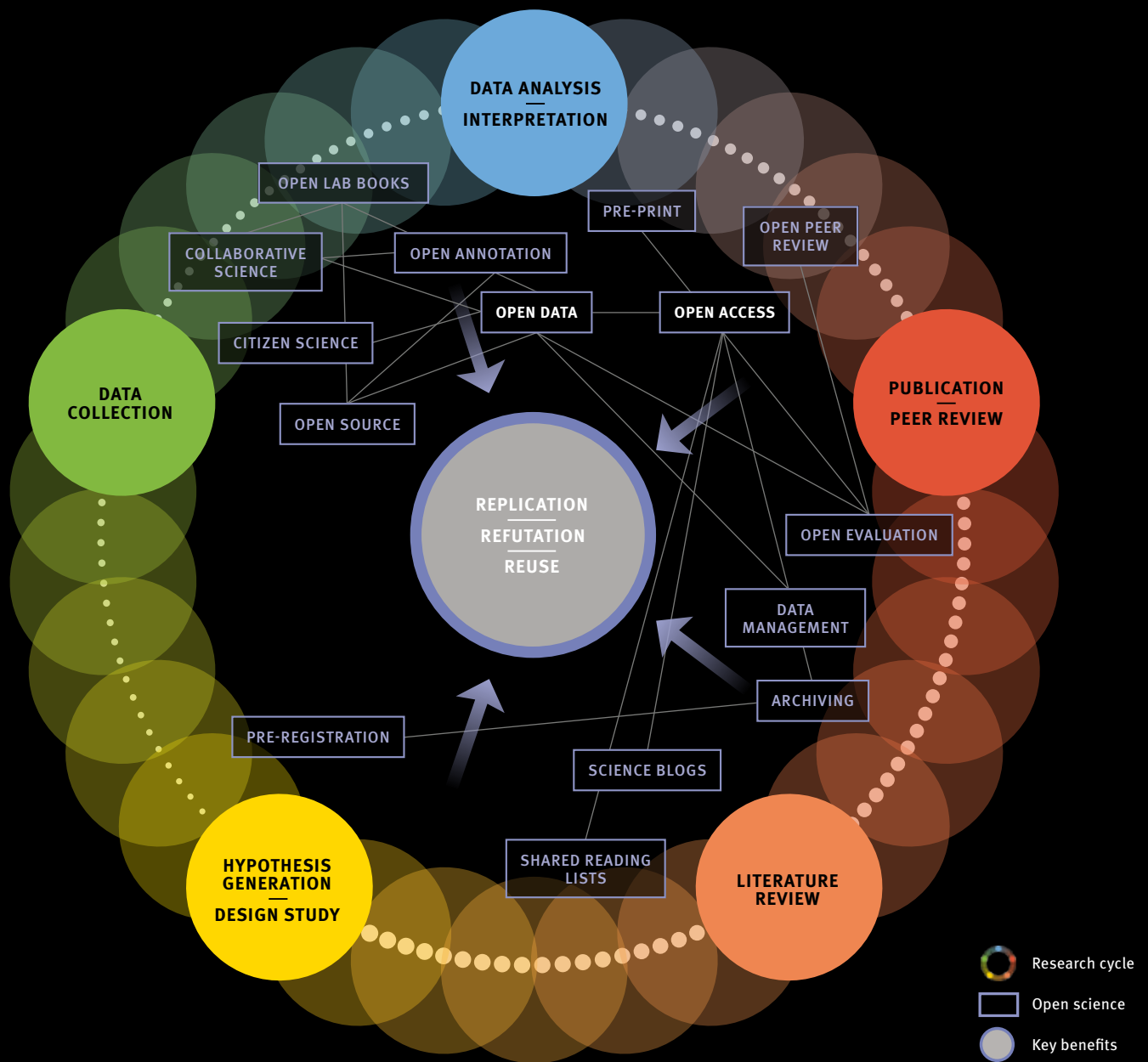
The open-science movement aspires to a world where researchers resolve their problems in concert with each other and keep lab notebooks available to everybody on the Internet. "Science is tackling problems that are becoming increasingly complex and that therefore need greater collaboration", says Friesike. "Instead of meeting the often rigid requirements of research programmes, researchers should be more interested in organising themselves by launching calls to collaboration that are open to everyone. This would also up the pressure to share data, methods and facilities - without that there is hardly any incentive for others to join a project".

Daniel Saraga is the chief editor of *Horizons*.

B. Fecher and S. Friesike: Open Science: One Term, Five Schools of Thought (2013); [dx.doi.org/10.2139/ssrn.2272036](https://doi.org/10.2139/ssrn.2272036)

The elements of open science

This grassroots movement has created a plethora of new concepts. Here's an overview.



Open science glossary

Archiving ▶ Long-term storage of research results
Citizen science ▶ Research conducted by non-scientists
Data management ▶ Long-term maintenance of research databases
Shared reading lists ▶ Putting your personal literature lists on open online access
Collaborative science ▶ Solving problems together, e.g. on a blog
Open access ▶ Free access to scientific articles
Open comment ▶ Research data (genomics, editions etc.) are commented on and supplemented

Open data ▶ Raw research data placed on open access to other researchers
Open evaluation ▶ Public online evaluation of a published article
Open lab books ▶ Lab notebooks placed online and discussed in public
Open peer review ▶ Public, non-anonymous peer review of an article before publication, or as part of an evaluation
Open science ▶ Open, transparent and collaborative science
Open source ▶ Software and hardware that can be used and developed freely
Pre-registration ▶ Announcing a research plan in advance, in order to exclude the

possibility of a-posteriori modifications
Replication ▶ Reproducing and validating earlier research results
Pre-print ▶ Manuscripts made generally available before official publication
Science blogs ▶ Critical discussions of research results by scientists and journalists
Reuse ▶ Getting new knowledge from existing research data.
Refutation ▶ Unsuccessful attempts to reproduce earlier research results

Tools:

- List of tools: bit.ly/Ho_tools, bit.ly/Ho_tools2
- Research workflow: osf.io
- Lab books: labguru.org; openwetware.org
- Annotation: t-pen.org (historical texts) opencontext.org (archaeological artefacts), hypothes.is (web pages)
- Research data repositories: re3data.org (list), datadryad.org, openresearchdata.ch; ckan.org (data management tool)
- Other repositories: [figshare](http://figshare.com) (data, figures and misc.), [github](http://github.com) (software and notes), [zenodo](http://zenodo.org) (misc.)
- Pre-print archives: arxiv.org, biorxiv.org, SSRN.org, [PeerJ Preprints](http://PeerJ.com)
- Open evaluation: [thinklab](http://thinklab.org) (proposals), [ACPDiscussion](http://ACPDiscussion.org) (articles), [F1000](http://F1000.com) (recommendations), [PubPeer](http://PubPeer.com) (comments)

The see-through scientists

It's in laboratories and out in the field that the shape of future science is being decided. Here are four portraits of researchers who campaign for open science – each after his or her own fashion.

By Roland Fischer. Illustrations: Karoline Schreiber

Transparency is his ideology

Malte Elson is a young psychologist whose specialist field is aggression and computer games. He understands open science as “the maximum of transparency in scientific work – in all areas”. The idea has been about for a long time, he says. But now a new generation is emerging that would like “to make accessibility accessible”, and is creating the necessary structures to ensure that open science doesn't remain an empty promise. Elson sees himself as part of this new movement: “It's not just ideological, it's technological”. He has launched two websites himself: journalreviewer.org, a collection of progress reports on review procedures, and flexiblemeasures.com, where aggression measurements made by other researchers are painstakingly investigated, and where the lack of standardisation is subjected to critical attention.

Most of all, Elson uses the Open Science Framework, which allows the research process to be documented entirely, “from the initial idea up to publication”. This massively increases the degree of transparency of the whole process, also for the researcher himself. Even years later, he can retrace exactly what he did: “Furthermore, this highly reflective manner of research prevents you from deceiving yourself”.



Opening up the laboratory diary to everyone

At the Open Source Malaria Project, the Internet is more or less a guiding principle – in its network design, its open flow of information and its renegotiation of the public and the private. “Whoever invests the most work in the project becomes the project leader, regardless of where they might be in the world”, says the biochemist Alice Williamson, who launched this initiative to develop a new malaria drug. She works in Sydney, but researchers from all over the world are involved in the project, including a software specialist from EPFL.

All the research data is made publicly accessible straight away. Even the communication between the researchers takes place “as little as possible by e-mail”, but preferably on websites such as GitHub or via Twitter. In this way, says Williamson, their research can become both more transparent and more efficient. It's “a terrible waste of research money” when different laboratories research into the same substances, and everyone lands in the same dead-end. She regularly organises workshops on keeping open laboratory diaries, and she has noticed that it's perfectly normal for young researchers to share both their successes and their experimental wrong turns – just like they do in their private lives.



Seminars in an online forum

The deep learning community is using online forums to test how to discuss research ideas and procedures. Initially, the content is made accessible in the simplest possible way: “The tendency is towards publishing everything on the pre-print server Arxiv”, says Oliver Dürr, a professor at the Zurich University of Applied Sciences (ZHAW). The code is usually published at the same time. Arxiv also serves as a source of links offering access to a host of other discussion forums.

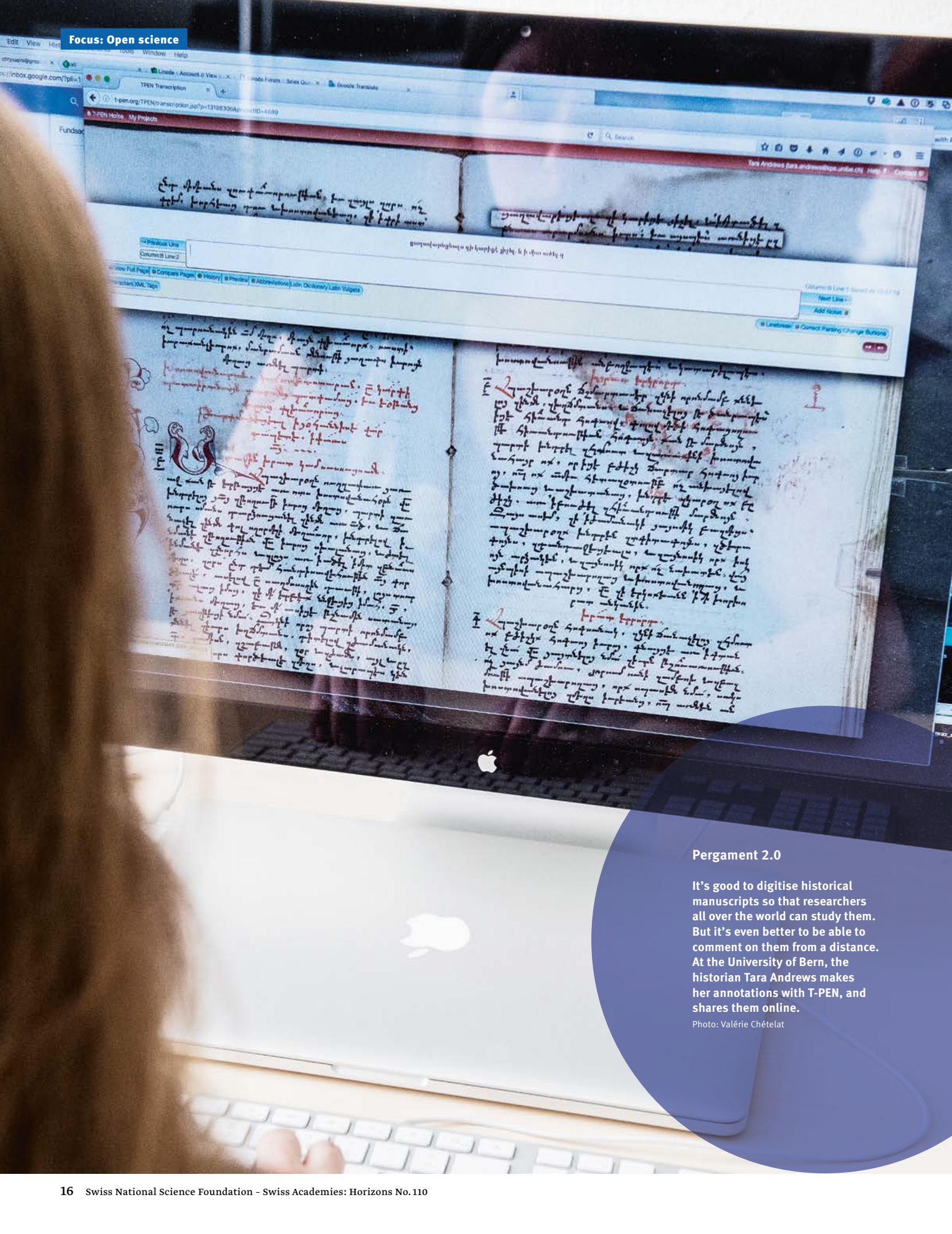
According to Dürr, Reddit is very popular. Here, specialised sub-forums provide links to articles and offer commentaries on them. And in the ‘Ask Me Anything’ forum there are regular ‘question times’ with highly renowned researchers. Peers submit questions that are then evaluated thoroughly. Dürr also likes to read blogs about research into artificial intelligence. His own blog serves more as a diary to record his ideas. Some blogs get more attention, like that of Andrej Karpathy. Its long entries are similar to reviews, and the commentary column is full of questions and suggestions. In this manner, new discussion groups are constantly being formed. In principle, everyone has access to them, regardless of whether or not they actually have a university training.

Breaking down walls between academia and industry

At EPFL, the robotics researcher Francesco Mondada builds his own laboratory equipment, using Computer Aided Design (CAD) software for his components. He would like to put his construction plans on open access to everyone – it would be the most natural thing in the world to him. But he’s trapped by the fine print. There are special CAD software licences for educational institutions, more expensive licences for industry, are different data formats according to the licence in question. Then there’s a whole mess of regulations that you have to accept when you buy the software, and these were never intended to promote the open dissemination of data. It’s as if a novelist had to ask Microsoft for permission to publish, just because he’d used Word to write his book.

Mondada doesn’t believe that robotics is an unusual case: “Even biologists are starting to use 3D printers in their laboratories, and they need specialised software”. He’s been campaigning for simpler regulations for years. “But there’s a clash between two ideas of what a university should be about”, he says. The old model means assessing the transfer from academia to industry on a case-by-case basis; but the new, more open model favours a simple, unbureaucratic exchange – not just among academics, but also with industry.





Pergament 2.0

It's good to digitise historical manuscripts so that researchers all over the world can study them. But it's even better to be able to comment on them from a distance. At the University of Bern, the historian Tara Andrews makes her annotations with T-PEN, and shares them online.

Photo: Valérie Chételat

The long march to open science

Many researchers are positive about the new, burgeoning science culture, but they still hesitate to enter into an open exchange of knowledge. There are many reasons why - such as a lack of knowledge about data management and the fear of intellectual property theft.

By *Sven Titz*

Scientists disclose all their study plans and experimental designs; they write daily blogs about their progress in the lab, revealing every detail; and then they publish in open-access journals that are assessed through an open peer-review process. And their results are stored in databases that are on open access to everyone.

This is the utopia of open science.

Are we about to attain such a state of transparent research? Well, things are unlikely to develop quite so straightforwardly. Sometimes it's because there's just not enough money. Sometimes people aren't in a position to set up the required databases. And sometimes scientists hesitate to reveal their data because they fear that competitors could steal their ideas and publish them first.

Tougher than expected

The successes achieved by Big Science in laying open research data are deceptive - whether at the nuclear research centre CERN or in genetics research. In many fields outside the big projects, there are still major obstacles to progress. It's easy to insist that data should be made freely available. But individual researchers who have neither the means nor the expertise can be driven to despair over it. And because individuals and small research groups find it difficult to place their data on open access, it means other scientists find it difficult to use that data. "Many researchers lack the time and the knowledge they need to be able to document their data adequately and make it available", says Benedikt Fecher. He is currently doing his doctorate at the Ger-

man Institute for Economic Research and the Alexander von Humboldt Institute for Internet and Society in Berlin, and he has been investigating researchers' attitudes to open science.

In the USA and Europe, the research funding organisations have proclaimed their support for data disclosure. But this isn't enough to enforce the standards of open science. Researchers also need organisational, financial and personnel support. This is just what is offered by the Swiss Centre of Expertise in the Social Sciences (FORS), for example. It helps with processing, documenting and storing research data in the social sciences, and provides the necessary infrastructure for it. Researchers can attend workshops to gain further skills and get access to online tools for data management, for instance.

"Many researchers don't realise that their data can have an existence after their own work is completed".

Alexandra Stam

Open data is already established in the natural sciences, but the social sciences are still shy about the concept. This is partly because they usually work with personal data that is subject to data-protection laws. But this isn't the only reason. According to Alexandra Stam, the head of the Data Promotion group at FORS, one of the problems is that social scientists are in general not

used to documenting their data in a standardised fashion. "Many researchers don't realise that their data can have an existence after their own work is completed". This means that much potentially valuable data and many important details are lost unnecessarily.

This predicament is in part a result of how people are trained today. Data management isn't taught formally as part of degree courses, says Stam. And often, researchers simply fail to document their data during their project, but instead only start the documentation process when it's nearing completion.

In some countries, such as the USA and the UK, a data management plan often has to be provided when an application for research funding is submitted. In Switzerland, this is not yet the case. Stam hopes that it will happen soon. Furthermore, it's essential that data should be stored in permanent databases after it's been documented and placed on open access. Otherwise, the issue of data maintenance can be left up in the air after the end of a project.

In principle yes, but ...

We still can't be overly optimistic about the prospects for open data - despite institutional assistance such as that offered by FORS. Even when researchers aren't left to cope on their own, many still hesitate to reveal their data. In his survey, Fecher has discerned a discrepancy between a generally positive attitude to open science on the part of researchers, and their personal hesitance to reveal their own data.

Often, the fear of intellectual property theft is what holds researchers back. This

“Many researchers lack the time and the knowledge they need to document their data adequately and make it available”.

Benedikt Fecher

risk might be heavily overstated, but it can't be denied that there have indeed been such cases. The genetics researcher Titus Brown at the University of California in Davis reports that competitors once used his data for their own articles after he had placed it on open access - articles he could have written himself. Nevertheless, he remains an advocate of open science. Brown is convinced that it's of use to research.

Naturally there are also other reasons for this hesitation. People might be in favour of transparency, but it can still be held back by certain established rights. In empirical medical research, for example, it is still the custom today - however antiquated it might seem - for the author of data to be listed as the co-author of any new studies based on it, says Fecher.

Few incentives

Many observers complain that there is a general lack of incentives to disclose data. Today, researchers are measured by the quality and quantity of their publications. But there is no similar academic recognition for datasets. “Researchers would welcome it”, says Fecher. Stam also believes that such an incentive would be significant. “It's important that people recognise the usefulness of good data management for their own research - above and beyond the act of sharing data”.

Nevertheless, in recent years, many so-called data journals have emerged that place their main focus on publishing new datasets. The best known of these is probably ‘Scientific Data’ from the Nature publishing group. But archaeology, the geosciences, chemistry and other branch-

es of science have also seen the emergence of subject-specific data journals. These specialised media will fill the gap until the day when research data is given formal recognition.

The frivolous candour of notebooks

When it comes to revealing the research process itself, things are a little different. Such as in ‘open lab notebooks’. The ecology researcher Carl Boettiger of the University of California, Berkeley, began putting his research notes online when he was still a doctoral student. As he admits today, he was simply lucky: he went about it quite naively, and none of his bosses took umbrage at his notebook. But this isn't usually the case. Some young researchers irritate their colleagues by being a bit too candid about what they put on open online access. In some cases, they can even damage their careers.

“For drones, the open-source solutions are even better than military software”.

Lorenz Meier

Boettiger uses his notebook primarily as an aide-memoire and to exchange information with colleagues, whom he can refer directly to specific content. Now and then, his co-authors of articles ask him to hold back sensitive information, he says. But otherwise, he always writes up everything straight away. None of his ideas have as yet

been stolen from his open notebook. Along with the assorted vague worries that exist about open science, there is, however, a real problem with open lab notebooks: they can eat up too much time. According to Boettiger, you have to familiarise yourself with special programs, depending on your degree of IT knowledge. Because he is overall keen to simplify open science in all its facets, Boettiger founded the project ‘rOpenSci’ a few years ago. It's a platform that offers software for processing and disclosing scientific data, and which is also useful for keeping lab notebooks.

Companies holding back hardware

Naturally, open science isn't confined to data and communication. In open-source projects, hardware and software are also transparent. Circuit diagrams and construction plans are placed on open access - just like the source code of open-source software, explains Lorenz Meier, a doctoral student at the Institute for Visual Computing at ETH Zurich. Meier has worked on several projects together with outside companies. He was usually able to insist on working with open hardware and software. In the case of open-source software, that also meant companies were often prepared to pass on the improvements made during the course of a project.

Together with his colleagues, for example, Meier developed the autopilot software ‘PX4’ that allows you to control drones and miniature airplanes. The software and the instructions for the hardware are offered as free downloads. Nothing else would make any sense, says Meier. “For drones,

From the lab bench to the world

Experiments, successes and failures – biologists store all their observations on either paper or computers. The researchers of the international Open Source Malaria Project go one step further and open up their lab journals online to everyone – as does Volker Heussler of the University of Bern. This is the best way to document progress and to prevent other scientists from repeating the same mistakes.

Photo: Valérie Chételat



“It’s important that people recognise the usefulness of good data management for their own research – above and beyond the act of sharing data”.

Alexandra Stam

the open-source solutions are even better than military software”. No longer is any company in a position to prevent the new development of better software.

Meier thinks that his collaborations with companies work well – though not always right from the outset. In his experience, companies tend to block open access when problems occur – for example, if they feel that their business model is under threat. In order to dispel such resistance, you have to explain where a company can actually make money from a project. And it’s rarely the construction plans or the software that bring in income. Instead, it comes from marketing the company’s expertise and services.

Oliver Gassmann works at the Institute of Technology Management at the University of St. Gallen. He confirms that models such as Linux, where the source code is openly accessible and enjoys no protection, have proven themselves in the marketplace. Companies have recognised their advantages to the extent that they sometimes even donate patents to the open-source movement. “That means new standards prevail much quicker than they would with protected solutions”, says Gassmann. In such cases, the company’s task is to seek added value elsewhere.

Basically, Gassmann finds that the cooperation between research institutes and private companies is a positive thing. The companies get access to fundamental knowledge, and the researchers get additional funding. Open science could cause conflict, however, if the researchers were to publish so early that they reveal the current state of the technology while a patent

application is still being processed. But this is a fundamental problem that also occurs in classical collaborations between universities and business partners, says Gassmann. With open science, the problem is simply exacerbated.

The problem of the private sphere

This call for transparency can be pushed too far, however, if open information is misused in order to damage the reputation of scientists. Climate researchers – especially those in the English-speaking world – can testify to the frustrating impact of data disclosure such as is allowed by the 1967 US Freedom of Information Act. Often, such information has subsequently been used to disparage mainstream climate research. Michael Mann of Pennsylvania State University is probably the most prominent victim of such activities.

So it’s not so easy to decide just how far researchers should go in disclosing their work. The pressure to be overly transparent can also lead to unwanted results. Self-censorship, for example, can lead to conformist behaviour. And that in turn would be counterproductive to open science’s hopes for success.

When the rights of third parties are involved, the private sphere can become a minefield for open science – such as when patient data from clinical or genetic studies is made accessible to third-party medics. The consequences can be really exasperating. Doctors with patients suffering from very rare diseases need to know of concrete, comparable cases to help them find the best possible therapy – but data protection laws have until now often stood in their way.

Nevertheless, solutions do exist, even for such difficult cases. In 2013, for example, the ‘Global Alliance for Genetic Health’ was founded – a worldwide association with more than 380 institutional members. It develops sophisticated procedures so that patient data can be shared safely and effectively on a volunteer basis. It has made a carefully differentiated permit model for the release of data by patients, and has developed algorithms to aid data access. Ultimately, such an exchange of patient data should support research into cancer and into rare and infectious diseases.

There is still a lot to be done if we are going to realise the cultural shift towards open science, despite all the obstacles.

Sven Titz is a science journalist in Berlin.

“I’m frustrated”

Martin Vetterli, President of the National Research Council of the SNSF, has been lobbying for open science for years. “You can’t simply command it to happen”, he says. As a researcher at EPFL, he discloses all his own raw data.
By Atlant Bieri



“If we shift to open science, then we’ll produce fewer, but better-quality papers”.

What does ‘open science’ mean to you as a researcher?

At the School of Computer and Communication Sciences at EPFL, we traditionally make all our published papers freely available online. We also provide all the associated data and source codes. In this manner, all our results can be reproduced by other research groups.

Researchers are already drowning in papers today. How can they hope to keep up if everything is going to be made freely available?

With open science, the exact opposite will happen. Publishing an article on this basis means that all data is documented clearly. Every step in our work that led to a result is described so that others can comprehend it. This means that, overall, fewer papers will be published, while their quality will rise at the same time. It will also make research more transparent.

How exactly do you go about this?

We still publish in the traditional journals. But even while we’re submitting the paper, we put all our data on our server. As soon as the article is accepted, we also place it on free online access.

Shouldn’t a researcher have the right to keep his laboratory recipes to himself?

Certainly not in my field, the computer sciences. And maybe the same should apply in other fields too. 350 years ago, we moved from the age of alchemy into chemistry. The alchemists simply claimed that they could produce gold according to a secret method. There was no possibility of checking their claims systematically. You could choose to believe them, or not. But all that changed with the onset of chemistry. We began to publish our methods. That was the moment when modern science was born. If we do things differently today, then we’re returning to an age of alchemy.

Of all the publications that have resulted from SNSF funding, only 40 percent are freely available. As President of the Research Council, are you OK with that?

No. I’m frustrated. We are much too slow. Today, the Swiss taxpayers pay three times. First for the actual research, secondly for their subscription to the specialist journals where it’s published, then thirdly for open access. This means the publisher profits twice. That’s truly shameful. We can’t tolerate it.

So what are you doing about it?

The SNSF is developing a strategy in tandem with Swiss universities. We want to reach a point where all papers are available

on open access, without our having to pay a further fee for them. We hope that we can conclude an agreement with the publishers so that researchers in Switzerland can get automatic open access.

How do you want to achieve this?

If Switzerland as a centre of research is able to present a united front, then we can go to the publishers and say: Either you do a deal with us now, or the Swiss research community will boycott you. That will be difficult, of course. But the Netherlands have managed it. And they’ve been successful.

Is Switzerland ready for such a step?

The whole situation is rather complicated. The many different researchers active in Switzerland have different interests. We’re still finding it a little difficult to coordinate all these interests.

Couldn’t the SNSF simply compel researchers to publish their data only in open-access journals?

That’s not so simple, because in some cases it would be bad for their careers. Researchers have to endeavour to publish in journals that are best suited to their results. It’s also our goal to further the careers of our researchers, not to hinder them.

“There’s a bit too much competition between researchers today”.

Why doesn’t EPFL found its own specialist journal?

A specialist journal of our own would be a very good idea. But it’s not something that we can make happen on a top-down basis. It has to come from the research community itself. If a community decides to leave the traditional path, it will happen. But I’m not the person to decide that. Such a process would require a cultural shift among researchers.

Have researchers elsewhere already gone down that path?

Yes. Together with other researchers, the famous mathematician Timothy Gowers at the University of Cambridge has founded the journal ‘Discrete Analysis’. It’s a virtual journal. The editorial board can concentrate solely on peer-reviewing because the papers submitted are managed by an external company. The costs amount to about ten francs per manuscript. So it’s a hundred to a thousand times cheaper than publishing in a traditional journal.

In 2012, an article in Nature showed that 47 of 53 important cancer studies were not reproducible. How is that possible?

To be fair, we have to admit that research is more difficult in some fields than in others. In medicine, for example, you only have a small amount of data because you're dealing with real people. That means that there are often problems with both statistics and reproducibility.

“If a community decides to leave the traditional path, it will happen”.

Nevertheless, the reproducibility crisis also affects other areas, such as biology, where you can choose your volume of data more freely.

I've heard well-known professors claim: “The other group couldn't reproduce that because they're not as good as us”. There are indeed people who have a real knack - they can work with organisms so well that their experiments succeed, while others can't reproduce them. Nevertheless, I think that it's a weakness, because the goal of science is absolute reproducibility.

Isn't it just that people are cheating?

This can happen, but it's certainly not the norm. Here we also have to remember that researchers are in competition with each other. A bit too much competition today. The resulting pressure makes researchers feel compelled to publish their work, even when it's inadequate.

So is competition bad for research?

No, I wouldn't put it as simply as that. In science, we have always been keen to be the first to discover something. That's how we make progress in research, by being cleverer and better than the others. It's part and parcel of research that we compete against each other.

So what's the problem?

Today, it's particularly difficult for young people to become real researchers. Fifty years ago, we still had the leisure to think differently about the world and to generate new ideas. Today, research has become a business. The general public, politicians and the private sector think that you can pour money into research at one end, and get useful results out of the other end shortly afterwards. But of course it's not like that. Research needs time and space if people are going to be able to think creatively.

But researchers have it good at EPFL, don't they?

This is not just a Swiss matter. Research is global. And there are several alarming phenomena. In certain Asian countries, for example, researchers' wages depend on the specialist journals in which they publish. That's a dubious practice, because it almost encourages dishonest behaviour.

And does this have an impact on Switzerland as a centre of research?

Yes. Young researchers feel under pressure to publish. They'll turn the material for one article into three articles, because it looks better on their publication list. We also see this in requests for peer review. There's been a huge increase in recent years. The whole system is being swamped. And quality considerations naturally get left behind.

How can open science improve the current system?

If we shift to open science, then we'll produce fewer, but better-quality papers. And they can be reviewed quicker because everything is documented.

You're the next EPFL president. What concrete measures are you planning so as to promote open science there?

In those research fields that have already taken major steps into open science, I want to promote a research culture in which other fields are encouraged to join them. We're providing an online tool for this. It allows researchers to upload their data easily and let others see it. Third parties can then check it. But this tool is also intended to promote collaboration between different research fields. In the environmental sciences, for example, people aren't necessarily accustomed to dealing with large volumes of data. Here, the mathematicians or computer scientists could help them out.

How can you convince young researchers about the value of open science?

I tell them: The most important thing for your career is that your work has a big impact. If you place your data online, your work will become more visible and people will also trust you. And that will help your work to have a bigger impact. I can't compel them to embrace it. It's something they have to realise by themselves.

Atlant Bieri is a freelance science journalist.

Happy in the hot seat

Martin Vetterli is one of the pioneers of open science. He is a professor at the School of Computer and Communication Sciences at EPFL. He is also the President of the National Research Council of the SNSF until the end of 2016, and has been elected the new President of EPFL as of 2017.

For a better science

At the congress 'We Scientists Shape Science' on 26 and 27 January 2017, researchers and decision-makers together will take the first steps towards a creative, robust, committed science scene. This congress is being organised by the Swiss Academy of Sciences and the Swiss Science and Innovation Council.
www.naturalsciences.ch/wescientists

INTERVIEW

“Physics can be simple and beautiful”

Roman Ernst, iPHO 2016



Chenkai Mao from China won first place and a gold medal at the International Physics Olympiad held in Zurich in July 2016. This 19-year-old son of a nurse and a doctor of traditional medicine came first out of 400 participants from 86 countries.

How did you prepare for the Olympiad?

These kinds of competition play an important role in China, as they are related to university entrance exams. I started physics at high school three years ago, then went through four competitions before my national selection. I prepared for a couple of months. We've helped each other in the team, but at the end you stand on your own!

Why did you participate?

First, because of my passion for physics. At my age it's the perfect choice, and an honour to represent my country.

The hardest part of the test?

To be honest, the theory part was challenging but not so hard for the Chinese team. It was more difficult to manage the available time to carry out all the experiments, about five hours. You have to prioritise - should you take extra time for more precise measurements, or carry on instead?

Apart from your medal, what will you take back home?

It was a most inspiring experience, an unforgettable one! It was great to meet so many participants from around the world.

You want to become a researcher?

Physics is a fundamental subject that can lead to many different things - maths, chemistry. It's hard to say what will happen in ten years, but my dream would be to become a university professor or to work in a research institute.

What does physics represent for you?

It changed my view of the world. It describes it using universal principles - and, above all, accurate principles. Physics can be simple and beautiful. In China, most people think that it is not so practical and too far removed from society. They have their own experiences and reasons for their opinion, but I think it's important to inspire the younger generation.

IN BRIEF

THE QUOTE

“All scientific articles in Europe must be freely accessible as of 2020”.

The Netherlands EU Presidency, 27 May 2016.

THE NUMBER

1,000

The number of new tenure-track professorships to be created in Germany with a budget increase of EUR 1 bn. Hiring waves will take place in 2017 and 2019.

THE GRADE

Between “low” and “very low”

The scientific credibility given to an article by Bjørn Lomborg in The Telegraph in May 2016. The platform Climate Feedback allows researchers to review, grade and annotate popular reports on climate science.

THE MOVE

EUR 3 million for replication

The grant money to be awarded by the Netherlands Organisation for Scientific Research (NWO) over three years for projects aimed at reproducing existing results.

THE CALL

“Scientific and industrial suicide”

After a dramatic call from seven Nobel Laureates, the French government has halved its planned cut of EUR 256 million in research and higher education.

THE TOOL

Turkprime

This platform facilitates online surveys in psychology and sociology research with the help of Amazon Mechanical Turk, a crowdsourcing platform. More than 160 million questions have been answered since its launch in January 2015.

THE NEW LOBBYIST

The Guild

The newly created Guild of European Research Intensive Universities brings together nine institutions to lobby the EU. It will join existing alliances LERU (21 universities), the Coimbra Group (38), the mammoth EUA (850) and the tiny EuroTech (5).

THE INFRASTRUCTURE

ESFRI

21 projects and 29 landmarks make up the new roadmap for the European Strategy Forum on Research Infrastructure. They cover the usual big science (energy, physics) and also health, food and digital humanities.

NEWS

A wellcome push

The British private biomedical funder Wellcome Trust is getting serious about open access. It has contributed GBP 25 million of extra funding for the open-access journal eLife along with the Max Planck Society and the Howard Hughes Medical Institute. It will also launch ‘Wellcome Open Research’, an open-access journal for articles by its grant recipients. Wellcome will pay between USD 150 and USD 1,000 per article to use the publishing platform of F1000 Research. doi.org/bjhr doi.org/bmcj

What's research integrity?

A survey carried out by Science Europe has shown that 24 out of 27 research funders and institutions have policies to deal with issues related to research integrity, though just 18 of them have a formal definition of it. Only 15 of them organise, support or recommend training on the topic for their employees or grant holders. bit.ly/Ho_Integrity

Diverse family models in academia

How professors in Switzerland - women and men - combine family life with an academic career.

Teresa Montaruli

A balancing act

“As a single mother of three-year-old twins, it’s kindergarten that makes my work-life balance possible. Luckily, I also have my mother and a salary that provides just enough for babysitters when work takes me away from Geneva. When I had to start teaching in French, after only two years in Geneva and without knowing the language, I was exhausted by trying to cope with teaching, research and the twins. Back then, I thought of taking unpaid leave for the sake of the kids. But expenses for child care are quite high, so I didn’t do it. I think physics, as a male-dominated environment, is particularly difficult when it comes to gender issues. I’m relieved to see that my postdocs have a different relationship with their families than colleagues of my own age. The postdocs are much more balanced”.

Teresa Montaruli (48) has been a full professor (100%) of particle physics at the University of Geneva since 2011. She runs a project to construct gamma-ray telescopes and leads Gender in Physics Days, a Horizon 2020 project. She lives near Geneva.

- 1994 Degree in physics, Bologna
- 1998 Doctorate, Bari
- 1998 Postdoc and assistant professor, Bari
- 2005 Assistant, associate and full professor in physics, Wisconsin
- 2013 Birth of her twins



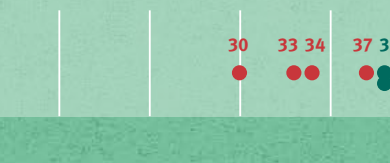
Alexander Bertrams

The sister-in-law as a replacement dad

“I am determined to be there for my wife and the twins, as well as being able to teach well and to produce good research. That’s also why I cut back on my research last semester. And of course I have too little leisure time. I should take up sports again sometime. My wife has taken a break from her job as a teacher to look after our two-year-old daughters. Until August I’ll be commuting between my work and my family in Augsburg. My sister-in-law takes my place as daddy when I’m in Bern. None of it would be possible without this social support. When the children were very small and sleep was in short supply, I sometimes doubted whether I’d have the mental and physical resources to get established as a professor at the same time”.

Alexander Bertrams (40) has been a full professor in educational psychology (100%) at the Institute of Educational Science, University of Bern, since 2015. He was also appointed Head of Department in 2016. He has lived in Bern since 2016.

- 2006 Degree in psychology, Erlangen
- 2009 Doctorate, University of Mannheim
- 2010 Junior professor in educational psychology, University of Mannheim
- 2013 Habilitation, Mannheim
- 2014 Birth of Ida and Ilvy



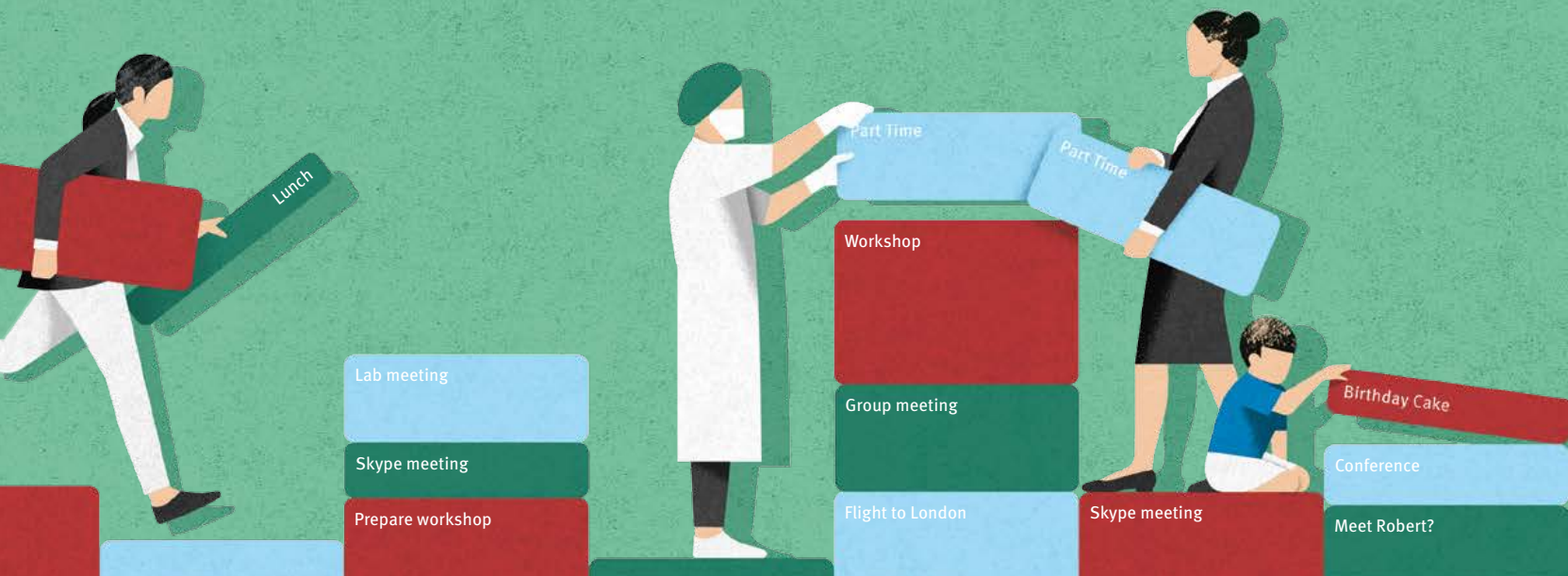
Patricia Purtschert

Shared lives

“Life as both a professor and a member of a family is something I find rewarding, even if sometimes it leaves you breathless. I used to spend many weekends at my computer, but today I go hunting for snails in the garden with the kids. These experiences enrich my work at the university – I’m convinced of that. My partner is also active in research, and she shares the family work with me. That means you have to agree on a lot of things, but it has the advantage that we can share our living environments. Given my experiences, I’m very concerned about the current debate on excellence. It’s designed for those with a straightforward, fast-track career. The people who have to care for others – and it’s mostly women – risk falling through the cracks”.

Since 2016, Patricia Purtschert (43) has been an associate professor (75%) in gender studies and joint head of the Interdisciplinary Centre for Gender Studies of the University of Bern. She lives near Zurich.

- 2000 Degree in philosophy, modern general history and literary studies, Basel
- 2002 Research visit to the University of California, Berkeley
- 2005 Doctorate, Basel
- 2009 Birth of her first child
- 2010 SNSF Ambizione, ETH Zurich
- 2013 Birth of her second child
- 2014 Postdoc at ETH Zurich



► For detailed answers on reconciling family life and academic careers, go to: bit.ly/Ho_diversity

Claude Hauser

You have to choose

“We decided on the job-sharing model right from the start. My wife has a 50% job as a speech therapist and I share the Chair of Contemporary History with Alain Clavien. With a part-time post, it’s a challenge to decide which tasks to take on, and which not. I turned down a long research visit to Quebec because organising it would have become too complicated, and my wife would probably not have found a job there. Our children are bigger now, so you have to be around a lot when you’re needed – when they need you to listen, to discuss things and manage agendas. And you have to do all that without neglecting your partner. The most important thing is to nurture your relationship with your partner. If that functions well, there’s less friction”.

Since 2014, Claude Hauser (51) has shared the Chair of Contemporary History at the University of Fribourg in a job-sharing arrangement (50%). He is also Dean of the Historical Sciences Faculty at Fernuni Switzerland (20%). He lives in Fribourg.

- 1992 Degree in history, Fribourg
- 1997 Doctorate, Fribourg
- 1997 Birth of Gilles
- 1999 Birth of Félicien
- 2001 Birth of Zacharie
- 2003 Associate professor in contemporary history, Fribourg
- 2003 Birth of Perrine
- 2009 Habilitation, Fribourg
- 2009 Professor in contemporary history, Fribourg



Isabelle Wildhaber

Getting a professorship through part-time work

“When you’re competing for a professorship, it can be difficult if you’ve only ever worked part-time. And because of the children, I’ve not been to many international conferences. At present I’m working two days a week in St. Gallen in term-time, but the life of the family is in Berlin, where my husband is deputy chief physician in cardiology at an academic teaching hospital. In order to accommodate me and our family, he has turned down several offers to become chief physician. He reduced his working hours in 2012 and founded a medical technology company”.

Since 2015, Isabelle Wildhaber (43) has been a full professor (75%) in private and company law with a special emphasis on labour law at the University of St. Gallen. Since 2016 she has also been the Chairwoman of the Committee for the Equality of Women and Men at the university. She lives in Berlin.

- 1996 Law Degree at the University of Basel
- 1999 Doctor iur. at the University of Basel
- 2001 Lawyer in New York/Frankfurt
- 2003 Birth of Aron
- 2005 Birth of Sophia
- 2008 Birth of Dan
- 2010 Habilitation, Zurich
- 2010 Assistant professor for labour law and liability law at the University of St. Gallen



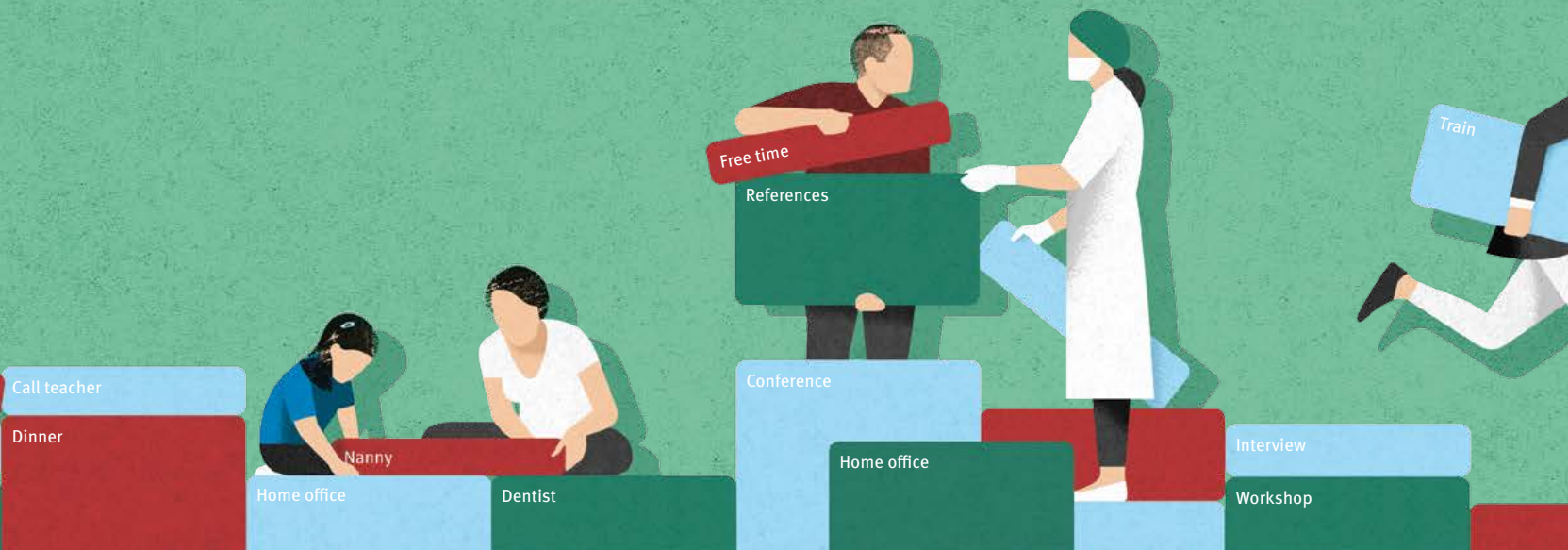
Anna Oevermann

Flexibility is crucial

“A family and a scientific career can offer each other valuable impetus. My children learn a lot about my work, and when I’m organising things I profit from my experiences in my family life. Reconciling both means you have to be enthusiastic about your own work, you have to be able to coordinate things, and you must be flexible. That goes both for us and for our employers. My husband is originally from Turin and since 2016 he’s been Professor of Environmental Engineering at the University of Edinburgh. Our lives have been based in Bern since 2003, after many years of having a long-distance relationship. Looking after our children is a complicated matter involving us, day care, and a nanny at home. Only if you know your children are in good hands can you concentrate properly on your professional activities”.

Since 2015, Anna Oevermann (42) has been an associate professor (100%) in veterinary neuropathology at the Vetsuisse Faculty of the University of Bern. She lives in Bern.

- 1999 Degree in veterinary medicine, Giessen
- 2001 Doctorate, Zurich
- 2006 European specialisation in veterinary pathology
- 2008 Birth of her first daughter
- 2012 Birth of her second daughter
- 2012 Habilitation, Vetsuisse Faculty, Bern
- 2013 Assistant professor in veterinary pathology, Bern



The present culture is slow to change

What has changed in the academic world after 15 years of promoting gender equality? According to the statistics: not enough.

If they haven't already realised it, then by the time they've finished their doctorate, talented scholars will have grasped that an academic career is rarely possible without night shifts, weekend work, long research trips abroad, temporary employment and low starting salaries. Having to take on such a major commitment despite uncertain prospects of success means that many are dissuaded from ever embarking on an academic career. This is especially the case with women who would like to start a family. Because female academics "are often still under greater pressure than their male colleagues when it comes to trying to combine career, marriage and family. And this also influences their chances for an academic career". This is the conclusion of the report 'Dual career couples at Swiss Universities' of 2012. It evaluated the third phase of the Swiss Federal Equal Opportunity at Universities Programme, which has been running since the year 2000 and is meanwhile under the auspices of Swiss universities. It is funded to the tune of several million francs a year.

"It's high time to demystify academic careers".

Patricia Felber

French-speaking Switzerland is ahead

Since the Programme was started, equal-opportunity offices and other such structures have been set up at universities, and action plans developed to promote equal opportunity. Kindergarten places at universities have been expanded, in some places even doubled. Mentoring programmes and specific postdoc funding programmes for women have been set up. And the SNSF has been involved since 2001 in providing project and career support on an equal-opportunity basis. It has given monies to promote equal opportunity, and since 2013 it has been providing funding to ease the burden on women and men who are responsible for looking after children.

Innumerable evaluations and reports have been drawn up on the efforts made over the past 15 years.

The impact of these many parallel measures has been as follows: since 2002, the proportion of women professors has doubled, going from 9.7% to just under 20%. However, compared to other European countries, Switzerland is in the lower middle rankings. In 2015, almost 37% of newly appointed professors were women.

"On the level of university institutes, we still need to be patient".

Martina Weiss

It's clear that Switzerland has failed to achieve its goal of ensuring that 25% of all professors were women by 2016. "For Switzerland, it wasn't a very realistic goal", says Martina Weiss, the General Secretary of Swissuniversities. The Swiss Federal Statistical Office has forecast that this goal will not be achieved before 2023. Weiss also warns of using this number as the only yardstick. It is more meaningful to compare universities with each other and to differentiate instead between different subject areas. For example, the University of St. Gallen has tripled its proportion of women professors since 2000 - it stands today at 12.8%. Furthermore, on the level of assistant professor, the goal of 40% women is within reach. This progress is particularly noticeable in those subjects that already have a large percentage of women, such as the humanities and social sciences. "There, the proportion of women professors is in some cases 50%", says Weiss. And French-speaking Switzerland is a little ahead of German-speaking Switzerland in this regard. There, women often work in 80% jobs. A further reason for the high percentage of women professors in western Switzerland can be seen at the University of Geneva, which has decided that the shortlists for new appointments should include at least 30% women. If this quota

is not met, then the faculty in question has to explain why to university management. The University of Lausanne is planning a similar measure from 2017 onwards.

Only an iron will succeeds

Overall, the chances of success for women in academia have improved a little over the past 15 years - as have their circumstances for being able to combine a family and an academic career. Nevertheless, the shift in our culture and in our organisational structures is taking place more slowly in university institutes themselves. "Here we still need to be patient", says Weiss. The management of a university can send out signals that it wants to promote part-time working and job-sharing. But such a policy can only be implemented by the line managers in the faculties and institutes.

And this is where more action is required. "Young female researchers often don't insist on their rights to promotion and part-time work because their line managers are also their research partners", says Patricia Felber, a social geographer who is coordinating several mentoring programmes. She is also the author of the report 'Assessment of the career situation of young female scientists in Switzerland', published by the Swiss Academies of Arts and Sciences. Then there is the discrepancy between the job description on paper and what's actually demanded on an informal basis. This is a major hurdle for young families, and also a reason why coordinating career and family still takes an iron will and a lot of creativity.

"It's high time to demystify academic careers", says Felber. She means the culture that leads many to have a bad conscience when they leave the office at 5 p.m. She's simply saying out loud what many academics, both men and women, don't dare to think: "Even at a university, a job is just a job".

Pascale Hofmeier is a science editor at the SNSF.

“If you don’t want to know something, then you don’t collect the data”

The commodity industry has grown rapidly in Switzerland. “But we don’t know much about it”, says the lawyer Elisabeth Bürgi Bonanomi. *By Marcel Hänggi*

Dr Bürgi, the commodity industry is a hot topic on the Swiss political scene. What do we really know about this sector?

Switzerland is the biggest trading centre for commodities. It’s long been known that an abundance of natural resources is often detrimental to developing countries. Their economy can become very one-sided in its focus, they lack processing industries, and post-colonial dependencies remain. These developing countries can only improve their situation if the developed countries where the commodity companies are based also exercise their responsibilities. It’s these countries that enable financial outflows and distort the markets in their favour by offering subsidies and erecting tariffs. If you take a closer look at the situation, then you notice that we have no precise knowledge of what’s happening. The flow of money is covert, official statistics offer no comprehensive records of trading data, and no one discloses just how much tax the sector pays in Switzerland.

Why is the data situation so poor?

If you don’t want to know something, then you simply don’t collect the data ...

So is a lack of political will the real problem, rather than a lack of scientific knowledge?

Both are lacking. Of course the political will has to be there if you’re going to change something. But research as we understand it can make an important contribution. We are consciously trying to pursue a strategy of sustainability and development. But



Valérie Chételat

in recent years it’s become clear that it’s not enough just to conduct our research in developing countries. The question of tax avoidance is absolutely crucial - and here we are still at square one.

How would you describe a healthy commodities sector?

In the extraction countries, those involved should have a voice in deciding what’s to be mined, what’s to happen with the income from it, and so on. There would be a processing industry on the spot. Human rights and environmental responsibilities would be respected. The companies would pay their taxes in the same countries where

value is created, and all participants would have access to a functioning judicial system. There will always be losers, but they shouldn’t be the most vulnerable in society.

Marcel Hänggi is a freelance science journalist.

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Switzerland and the Commodities Trade. Swiss Academies Factsheets (2016)
Making the Commodity Sector Work for Developing Countries. Swiss Academies Factsheets (2016)

Elisabeth Bürgi Bonanomi

Elisabeth Bürgi Bonanomi is a lawyer who researches at the Centre for Development and Environment (CDE) of the University of Bern. She is coordinating a literature study on the commodities trade for CDE, the World Trade Institute of the University of Bern and the Institute of Business Ethics at the University of St. Gallen.

Politics redoubles its efforts

In recent years, increasing attention has been paid to the negative consequences of commodities trading, particularly following the release of a Berne Declaration report in 2011. The Swiss Federal Council later presented a ‘Background report on commodities’ in 2013. The imminent revision of the Stock Corporation Act is intended to introduce stricter regulations

on transparency. In April 2016, the ‘Responsible Business Initiative’ was submitted to parliament, thereby also exerting political pressure for change. For its part, the Swiss Academies will hold a congress on transparency in commodities trading on 20 September 2016 in Bern.



A woman researcher in a men's prison

Some 150 inmates are currently committed in Swiss correctional facilities. The ethnologist Irene Marti, a doctoral student at the University of Neuchâtel, has been looking into how they cope. She participated in their everyday routine and played ping pong with them.

“ Prison is a very practical place to do research. The people are there, they've got time and want to talk. Prisons are characterised by a kind of artificial normality: people are polite to each other, their daily routine is prescribed, and things usually run smoothly. A woman researcher is a welcome distraction. I've visited the correctional facilities of Lenzburg and Pöschwies for four weeks each. I wanted to find out how being in custody affects the prisoners, and how they deal with their life situation. I make no judgements about their being in prison; I just want to make their experiences visible.

“At the beginning I had to build trust. That's why I spent the weekdays with the prisoners. I arrived at 7 a.m. and went along to work in the painting group or the print workshop. In the evening I played ping pong or badminton with the prisoners, and they taught me how to play the

card game 'Jass'. The fact that I'm a woman certainly also played a role. One prisoner told me it really did him good to be able to talk with a woman again.

Man and murderer

“As a woman in a men's prison, my femininity was really on my mind during this time. I paid exact attention to what I wore every morning. Especially during sports, I made sure that my clothing wasn't too tight. But I also didn't want to pretend to be what I'm not, and wanted to feel comfortable in my role as a woman researcher. I was never afraid. There are cameras in lots of places, there were usually prison wardens nearby, and when I was alone in a room with a prisoner, I had an alarm device with me. With some prisoners, the warden advised me that I had to be careful.

“I didn't read anyone's files in advance, as I wanted to meet the prisoners without



A welcome change: Irene Marti in conversation with a prisoner at the Lenzburg Correctional Facility (left). The smaller images show the Pöschwies Prison. Observing everyday life in prison made Marti very aware of the value of freedom.

Photos: Andreas Moser (JVA Lenzburg, large photo) and the Zurich Cantonal Office of Corrections (small photos)

prejudice. That changed after a week, and I read everything. The younger prisoners in particular come across as sympathetic and friendly. But behind their pleasant appearance, they've committed a crime, sometimes a brutal crime. It was difficult for me to comprehend that. I soon realised that I had to separate the crime from the person seated opposite me. That helps you to engage with them meaningfully. A murderer isn't just a murderer, but also a human being. I didn't talk with them about guilt. But their crime was still there in the background the whole time. That's why they were in prison, whereas I was able to go home in the evening.

"During my visits, I tried to have 'normal' relationships with the prisoners. I think I succeeded. Otherwise, I would have been unable to pose such personal questions in my extensive interviews. They were open with me in return, as much as

was possible in that particular context. Altogether, I interviewed 18 prisoners.

Precious freedom

"Those men who had only recently been sent to prison weren't yet able to grasp their situation - the fact that things might stay the same until the end of their lives. Some of them fight against it. For them, this fight is a kind of motor - it's their way of holding on to life. Others have given up on themselves and only want to watch TV and eat. It seems to me that they're broken by their lack of prospects. But there are also some of whom you couldn't imagine that they've been imprisoned for many years. They are full of strength and are motivated. They do further education courses or learn foreign languages. They have worked on themselves, they've changed. They want to show the world outside what people they have become. One of them said to me, he

didn't think about the future because he had none. The future was outside, and he wouldn't be going outside any more. In fact, only very few of them are ever released from custody.

"On the evenings, I went back to my rented room and typed up my notes. I was full of impressions, because I pretty much immersed myself in their world. Some of their life stories were tough, and it weighed on me. At that time, I often dreamed of keys. That's a powerful symbol of prison. I emerged again at weekends when I was together with friends and family. I enjoyed being able to organise my days myself. I walked over a meadow and the sun was shining. Then I could really feel how precious freedom is. ”

Recorded by Anne-Careen Stoltze.

Overlapping identities

Ukraine is a landscape torn by the battle for influence between its neighbours, Europe and Russia. But, according to researchers, this has opened fertile ground for being Ukrainian, even in the east of the country. *By Benjamin Keller*

In 1992 the artist Benjamin Vautier declared that “Switzerland does not exist”. Could the same be said for Ukraine? The country has always been an area of contention in the battle for influence between its neighbours. It has been continually appropriated and subjected to varying identities, from the very beginning of its history until the war that afflicts it today. On 24 August 1991, however, the former Soviet republic declared its independence and made a relatively late and sudden entrance onto the international stage. Consequently, and as a newly emerged state, it has only recently begun to be considered as an autonomous entity.

The current conflict has unveiled Ukraine’s complexities and multiplicities. Fighting broke out in 2014, following the uprising known as Euromaidan – which had led to the deposition of President Viktor Yanukovich, who in turn had refused to sign an association agreement with the European Union. Everything has since changed: the new, Western-backed president, Petro Poroshenko, has had to face a pro-Russian and Russian-backed rebellion in the south east of the country. In other words, Ukraine is still the stage for the East-West struggle for power, which has always been the case, at least to a certain extent.

Ukraine (which translates roughly as ‘borderland’) has a shared and antagonistic history with its neighbours. “The hostility is fed by diverging interpretations of history”, says Korine Amacher of the University of Geneva. Amacher is a professor of Russian and Soviet history, and this January began research that aims to draw attention to the overlapping paths of Ukraine, Russia and Poland.

Little Russia

By the fall of the Mongol Empire in the 14th century, the north east of today’s Ukraine was largely dominated by Western forces (Poland, Lithuania, Prussia, Austro-Hungary), whereas the south east was controlled first by the Tatars and the Ottomans, and

later by the Russian Empire, whose grip became tighter from the 17th century onwards. So tight was it that in the 19th century, the territory became known as “Little Russia”. Although Ukraine was briefly independent following the Bolshevik Revolution of 1917, it was reinvaded by the Red Army and integrated into the USSR. In 1939, as part of the deal with Nazi Germany, Stalin also took hold of the regions that had been under Polish control. “This is why we often say that Ukraine’s current borders were the work of Stalin”, says Amacher.

Antagonistic views

Ukraine wouldn’t be independent again until 1991, but the result was a country composed of historically disparate constituents. “Galicia (West) first aligned with Austria, then Poland, in other words towards the West; whereas the Donbass region [the location of current conflict, Ed.] has been Russian since the 18th century”. There are of course other influences, such as Romania and Hungary. “Some Russians still consider that Ukraine shouldn’t even be a state”, says Amacher. “We even sometimes hear – both from Russians on the street and in parliament – that all of the problems would be resolved if only each former empire regained its former piece of Ukraine”.

“We often say that Ukraine’s current borders were the work of Stalin”.

Korine Amacher

Daniel Weiss is an emeritus professor at the University of Zurich. He and his team have been studying interviews, government statements and televised and parliamentary debates on the Ukrainian conflict with a view to identifying the most commonly used terms. “Russians see themselves as having always been on the defensive against attacks from the West”, says Weiss.

“As with Poland, the Ukrainians see themselves as the last bastion of civilised Europe, encroached upon by the brutal force of the barbarous Russian military. A key moment for the Ukrainians was the Cossack Hetmanate of 17th-century central Ukraine, an area that was more or less sovereign at the time. The Kremlin never accepted this state and eventually destroyed it”.

According to Weiss, pro-Russian Ukrainian separatists argue that there is “a fear of an economic catastrophe should the country accede to the European Union, because the east of Ukraine has very tight economic ties to Russia”. As with nationalist and populist movements in many European countries, pro-independence Ukrainians also claim that joining the EU means losing sovereignty. The disagreements do not stop there either: in 2014 the Ukrainian parliament repealed a law granting a special status to the Russian language – although the government never supported this modification.

Shared values

The tumultuous history of Ukraine has also led to the creation of a wide array of identities. These form the work of Ulrich Schmid, a professor of Russian culture and society at the University of St. Gallen, who,





Regardless of whether they're oriented to the West or to Russia: Vladimir Lenin provides people in Ukraine with a sense of community. This was also apparent during the Euro-maidan movement of 2014. In the East Ukrainian city of Kramatorsk, Lenin was decked out in the Ukrainian flag.

Photo: Keystone/EPA/Roman Pilipey

in spring 2013 and 2015, conducted two surveys in Ukraine, each involving 6,000 subjects. The aim was to create a detailed map of values according to geographical region (mapsukraine.ch) by examining the following five topics: literature, language, history, religion and economics.

"We gathered a clearly differentiated view from the a priori ideas often found in the press", says Schmid. "One misconception is that eastern Ukraine is backwards, Soviet and pro-Russian whereas the West is modern and pro-European. What we have seen in reality is more nuanced and highlights common Ukrainian values". One example is the fight against corruption. Another is public figures such as Lenin and the Romantic poet Taras Shevchenko, although nothing prevented nationalists from pulling down a statue of Lenin during the Euromaidan protests. In fact, this event actually irritated the leaders of the movement, who were conscious that he was held in high regard in both the east and the south of the country.

Schmid also points to "another often oversimplified issue: language. Having analysed the behaviours of readers in Ukraine, we noticed that Russian has its place in every region and not just in the East. There is also consensus on the gener-

al requirement of mastering the Ukrainian language. In fact, a considerable portion of the population speaks both languages. There is also a dialect which mixes Russian and Ukrainian: Surzhyk. It is interesting to note that, occasionally, people think they're speaking Russian when actually they're speaking Surzhyk".

"Neither Kiev nor Moscow holds any attraction for the occupied territories".

Ulrich Schmid

The indecisive majority

Even more unexpected is that Schmid discovered a unifying effect of the war among the regions. "We see patriotism even in the areas where it has historically been low, such as in North Bukovina". Generally, the 'consensus on Ukrainian citizenship' is drifting eastward, with the sentiment of Ukrainian belonging being the strongest among those born after the fall of the USSR.

The separatists appear then to be isolated. "In the occupied territories, other surveys conducted before and after the out-

break of hostilities show that the rates of identification with Ukraine and with Russia have fallen and that indecision has become the majority stance. This leads us to think that neither Kiev nor Moscow holds any attraction for them. In a certain way, they see their region as being lost".

A commonly invoked solution is to decentralise Ukraine, but would it work? "It's desirable but not realistic", says Schmid. "The last time that this possibility was discussed in the Ukrainian parliament, it led to three deaths among angry demonstrators. The issue with decentralisation is that it is a condition of the Minsk Two Treaty signed in February 2015. Ukrainians, however, clearly recognised it as a Russian demand, and so it was a relatively unpopular option. It remains to be seen whether the treaty will be reformulated, but I think that Russia will continue to insist on the extended autonomy of the occupied territories in Donbass".

Benjamin Keller is a freelance journalist in Tunis.

Where to draw the line?

Raphaela Cueni has been investigating the constitutional protections afforded to satire. In Switzerland, she finds signs of a healthy culture of debate.

By Isabel Zürcher

Satire doesn't always stick to the rules of good taste. And when political or religious differences resist conceptual unambiguity, freedom of expression can be at risk. In her doctoral thesis, Raphaela Cueni has taken a close look at this constitutionally delicate area.

Ms. Cueni, from a legal standpoint, does any valid definition of satirical communication actually exist?

There is no legal definition of satire that is easy to apply. However, courts in different legal jurisdictions have developed more or less expedient definitions - including the Swiss Federal Supreme Court. One constitutive element of satire is irritation, and this can transmute into rage or aggression. Satire rubs up against socially accepted norms, and to do this it utilises the aesthetic possibilities of linguistic and gestural expression.

In Switzerland, which after all is the homeland of the satirical 'Nebelspalter' magazine, there have been but a few large-scale legal cases involving satire. Do you have an explanation for this?

Various courts, along with the Swiss Press Council, repeatedly have to assess satirical expressions of opinion. On a federal level, there is less case law regarding satire than in Germany, for example. This could well be a sign of a healthy culture of debate, because in such a culture, legal proceedings are not advisable. Great Britain is exemplary in this respect. Even though British satire is openly aggressive and intentionally malicious, no large-scale legal cases are brought against it. If people try to take action against satire on grounds of defamation, the potential plaintiffs know that they'll be subjected to publicity that's absolutely counter-productive, regardless of the actual outcome of their case.

The explosive nature of satire becomes obvious time and again. We see it in the intense reactions to the Mohammed caricatures in Denmark, in the attack against Charlie Hebdo in Paris, and in the controversy surrounding Jörg Böhmermann's vulgar poem about Erdogan.



British satire is openly aggressive and especially mordant and malicious. But no large-scale legal cases are brought against it.

Photo: Keystone/Camera Press/James Veysey

These highly mediatised events have underlined just how relevant and timely it is that we should think hard about satire, and about how we perceive freedom of expression. The French situation is especially interesting: seemingly without noticing any contradiction, the President insists on freedom of expression, but at the same time argues in favour of restricting it when it comes to the anti-Semitic statements of the comic Dieudonné.

But if we only consider the high-visibility cases, it's too limiting, as we need to look at the relatively unspectacular cases too. Often, it's these that illustrate the most controversial legal issues surrounding the constitutional protection of satire, and the extent and boundaries of that protection. Back in 2007, the newspaper 'Confédération' in the canton of Valais published a photomontage of Adolf Hitler and Oskar Freysinger, a member of the Swiss National Council for the Swiss People's Party. The legal case that ensued raised questions about the relationship between satire and truth, though it is probably remembered only by very few people, even in Switzerland. In general, our legal foundations aren't good at providing conclusive answers to moral and ethical questions. Nor is that what they were intended for.

Switzerland is a country that is heterogeneous in matters of language, denomination and religion. And here, too, there are very many different perceptions of satire. What are the legal ramifications of such cultural differences?

The question is really: what leeway does a given legal framework afford to satire? The differences in how we express and perceive satire are closely connected to how we perceive the relationship between culture and the law. The law is nothing other than an expression of a specific culture. But at the same time it also creates a framework in which a culture can develop.

Raphaela Cueni is on a doctoral scholarship of the SNSF and is an assistant to Prof. M. Schefer at the Law Faculty of the University of Basel. She has recently returned from a research visit to Columbia Law School in the USA.

Isabel Zürcher is an art historian and a journalist in Basel.

Underestimating law clerks

The increasing workload of the Swiss courts means that more and more law clerks are being employed. “The public isn’t aware of the immense importance of law clerks”, says Peter Bieri of the Institute of Public Law at the University of Bern. He is himself a lawyer and specialises in the management of justice. He recently completed his doctoral thesis as part of a project entitled ‘Basic Research into Court Management in Switzerland’ (www.justizforschung.ch).

The broad spectrum of tasks assigned to law clerks is something specific to Switzerland, where they are highly involved in briefing and in the decision-making process. Many courts employ considerably more law clerks than judges. Increasing the number of clerks employed is a natural solution – but too many law clerks per judge would raise constitutional issues, says Bieri. A decision has to be made as to which judicial functions may be devolved to law clerks while still ensuring that the law is upheld by legally competent judges.

Judicial independence is threatened when a judge works with too many law clerks, says Bieri: “It becomes impossible to engage in a serious study of individual cases, and this can lead to judges being too dependent on the law clerks”.

For this reason, it is important that courts should at the same time seek to find other ways of getting to grips with their volume of work. Bieri suggests electing additional judges, managing cases more efficiently, or utilising more IT solutions. *Livia Willi*

P. Bieri: Law Clerks in Switzerland – A Solution to Cope with the Caseload? International Journal for Court Administration, 2016



Having a lot of law clerks per judge raises constitutional issues.



Sometimes boredom's used to justify drinking.

Difficult days after alcohol withdrawal

Alcohol-dependent mothers who undergo withdrawal treatment generally have a higher risk of relapse than alcoholic men with children. At the School of Social Work at the Zurich University of Applied Sciences (ZHAW), researchers have been investigating this discrepancy. They wanted to find out what challenges these mothers face in everyday life. “Just wanting not to drink any more, and hoping that everything will automatically get better – that often isn’t enough”, says the project head Silvia Gavez. She and her team have interviewed 14 women who underwent withdrawal therapy at the Forel Clinic.

They found that there were several challenging areas in the women’s lives. The mothers can succeed in returning to their social environment if they are able to express what support they need, and if they are able to face up to their own life stories and their addiction. The interviewees said that talking with those around them was a balancing act between trying to be open, while also trying to avoid the stigma of a taboo topic.

“The mothers also often don’t know how to discuss the topic of addiction with their children”, says Gavez. In fact, they are more likely to achieve their goals if they inform their children appropriately, instead of evading awkward questions out of a sense of shame. If women have a sense of self-appreciation in their roles as housewife and mother, they are more likely to return successfully to everyday life than those women who find their lives boring or banal. The latter group tends to use such dissatisfaction to justify their drinking. Making changes – such as separating from a partner or finding a new job after therapy – can have a positive impact. The comprehensive results of the study will appear this coming autumn in book form. *Kathrin Zehnder*

S. Gavez et al.: Zurück in den Alltag – Mütter nach Behandlung ihrer Alkoholabhängigkeit. Budrich (2016).

The Swiss chalet – not quite so Swiss

It’s supposed to be typically Swiss. But in his doctoral thesis for ETH Zurich, Daniel Stockhammer proves that the chalet – for many still the quintessential Swiss building style – was actually a German import. It proved a big hit, not least thanks to the nineteenth-century foreign enthusiasm for the Alps and the emergence of the Swiss nation state at the same time.

This wooden house is supposedly the epitome of Swissness (along with cows, cheese and watches), but Stockhammer does away with all the myths surrounding it. “The chalet isn’t a Swiss invention”, he says. To be sure, there has been a long tradition of building with wood in Switzerland, right down to the present day, “but the designs and the buildings in this ‘Swiss style’ were mostly constructed by foreign architects. For the European elites of the 18th and 19th centuries, the chalet was an architectural expression of what they idealised as being rustic, traditional and handmade. The ‘Swiss style’ existed abroad before it was ever known in Switzerland itself”, says Stockhammer.

It was tourism that brought the chalet to Switzerland – and it was successful, too. Chalet factories and local architects began to reproduce this ‘Swiss style’ according to pre-existing models. However, even these models were mostly made by foreigners. According to Stockhammer, “this act of whittling down the diversity of regional wooden building styles could only have been initiated from outside”.

This look back into history shows that the image of traditional Swiss architecture, and the formation of its national identity, were far more swayed by the outside influences of other European countries than many would like to admit today. *Astrid Tomczak-Plekawa*

D. Stockhammer: Schweizer Holzbautradition. Ernst Gladbachs Konstruktion eines ländlichen Nationalstils. Doctoral thesis, ETH Zurich, 2015
doi:10.3929/ethz-a-010657828



Sketch for the Rütli House, Seelisberg, by Ernst Gladbach, 1860.

Mission 'One Health'

The epidemiologist Jakob Zinsstag conducts his research in the poor countries of the Global South and is an advocate of 'One Health'. With its view to improving health care, this approach aims to promote synergies across human and veterinary medicine and the nutritional and environmental sciences. *By Irène Dietschi*

Since early childhood, Jakob Zinsstag - the second-youngest of eight children - knew exactly what he wanted to become in life: a missionary or an aid worker. His desire was so strong that when he was just 11 years old, he invited a missionary to his Sunday school in his home town of Visp. She had to explain all about her activities in poor countries. Later, he went to work regularly on the farms of his mother's family in the Jura, helping out in the fields and the cowsheds. His love of animals led him to study veterinary medicine. At the age of 25, fresh from qualifying, Zinsstag went to work at a veterinary clinic for large animals in Porrentruy, where his wife began her first job as a Reformed pastor. Their future seemed mapped out: secure, lucrative and free of worries. But Zinsstag was bored.

Today, Zinsstag is a titular professor for epidemiology at the Swiss Tropical and Public Health Institute in Basel (Swiss TPH) - and his life could hardly be more exciting. He has just returned from a two-day oncology symposium of the Collegium Helveticum. Before that he and his team were in Ethiopia, where, together with local partners, he is aiming to document and improve the health provision of the nomads in the Ogaden, the ethnic Somali region in the south of the country. "Right from the start we've been out and about with mixed teams - physicians and veterinarians, but also specialists in pasture farming, ethnologists and other experts from the human sciences", he explains. "We want to find out: what is the nutritional situation of the children? Do pregnant women have access to midwives? What's the condition of the soil? And of the animals?" The results of

these surveys will enable them to develop ideas as to how they could adapt the health services on the spot to suit the needs of the local people.

"The biggest kick of all: change"

One Health is the name of this approach that encompasses human and veterinary medicine, food production and environmental conditions. Zinsstag is one of the most important representatives of this research field. He has published innumerable articles and a book about it, and above all he has initiated many projects in very different regions of the world - in Africa, Asia and Central America. All these projects are committed to the idea of One Health. He spends almost a third of his work-time travelling. "There are a lot of projects, but we always find a way somehow", he says earnestly as we march to the nearest café. His rolling gait reminds one a bit of the farmer he could well have become. Besides One Health, his projects have another common denominator: they're all transdisciplinary. In other words, the people on the ground are just as involved in the research as the Swiss scientists who've launched the projects. "For me, the academic world is a means to an end: it's not publishing that gives you the biggest kick of all: it's the change that I can bring about", he says.

Zinsstag left the veterinary practice in Porrentruy back then to sign up as a post-doc at Swiss TPH. Afterwards, he and his wife lived in West Africa with their four daughters - born between 1989 and 1996. Zinsstag was the project head at an international research centre for sleeping sickness in Gambia, then Director of the Centre Suisse de Recherches Scientifiques in Abidjan in Côte d'Ivoire.





“For me, the academic world is a means to an end”.

It was Marcel Tanner who fetched Zinsstag back to Switzerland. “I suggested he could set up a research programme for the nomadic population of Chad, focussing on the perspective of veterinary medicine. This was because the nomads live so close to their animals, and because zoonotic diseases are a huge global challenge. These are diseases that occur in both humans and animals”. Tanner is the long-serving Director of Swiss TPH, and he’s clearly still delighted at having won over Zinsstag back in 1998. “The idea behind it was to bring veterinary and human medicine together and to implement the concept of One Health”.

An ounce of prevention ...

The idea caught on. Working with funding from the SNSF, Zinsstag and his team discovered in their field studies that the cows in these nomadic communities had been inoculated, but the same was rarely true of their children. “So it was a natural solution to set up inoculation services for people and animals alike, using the same refrigeration chain and the same transport”. The data collected by the Basel researchers also helped to combat rabies in Chad. This disease threatens millions of people in Africa and is primarily carried by dogs. The problem is at its worst in the towns. “We developed a mathematical model that shows how proactively inoculating all dogs is more effective and cheaper than treating people after they’ve been bitten”, explains Zinsstag.

In 2012 and 2013 he and his team carried out a mass inoculation of 20,000 dogs in the capital city of N’Djamena. As a result, the rabies transmission rate in the city plummeted. They had their proof: “Rabies can indeed be eradicated – and this is a

goal that Africa aims to reach by the year 2030”. The commitment of the authorities in Chad was decisive, insists Zinsstag. They participated in the campaign by providing personnel and logistics.

In parallel with his activities out in the field, Zinsstag has continued with his academic career. In 2004 he was appointed assistant professor at the University of Basel, and in 2008 he was made two tempting offers: one from the University of Munich to take up a professorship in tropical veterinary medicine, and one from the University of Zurich as Professor of Epidemiology. He refused both, out of loyalty to Swiss TPH. “The working conditions here are unique”, he says. Zinsstag goes into raptures as he speaks, his eyes glistening as he describes his ‘epiphany’ when he realised that, as a vet, he could have access to the knowledge of 20 or 30 different disciplines and could use it to help the developing world.

It seems he did become a kind of missionary after all.

Irène Dietschi is a freelance science journalist in Zurich.

One doctor for all

Besides advocating One Health, Jakob Zinsstag is transdisciplinary in his work and employs local partners from other disciplines. At the Centre Suisse in Abidjan, he already achieved a paradigm shift, incorporating local researchers into what had hitherto been a destination for Swiss scientists.

Microbes: the farmer's new friends

In croplands, fungi and bacteria do both good and harm. Using molecular biological methods, researchers are trying to differentiate them from each other. *By Florian Fisch*

Humanity is facing considerable challenges in that it wants to produce more foodstuffs for the growing global population while causing only the minimum of damage to the environment", says Mark Bailey, who works at the Centre for Ecology and Hydrology in Wallingford, England. He's looking at the big picture - but his actual object of study is too small for the naked eye. He's researching into the community of bacteria, fungi and other microbes found in the soil.

Many specialist articles are talking of a revolution in soil microflora - one on par with the invention of agriculture 10,000 years ago, or the development of high-yield varieties 50 years ago. The current euphoria has been triggered by new molecular biological methods that can analyse whole microbial communities at once (see 'Identifying microbes by the metre').

"A single gram of soil can contain up to ten billion microorganisms".

Franco Widmer

In another habitat - the intestine - bacteria are already hitting the headlines. They help our digestion, protect us from illnesses and allergies, produce vitamins, and might even have an influence on our emotional state. In the USA, several projects have already been launched to study these communities. The Human Microbiome Project started back in 2008. In 2010, it was the soil that moved into focus with the Earth Microbiome Project. Bailey is participating in it. And in May 2016, the US government invested over USD 100 million in an overarching National Microbiome Initiative.

Dung brings variety

At the Swiss Federal Research Institute 'Agroscope' in Reckenholz, Franco Widmer is one of the experts for microbial diversity in the soil. It's a huge challenge: "A single

gram of soil can contain up to ten billion microorganisms belonging to some 7,000 different species". Together with a team from the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) and the Research Institute of Organic Agriculture (FiBL), he has been comparing the microflora in soils that have been cultivated for decades, either for organic or conventional agriculture. (See 'Arable farming in a long-term comparison').

They have thereby discovered that it is the type of fertiliser that has the biggest impact on microbes. Soil that has been fertilised with dung and liquid manure has a greater diversity of microbes than soil that has only been fertilised by minerals. If the soil hasn't been fertilised at all, it becomes home to yet other bacteria and fungi.

In a study that has not yet been published, Widmer and his researchers observed ten different soils in Switzerland for five years - from woodland to arable land and meadows. Here, too, the microbial diversity of species in the soil was seen to be characteristic of how the land was used. "Based on the microflora, we can tell you what type of soil it is", says Widmer. And the composition of the soil barely changed over the period of study.

Bacteria protect against fungi

In her lab at ETH Zurich, Monika Maurhofer is studying the influence of bacteria and fungi on the health of plants. "We know that there are soils that stimulate disease and others that suppress it", she says. The big question, however, is this: which of these many microbes have what function? As part of the National Research Programme 'Soil as a resource' (NRP 68), the researchers wanted to find out whether certain soil bacteria that are known for their antifungal activity - so-called pseudomonads - can indeed protect plants. To this end, they collected soil samples from ten different wheat fields and analysed them to see which of three pseudomonads were present. They determined whether the genes typical of the species were present. Subsequently, the soil samples were

planted with wheat again in the laboratory, two pathogenic fungi were added, and the effect of them was measured. As expected, there were big differences between the different soil types. There was also a connection with the presence of the pseudomonads - though it was rather weak.

"It's not a general rule that more diverse microflora necessarily mean healthier soil".

Monika Maurhofer

Diversity isn't everything

"It's obviously not quite so simple", concludes Maurhofer. "It would be ideal if we had indicator organisms to tell us whether a soil is suitable for wheat growing or not". Soil biologists are aware of historical tobacco monocultures in Morens near Payerne in the canton of Vaud where for decades - astonishingly - hardly any problems with pathogenic fungi have occurred. They would love to know what makes this soil so healthy. But one thing is clear to Maurhofer: "It's not a general rule that more diverse microflora necessarily mean healthier soil. A certain diversity is important, but we don't yet know which are the relevant species". So we're still a long way from a molecular-biological classification of the quality of arable land.

Back at the Earth Microbiome Project, Bailey agrees. "It's difficult to manipulate the microbiome by experimental means under field conditions". The role of the total microflora is difficult to determine. Despite the lack of clarity, he insists that "fertile arable surfaces also display the highest degree of bacterial diversity". A greater degree of diversity can bring more protective organisms, yet also more pathogens at the same time.

The health of the soil can certainly be influenced. Working the land by mechanical means brings about a greater compres-



The carrots in the drained moorlands of the Bernese Lake District also profit from a diverse microflora.

Photo: Agroscope (Gabriela Brändle, Urs Zihlmann) and LANAT (Andreas Chervet)

sion of the soil and thus less aeration. The concomitant shift in the microflora can be toxic to certain plants. So it's better to work the land without a plough. And varied crop rotation can also prevent a concentration of certain pathogens.

Even adding certain microbes can have a positive effect on the health of plants. For example, insect pests can be combatted biologically by adding threadworms. Good fungi can be used against ladybirds, and pseudomonads against bad fungi.

Cultivating symbiotic fungi

The best-known beneficial microbes are mycorrhizal fungi, which enter into a symbiosis with the roots of plants. In organic farming, the fungus spores have

long been sown alongside seeds. Ian Sanders of the University of Lausanne has gone one step further and invented a method by which these fungi can be cultivated specifically. Rice cultures in the laboratory and his initial field trials with cassava cultures have demonstrated impressive increases in yield.

In 2014, Sanders spoke of his dream in the podcast *Gastropod*: "For millennia, humans have been breeding plants by using natural genetic variations to increase their crop yield. There's no reason why we can't do this with the mycorrhizal fungus too". But this revolution, too, will take many years to come about.

Florian Fisch is a science editor at the SNSF.

Arable farming in a long-term comparison

Since 1978, a unique long-term comparison has been running in Therwil near Basel, featuring five different types of farming: bio-dynamic, bio-organic, conventional/integrated, conventional with mineral fertiliser only, and completely unfertilised. After running for almost 40 years, this DOC trial shows that the yield from organic farming is up to 20% less, depending on the culture in question. However, up to a total of 35% less energy has to be expended on it – including the production of manure and sprays. The trial is a collaboration between Agroscope and the research institute FiBL.

Identifying microbes by the metre

Using modern molecular biological methods, it's possible to identify almost all the bacteria and fungi in different habitats within the space of just a few days – whether in the human intestine or in the soil. It's done by searching for specific genes, according to which the microbes can be allocated to different groups. The result is an overview of the whole microbial community – the microbiome – and its diversity.

How the stomach talks to the brain

Our eating behaviour is influenced by the way our digestive tract communicates with our brain. If we can achieve a better understanding of the signalling pathways between them, it may help us find new treatments for obesity.

By Stéphane Praz

We eat because we're hungry - and for a thousand other reasons too: for pleasure, out of frustration, or because we're stressed. We've known for a long time that the digestive tract and the brain together determine our eating habits. And finding out how they do this is becoming increasingly relevant, given the current spread of overweight, obesity and type-2 diabetes.

However, the most efficient methods to reduce obesity today are all surgical interventions in the digestive tract: the gastric bypass, and the gastric sleeve that reduces stomach volume. "Surprisingly, while these alterations are completely different in anatomical terms, they have the same principal effect, namely a total and lasting rearrangement of the hormonal balance", explains Ralph Peterli, a visceral surgeon and researcher at the Claraspital in Basel. His team first succeeded in proving this in 2009, in a sleeve gastrectomy case.

"And then there's the role of the brain", says Peterli. "It's got to be involved, for instance, if patients suddenly don't want fatty foods any more after their operation, but instead have an appetite for vegetables". The researchers at the Claraspital are currently using functional magnetic resonance imaging (fMRI) to analyse how the brains of test subjects react to eating different foodstuffs.

Rats eat more, but less often

But how does the stomach actually send its signals to the brain? That's what Wolfgang Langhans is trying to find out. He's a physiologist at ETH Zurich. "If we knew this, it could help us to develop pharmacological strategies as an alternative to surgery - because surgery involves risks", says Langhans. One of the topics of his research is the role of 'glucagon-like peptide 1' (GLP-1), which has been known for some time to be an appetite-suppressing hormone. It is produced in large quantities as soon as the

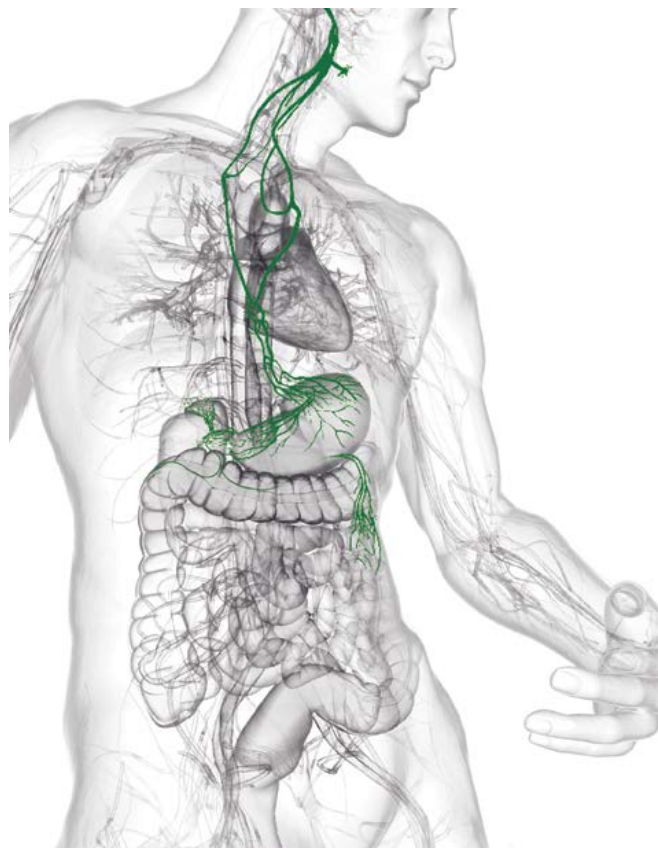
intestine is full of food. Just like all hormones, GLP-1 presumably travels through the bloodstream to the brain, where it has its impact. But Langhans and his team believe that GLP-1 also sends nerve signals by docking onto the GLP-1 receptors of the vagus nerve that connects the intestine to the brain.

"Surgery influences fifty or a hundred hormone mechanisms at the same time".

Ralph Peterli

In order to test their hypothesis, they used rats in which GLP-1 has the same function as in humans. The researchers injected viruses with genetically altered material - so-called viral vectors - into the vagus nerve of the animals. These viruses inhibit the production of GLP-1 receptors in the intestinal nerve cells. The number of receptors consequently fell by roughly half.

These downregulated GLP-1 nerve connections from the intestine to the brain indeed brought about a shift in eating behaviour. The rats ate for longer and ingested more at every mealtime, and afterwards they showed considerably higher levels



The vagus nerve (green) and the hormones work closely together to inform the brain about the state of the intestines.

Image: Bryan Christie Design

of blood sugar. However, the amount that they ate each day did not increase. They ate more at any one time, but less often.

Surgery has a longer impact

"The result might seem perhaps a little disappointing", says Langhans, "but in physiological terms it's fascinating. It confirms the role of GLP-1 and the vagus nerve in achieving satiety, but it also shows that the control mechanism for the ingestion of food is highly robust".

Peterli is also convinced of this. But this is precisely why he doubts that there will be a pharmacological alternative to his surgical procedures. "Surgery doesn't just have an impact on one or two hormones. It influences fifty or a hundred mechanisms at the same time. We don't even know most of them". However, he too can imagine that hormone products or receptor blockers could support the impact of an operation. So the practical implementation of active substances seems imminent. But the day when science will be able to offer a comprehensive explanation of the multifarious connections between the intestine and the brain still seems far off.

Stéphane Praz is a freelance science journalist.

J. P. Krieger et al.: Knockdown of GLP-1 Receptors in Vagal Afferents Affects Normal Food Intake and Glycemia. *Diabetes* (2016)



Stray dogs spread viruses across the land.

Computer models to combat rabies

Rabies has by no means been conquered. Every year, more than 55,000 people die of it in Africa and Asia. Experts believe that the virus will sooner or later manage to jump from Indonesia to Australia, which continues to be free of it for now. It could happen, say, through an infected dog travelling on a fishing boat.

The possible consequences are shown by a new computer model that Salome Dürr of the University of Bern has developed with colleagues from Australia. It simulates the spread of rabies in the dog population through bites, and aims to help the authorities develop a control strategy.

The biggest risk of transmission would come from the dogs that run free in the Aboriginal settlements of Northern Australia. In a field study, Dürr used GPS collars to analyse the movement habits of 69 dogs in six villages. Some of the dogs moved so far away from the villages that they would have been able to infect wild dogs. A survey identified a further risk factor: roughly half of the dog owners in these villages often take their dogs out on hunting expeditions.

According to the computer model, this degree of mobility would suffice to trigger an epidemic. "Without suitable countermeasures, rabies could spread like wildfire throughout Australia", fears Dürr. But her simulation also demonstrates that the swift implementation of a vaccination programme could halt an outbreak within just a few months. Other measures – such as confining the dogs or putting them on a leash – would be insufficient and difficult to implement.

This model is due to come into use in other countries soon – such as in Chad, where a battle against rabies is currently being fought in the capital city, N'Djamena. *Yvonne Vahlensieck*

E. G. Hudson et al.: A Survey of Dog Owners in Remote Northern Australian Indigenous Communities to Inform Rabies Incursion Planning. PLOS Neglected Tropical Diseases (2016)

Assembling new antibiotics

Humanity is running out of effective antibiotics because bacteria are becoming resistant to them. Now a team of researchers from Harvard University, USA, has developed a technique that could allow hundreds of potential new drugs to be made synthetically in a short space of time.

The standard method only allows new drugs to be created by making slight changes to the periphery of existing antibiotics. This is how so-called macrolide antibiotics were made.

In this method, extra groups of atoms are attached to the macrolide in order to create a new, though very similar molecule. "But it's a very inefficient method, and in the past 60 years it's only allowed for the discovery of six new antibiotics", says the process chemist Audrey Langlois, who was a postdoc with the Harvard project in its early stages, and today works for Novartis.

In their new approach, the researchers first dismantled the macrolides into many small components. Then they changed these fragments and subsequently assembled macrolides from them again. But this time, the resulting interior structure was very different.

In this manner, 350 new molecules have been created. In initial tests, some 80% of them displayed an antibiotic effect against bacteria. Two molecules were even able to kill off multi-resistant germs. This technique could now also be applied to other groups of antibiotics, such as penicillin. "Of course it always takes years until a drug is created from new combinations. But at least we now have material that we can work with", says Langlois. *Atlant Bieri*

I. B. Seiple et al.: A platform for the discovery of new macrolide antibiotics. Nature (2016)



Multi-resistant bacteria (right) are immune to a growing number of antibiotics.



The timing of its birth partly determines a child's powers of concentration when it goes to school.

Highly premature babies have different brain networks

Medical progress means that extremely premature infants – those born before the 28th week of pregnancy – rarely suffer severe brain damage today. Nevertheless, they still have problems at school. They're not as quick to learn, they are less able to concentrate, and they find it difficult to interpret the emotions of their fellow pupils. This can become a considerable burden to them and their environment in later life.

Researchers have been searching for the reasons behind this. They have now used diffusion MRI to study the connectome of affected children – in other words, all the connections among the nerve fibres in their brain. Using network analysis, the researchers were able to describe both the intensity of communication between nerve fibres within defined modules in the brain, and the degree of connectivity between these modules themselves.

Petra Hüppi of the Geneva University Hospital has been leading this project, and she sums up the results succinctly: "We have localised the origin of this behaviour behind the forehead". There are specific areas in the frontal lobes that are laid out in the early phases of development. In extremely premature and highly underweight babies, these areas are connected differently, both to each other and to the limbic system, than in babies born after a normal, full-term pregnancy. The frontal lobes and the limbic system are precisely the areas of the brain that are important for concentration skills and for interpreting emotions in later life.

In the coming years, Hüppi wants to use this data to help affected children. By utilising music and training programmes to help children to learn and concentrate, she intends to investigate whether targeted support between birth and the age of 13 can influence these areas of the brain. *Karin Hollricher*

E. Fisch-Gomez et al.: Brain network characterization of high-risk preterm-born school-age children. NeuroImage: Clinical (2016)

The right movement

Robotic prostheses need greater reliability and precision. This may be achieved using a database of natural movements to feed machine-learning algorithms.

By Geneviève Ruiz

Most amputees use purely aesthetic prostheses. They find it difficult to accept a robotic limb that is not only by and large complicated to use but also has somewhat unnatural motion. Most of the models on the market today can only execute a few simple gestures, for example opening and closing the fist, and often in a very jarring way. Furthermore, users can't always properly control the magnitude of the movement, which adds a safety risk to the mixture.

Scientists are therefore striving to bring prosthetic movements closer to those of the human body by using machine learning, a technique also used in artificial intelligence. Thanks to algorithms, prostheses are learning to carry out the right movements on the basis of observing natural ones.

Studying gestures

At the Institute of Information Systems at HES-SO Valais-Wallis, Sierre, Henning Müller is compiling the largest ever database of hand movements and making it available to the scientific community. It currently contains some 50 gestures measured from 78 subjects, both amputees and otherwise. "We have joined forces with physiotherapists who work with amputees on a daily basis", explains Müller. "This data will allow us to create algorithms that will increase prosthetic dexterity. This in turn will make the movements more acceptable to patients".

Another aspect of the project is better understanding the neuropsychological mechanisms at play. "We don't yet know the effect of an amputation on the brain", says Müller. "But this is key to creating intelligent prosthetics that patients will want to accept as part of their bodies". He is also trying to understand why some people can use their prosthetic limb better than others. What he has found so far is that the precision of movements increases with the age of the amputation and with the intensity of phantom limb pain (which



Amputees can control their movements better with a sensory prosthesis that uses an implant to send feedback to the brain.

Photo: Lifehand2/Patrizia Tocci

is linked to the loss of a limb). The answer is probably related to the greater nervous-system connectivity.

"We do not yet know the effect of an amputation on the brain".

Henning Müller

Error-driven learning

Machine learning is also at the heart of José Millán's work. In 2010, this EPFL researcher developed a wheelchair that was driveable using thought. It used an electrode-filled headset that measured the brain's neural impulses. He has since developed further brain-machine interfaces that learn for themselves how to manipulate a robotic arm correctly. "The brain also emits a specific electronic impulse when we fail to make a movement", he explains. His device decodes an error signal and transmits it to the artificial arm, which distinguishes between correct or incorrect movements, and in that way creates a database of actions. "This approach allows us to obtain results more quickly. Without it, the patient has to

learn the equivalent of a new motor skill, which takes much more time, as our experience as children shows".

Other researchers are using implants that place the machine directly between the inner workings of the brain and the peripheral nerves of the arm. For example, Silvestro Micera (EPFL Center for Neuroprosthetics) first succeeded in restoring the sense of touch to an amputee in 2014. The artificial hand transforms sensorial information into an electric current which is converted into nerve impulses by electrodes grafted into the patient's arm. Micera is convinced that in future all prosthetics will be connected to an implant. "For a patient to integrate their prosthesis, it's important for them to have natural senses, and we get the best results with implants". One fundamental question remains, however: will amputees accept an artificial limb integrated so intimately into the body?

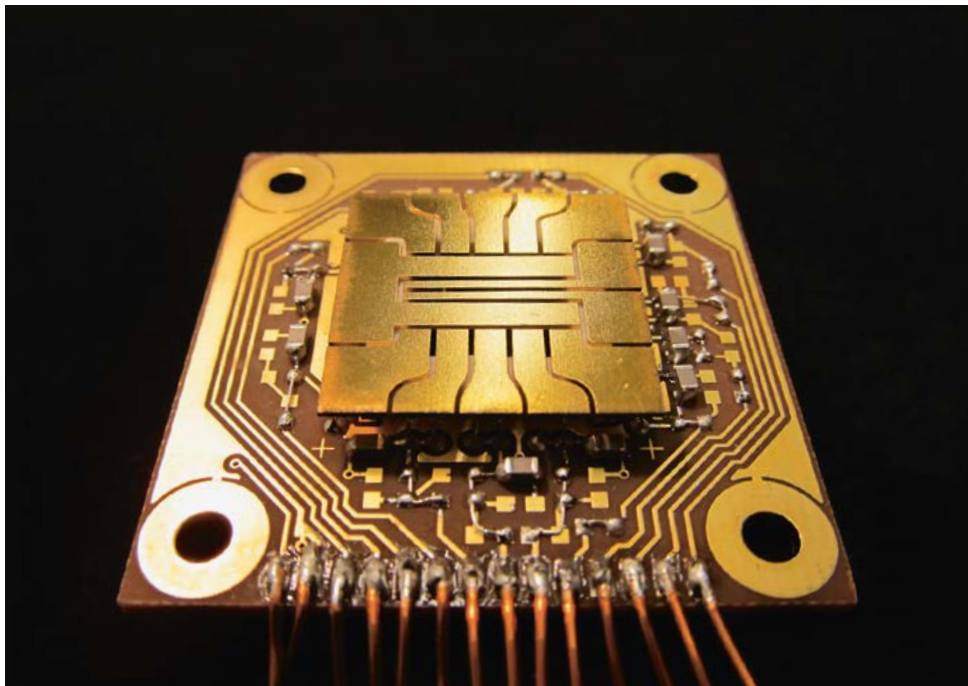
Geneviève Ruiz is based in Nyon and is a journalist and chief editor at the magazine *Hemisphères*.

M. Atzori et al.: Effect of clinical parameters on the control of myoelectric robotic prosthetic hands. *Journal of Rehabilitation Research & Development* (2016); doi: 10.1682/JRRD.2014.09.0218

A quantum leap for industry

The EU is providing one billion euros to develop quantum technology in a new flagship programme. Swiss scientists are already working to take it from the lab to the marketplace.

By Edwin Cartlidge



This chip, developed at the University of Basel, catches atoms and freezes them to -275° Celsius. Such equipment could one day store quantum information. Photo: Stefan Willitsch

Quantum computing is a beguiling idea. Whereas classical computers encode data in the form of digital bits, the strange laws of the microscopic world allow quantum bits (or ‘qubits’) to exist as a ‘0’ and ‘1’ at the same time and also to be ‘entangled’ with one another. These properties mean that quantum computers could, in principle at least, operate simultaneously on all the possible values held by a set of qubits, so making them exponentially faster than today’s devices when processing certain problems.

When it comes to fundamental research on these computers - or on other quantum technology, such as cryptography and sensing - Switzerland has become a prominent country. In the latest available international citation ranking on quantum science, published by the consultancy Technopolis in 2011, Switzerland came out top along with Austria. And for the past five years, groups at universities across the country have been linked together as a National Centre of Competence in Research in Quantum Science and Technology (QSIT) run by the SNSF, joint publishers of this magazine.

Quantum people next door

The country’s strength is its breadth of research, both across and within individual institutions, argues Klaus Ensslin of ETH Zurich, who heads NCCR QSIT. “If I

walk ten metres from my office, I meet quantum people who work on a variety of physical systems”, he says, “whereas I think elsewhere in Europe centres are more specialised”.

However, Ensslin and many others in the field say that Swiss institutions are less good at converting this scientific knowledge into commercial products. Daniel Loss of the University of Basel notes that universities in a number of other countries - including the Netherlands, Denmark, Japan and Australia - receive funding specifically targeted to the construction of a quantum computer. Such funding in Switzerland, he says, is “somewhat lacking”.

“It is no longer time to wait”.

Nicolas Gisin

The country already has one clear quantum success story: ID Quantique, a company spun off from the University of Geneva, sells cryptographic equipment and single-photon detectors. The former allows confidential messages to be encrypted and decrypted using a secret ‘key’ comprising the quantum states of a series of photons. Quantum mechanics dictates that anyone trying to eavesdrop will automatically reveal their presence by changing the key, making such encryption in principle

uncrackable. Set up in 2001, the company now sells its technology for a profit to banks, multinationals and governments around the world.

Other companies, however, have yet to follow suit. One of the founders of ID Quantique, Nicolas Gisin of the University of Geneva, points out that while quantum technology is being developed by the US companies Google, Microsoft and IBM and by the Japanese firm Toshiba, no large Swiss firm is doing likewise. He hopes this will be changed by a new EUR 1 billion ‘flagship’ project to develop and commercialise such technology, announced by the European Union in April. “Quantum information will revolutionise computing and communications over the next two decades”, he says. “It is no longer time to wait”. Loss agrees, hoping that Switzerland participates in the new flagship, or sets up its own analogous programme, or does both.

Size matters

For most of the time since the field’s inception about three decades ago, research on quantum computers has been largely academic. But in recent years physicists have made major improvements to the vital error-correction schemes needed to compensate for the destruction of delicate quantum states by outside interference. Researchers are now on the verge of making logic gates that operate reliably enough

(continued on page 46)

The promises of quantum technologies

Based on the unusual behaviour of microscopic quantum objects, new technology aims to bring radical computing capacity and bulletproof encryption.

Journalist: Daniel Saraga

Infographics: onlab, Thibaud Tissot

Gravitation

Based on the wave nature of atoms, atom interferometers can detect minute changes in the gravitational field, which can be useful as gyroscopes for inertial navigation (e.g., for submarines) or in geological surveys for mineral or oil.

Timekeeping

Clocks built on entangled qubits are already more accurate than the usual atomic clocks used in GPS satellites, and better for defining the official duration of a second.

Microscopy

A new imaging device using entangled photons could improve microscopy in low light.

Magnetic sensor

A crystal defect found in diamonds acts as an isolated artificial atom sensitive to extremely weak magnetic fields, useful for medical imaging or oil exploration. This sensor would replace SQUID, an existing quantum technology based on superconducting materials but only functional at -170°C .

Long term

Next decades

Present

Quantum sensing
The detection limit

Secure messaging

Quantum encryption has been implemented many times using optical fibres over distances greater than 100 km. In August 2016 China placed equipment into orbit to test satellite-based quantum cryptography.



A timeline for new technologies

Quantum sensing

The wave nature of quantum matter is extremely delicate and sensitive to its environment. Measuring how fast it decays (the decoherence) allows it to detect and quantify incredibly weak signals.

Quantum communication

Entangled photons (light particles) can be used for encryption. A sender and a receiver create and instantaneously share a random succession of bits (011011101011 ...), which acts as a secret key to encode a message. The latter is sent by conventional means, but only the receiver can decode it, as only she holds the key.

Quantum computers

Information stored as quantum bits (qubits) is very fragile, but quantum entanglement and parallelism in principle allow us to solve certain problems far quicker than with usual computers.

Quantum internet

Long distance transmission of qubits could be used to create a secure web. Circumventing signal losses would, however, require quantum repeaters – devices that do not yet exist. Improved single photon sources and detectors would also be needed to increase bandwidth.

A quantum Switzerland



With a CHF 115 million budget for 2011–2018, the research programme NCCR Quantum Science & Technology involves five universities and IBM Zurich.

The University of Geneva and its startup ID Quantique are world leaders in quantum cryptography.

The University of Basel has pioneered quantum computers in semiconductors and measurements at the atomic scale.

ETH Zurich scientists are an authority on D-Wave, work on various quantum computers and fix loopholes in quantum cryptography.

A universal machine

A genuine quantum computer would, in addition, solve algebraic problems such as factorising numbers (useful to crack current encryption protocols) and searching databases. It would require thousands or millions of individually addressable qubits.

Quantum simulators

Basic quantum computers will be able to imitate other molecular systems, which is impossible on standard computers. So-called quantum annealers could solve optimisation problems (such as finding the quickest route).

First steps

The best laboratory machines can control just a dozen qubits. The company D-Wave rents machines with 1,152 qubits, but its claims of quantum speed beyond standard computers have been invalidated.

Present

Next decades

Long term



Quantum computing

Calculating with quantum

communication messaging

Harnessing strange properties

Wave and particles

Very small objects such as electrons, atoms or photons exhibit quantum behaviour that can be manipulated – provided they are extremely well isolated from their environment.

Quantum information

Digital information can be stored in quantum bits or qubits, defined, for example, by the rotational direction of an electron or the energy level of an atom.

Superposition

One qubit can represent both 0 and 1 at the same time and with arbitrary weight.

Parallelism

Several qubits can be processed at the same time.

Entanglement

Entangled qubits share an intrinsic link: measuring one will instantaneously affect the other, whatever the distance.

so that errors don't spiral out of control as more qubits are added to a device, so opening up the prospect of scaling up today's tiny quantum computers - which consist of no more than about a dozen qubits - to ones containing hundreds, thousands or millions of qubits.

Physicists are also currently investigating a variety of different kinds of qubit. Loss carried out pioneering work on one of the leading candidates, known as spin qubits, having proposed in 1998 to encode data in the spin of electrons embedded in nanometre-sized pieces of semiconductor - systems known as 'quantum dots' (spin is a quantum-mechanical property describing the intrinsic rotation of a particle). Loss believes that these qubits are well-suited to building full-scale quantum computers because, he says, they are small and speedy, and also because they could exploit existing semiconductor manufacturing techniques.

“We will have to take a more engineering-based approach”.

Andreas Wallraff

Another solid-state technology is being investigated by Andreas Wallraff and colleagues at ETH Zurich. In this case qubits are encoded in the direction of electrical currents travelling around superconducting circuits - whether those currents travel clockwise, anti-clockwise or in both directions at the same time.

100 million qubits

However, solid-state qubits are not the only game in town. A group led by Jonathan Home, also at ETH Zurich, traps atomic ions in electric fields and then places the ions in superposition states using laser beams. This technology currently holds the record for the most reliable logic gates and the highest number of entangled qubits, and Home argues that because ions are identical to one another, it simplifies scaling and allows the use of error correction based on symmetry.

Whichever technology wins out, however, commercialising it will be a mammoth task. A quantum computer large enough to crack today's Internet security by factorising the long numbers used to encrypt

communications - one of the most widely advertised and feared applications of these devices - would require more than 100 million qubits, according to estimates by John Martinis of the University of California, Santa Barbara, USA. Scaling up to that kind of level, says Wallraff, will be less a question of mastering physics and more a question of overcoming major technical hurdles, such as supplying enough laser beams or cooling the qubits. “We will have to take a more engineering-based approach to build these systems”, he says.

How quickly these challenges can be overcome depends on how much industry is willing to invest, says Loss. “It is tough if you are a small team with just one or two postdocs on temporary contracts”, he notes. “But if you have a large permanent staff working on these problems, it is obviously much easier to make progress”.

Secret keys

Quantum cryptography by comparison has been relatively easy to commercialise because it involves sending and detecting just one photon at a time, rather than entangling multiple quantum particles. While today it is mainly used in a stand-alone capacity to connect organisations' main computer centres and back-up systems, Gisin envisages that quantum links in future could be established between Switzerland's largest cities. Internet users, he says, could then choose whether to connect via cheap but relatively insecure classical protocols or instead using quantum cryptography.

Measuring at the limit

Another technology being primed for markets is that of quantum sensing. Patrick Maletinsky and colleagues at the University of Basel place individual electron spins (created by adding nitrogen atoms to diamond) on the tip of an atomic force microscope (AFM) in order to detect any weak magnetic fields close to the tip. The rate of spin precession is proportional to the strength of that field, allowing very sensitive quantitative imaging on scales of nanometres.

Maletinsky says the technique could be used to map tiny spatial variations in the stray fields of thin magnetic films, which are important for data storage. Alternatively, he says, it could be employed to look at vortices in superconductors, relevant for technological applications such as MRI machines. In the life sciences, meanwhile,

the technique could potentially determine the structure of individual protein molecules (which contain nuclear spins that create very small magnetic fields). Maletinsky says his group should have set up a company to commercialise the AFM diamond tips by the end of this year, then have its sensor on the market “within the next year or two”.

The commercialisation of quantum computers is going to be a huge challenge.

The Holy Grail

In fact, even quantum computers have entered the market place. In 2007, the Canadian company D-Wave unveiled a 'quantum annealer' that can run optimisation programs and which, in its latest incarnation, boasts 1,000 superconducting qubits. The firm has leased machines for a million dollars apiece to NASA, Google and defence giant Lockheed Martin, but its technology has been and remains controversial. Many have doubted the extent to which it really uses quantum mechanics, while Matthias Troyer of ETH Zurich and other researchers in 2014 showed that it could operate no quicker than classical computers.

The first bona fide quantum computer that can carry out useful operations impossible to perform on a classical device is expected in about ten years, says Wallraff. That computer, he says, would contain perhaps a few hundred qubits and would likely be used to carry out simulations of small molecules and other quantum systems.

But Loss says that the 'holy grail' of quantum information science remains the construction of a fully-fledged 'universal' quantum computer capable of advanced operations like factorising large numbers. Now that industry is interested, he argues, that aim can at last be realised. He just hopes that Swiss and other European companies will join their American counterparts in the chase.

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

Munching maggots

In tropical countries, organic waste can be turned into compost quicker by using maggots. Not only does this improve hygiene conditions and increase soil fertility, but the maggots can even end up as valuable fish feed.

By Simon Koechlin



These soldier fly maggots are a nutritious delicacy for chickens, fish and other animals.

Photo: FiBL

The black soldier fly is a veritable eating machine - at least in its larval stage. Despite its rather martial name, it's not an insect that would ever do anyone any harm. Its larvae feed on rotting organic material such as food scraps or dung. "They can reduce most of just about any type of organic waste in a short space of time", says Noah Adamtey from the Research Institute of Organic Agriculture (FiBL) in Frick.

Adamtey is running the scientific section of a project that aims to employ the appetite of soldier fly larvae (*Hermetia illucens*) in developing countries. It is being implemented in the greater metropolitan area of Accra, the capital city of Ghana. "Just as in other big cities in tropical regions, composting is poor in Accra", says Adamtey. On the one hand this leads to immense hygiene problems because organic waste makes up more than half of the total refuse in developing countries. On the other hand, it's also a waste of natural resources - because while the rapidly increasing population is dependent on productive agriculture, the soil is exhausted and not very fertile.

Feed for fish, chickens and songbirds

This is why, in collaboration with Ghanaian colleagues in Accra, researchers at FiBL want to make composting worthwhile for the local population. To do this, organic waste is fed to tiny soldier fly maggots. Because they chew up the waste in record time, says Adamtey, composting time is

reduced by roughly a third to less than 80 days. Farmers can then use the valuable compost in their fields. An additional goal of the project is to provide a further use for the maggots of the soldier fly - as feed for fish farmers, who find it difficult to meet the Ghanaian population's appetite for fish. "The larvae are an extremely interesting source of animal feed when you consider their protein and fat content, plus their amino acid profile", says Adamtey.

"If the waste can't be used profitably, huge mountains of garbage lie around".

Stefan Diener

Stefan Diener agrees - he's studying the waste recycling properties of the black soldier fly at the Swiss Federal Institute of Aquatic Science and Technology (Eawag) in Dübendorf. For example, he sees potential in selling dried larvae to chicken breeders in Uganda, who traditionally mix their feed themselves. An Eawag project in Indonesia is also planned that will sell the living larvae to local songbird owners.

The most important aspect of such projects is to provide value to organic waste in developing countries, says Diener. "If the waste can't be used profitably, then huge mountains of garbage lie around and turn into a massive, stinking problem". But it depends on local conditions whether or

not the soldier fly is the best solution. "If the energy demand in a region is very high, biogas could be more profitable, for example". The organic waste would then be turned primarily into methane.

When larvae chew on scrap metal

You also have to make precise checks as to what the pitfalls might be in individual cases, says Diener. Because soldier fly composting means you have to produce fly eggs continually on the spot and have a rational separation process to separate the mature maggots from the compost. "And you have to be certain that the customers buying the larvae will accept animal feed that's been produced from waste". If these conditions can be met, then the soldier fly has great potential.

This is the case in Accra, where Adamtey says the FiBL project is on track. The basic biological checks have meanwhile been completed, he says, and guidelines for the local population are being drawn up to inform them how to make compost with soldier flies. One problem remains, however; in Ghana, organic waste is often not separated from inorganic waste. This makes composting more difficult. Because when they eat plastic, glass or electronics, the larvae of the black soldier flies ruin their mouths.

Simon Koechlin is a science journalist and chief editor of Tierwelt.

Belts for diabetics

What is the best way to measure blood glucose in diabetic patients? One very popular and precise method is testing blood by using a small needle to puncture the index finger. But it is painful and it cannot provide continuous monitoring, thereby adding an element of danger. “With this method, some diabetics experience hypoglycaemia without knowing about it”, explains Jean-Eudes Ranvier, a doctoral student of the Distributed Information Systems Laboratory at EPFL.

Alongside colleagues from HES-SO Valais-Wallis, Ranvier is working to perfect a new method for real-time glycaemia monitoring that will be able to detect these events. An estimate is established by taking into account the patient’s food intake, which is entered into a smartphone app, and energy expenditure, which is evaluated by a cardio-belt worn by the patient throughout the day. The belt also registers physical movement and breathing frequency, completing an overall assessment of physiological activity. Furthermore, it registers an electrocardiogram, which is known to be sensitive to hypoglycaemia.

Every five minutes, this combined information is uploaded to a remote server via the smartphone. “We’ve developed a model based on a semantic approach, in other words, one that is capable of finding meaning in this raw data and deducing the presence of hypoglycaemia”, says Ranvier. When it detects such an event, a notification is sent back to the patient’s smartphone to alert them quickly. The model still needs to be fed more data from diabetic volunteers, so as to boost its precision. Acquiring that data should be finished in the coming months. *Fabien Goubet*

J.-E. Ranvier et al.: Detection of Hypoglycemic Events through Wearable Sensors, Proceedings SEMPER 2016



This fitness belt warns of low blood sugar - but without needing a blood sample.

Jean-Eudes Ranvier



This probe is used to extract sediment samples from the seabed.

Studying prehistoric life through barium

Roughly three-quarters of the world’s oxygen is produced in the top few metres of the oceans. When researchers want to measure the biological productivity of the surface waters of prehistoric oceans millions of years ago, they analyse what has been deposited at the bottom of the sea. Since 2010, geoscientists from the University of Bern and the US Geological Survey have been investigating barium (Ba) in order to develop a new method for learning about ancient life.

Although barium isn’t an essential element for living creatures, organisms incorporate tiny amounts of it in their calcareous shells in place of calcium (Ca). The relationship between barium and calcium in limestone is a measuring rod for determining the amount of nutrients that used to exist in the surface waters of the ocean. This in turn lets us draw conclusions about the life that was active there.

Because some barium is actually washed back out of the sediment, however, the results risk being distorted. So the researchers are investigating how barium atoms of different weight are distributed. More of the heavy isotopes remain, and fewer of the lighter isotopes. “We want to establish barium as a geochemical fingerprint”, says Thomas Nägler, who leads the team from Bern.

“In order to be able to analyse the traces of life in the ocean sediment properly, we have to understand how ocean deposits of barium isotopes are affected today”. Using a series of standard measurements, the researchers have now ensured that their measurements are internationally comparable. Nägler admits, however, that “it’s still anyone’s guess whether or not our methods will one day really be practicable”. *Florian Fisch*

K. van Zuilen et al.: Barium Isotopic Compositions of Geological Reference Materials. Geostandards and Geoanalytical Research (2016)

Kirsten van Zuilen

Trees get more nitrogen

Among researchers, hardly anyone will dispute the fact that the Earth is getting warmer. But no one really knows what impact climate change is going to have on our ecosystems. As part of a team led by Melissa Dawes of the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), ecologists have been investigating the influence of higher temperatures on the circulation of nitrogen in the soil - something that’s essential for the growth of plants.

In a long-term study carried out over six years on the Stillberg research area near Davos, the researchers heated more than 40 square metres of earth by more than four degrees Celsius. By constantly measuring the nitrogen content of the soil, they were able to demonstrate that higher temperatures increased the rate at which nitrogen circulated between the soil and the plants.

Such an acceleration leads to a surfeit of mineral nitrogen in the ground. In the cold, nutrient-poor ground at the alpine treeline, this effect is particularly striking. The researchers accordingly observed that mountain pines and blueberry bushes grew more vigorously there - at least at first. After four years, however, the excess nitrogen disappeared and the original values returned. One explanation, says Dawes, could be that the plants reacted to the initial increase by taking in more of the nutrient - in other words, they simply used up the surplus.

This turnaround was only discovered thanks to the long duration of the study, explains Christian Körner from the University of Basel. “Our crucial message is that the changes in nitrogen circulation are not just short-term”. Furthermore, different species react differently, says Dawes. “If individual plants profit from climate change, then society will have to change as well, which again will have an impact on the ecosystem with its plants and animals”. *Martin Angler*

M. A. Dawes et al.: Soil warming opens the nitrogen cycle at the alpine treeline. Global Change Biology (2016)



On the Stillberg outside Davos, 40 square metres of forest soil are being heated.

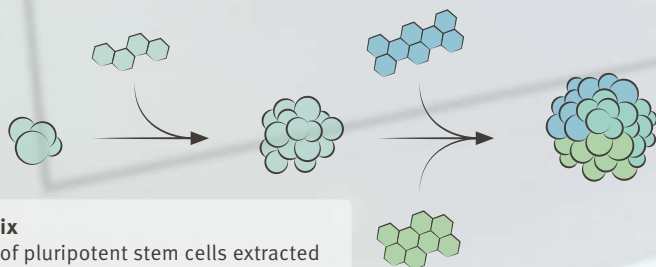
Nicholas Dawes

In vitro goes 3D

Several Swiss startups are developing cell tissues in three dimensions. Compared to standard 2D cultures, they offer more reliable testbeds for pharmaceuticals, biocompatible materials and toxicology assessments.

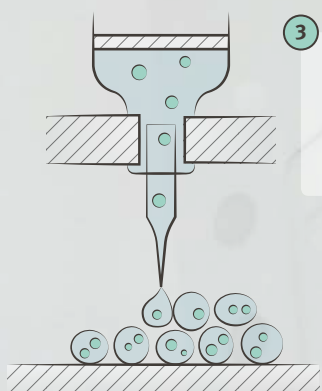
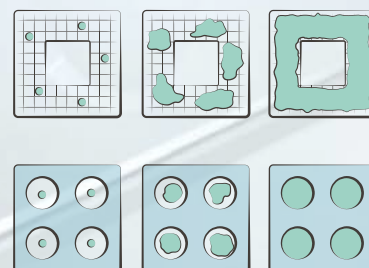
Journalist: Daniel Saraga

Infographic: ikonaut

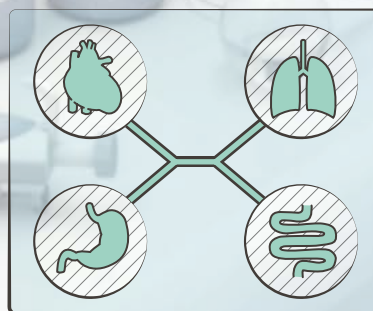


1 The right mix
The growth of pluripotent stem cells extracted from an organ can be stimulated by hormones, e.g., steroids. Then additional hormones kick-start the differentiation of stem cells in different tissues, creating a rudimentary 'miniature organ' or organoid. Rotation/agitation helps spread the cells to create a 3D structure.

2 Scaffolds to pilot expansion
New cells fill cavities formed from scaffolds or other materials, e.g., hydrogels. For tissues to be reimplanted, they must be made of biodegradable materials or be directly fabricated by the cells, like cartilage.



3 3D printing
A 3D printer builds the structure layer by layer by adding cells and a liquid to provide oxygen and nutrients.



4 Organs on chips
Microfluidic channels connect the cell cultures of different organs, mimicking the exchanges between organs in the body. This will allow for more reliable testing of substances which are processed first by one organ (such as the liver or kidneys) before reaching others. No Swiss startup has yet to commercialise such a product.

The challenges
Quality control is hard to ensure, says the tissue engineering specialist Stephanie Mathes of the Zurich University of Applied Sciences. "It's not easy to image and characterise dynamic three dimensional structures non-destructively. Commonly used methods for 2D cultures cannot simply be transferred". As blood vessels are usually missing, growth is limited by the accumulation of waste products and the lack of oxygen and nutrients within the structure. Creating artificial blood vessels or mimicking them with microfluidics could help.

Swiss startups	
Neurix (2011): minibrains	1
InSphero (2009): hanging droplets for organoids	1
Elanix (2012): connective tissues for transplantation	1
Celtec Biotek (2011): bioreactors	1 2
CellSpring (2015): ingredients for scaffold synthesis	2
Sun Bioscience (2016): hydrogel scaffolds	2
Qgel (2009): 3D tumors	2
Regenhu (2007): 3D bioprinters	3

A research network for one and all

By Maurice Campagna

Developments in the life sciences affect every one of us - and on a very intimate level. Personalised medicine is changing both our approach to sickness and health, and our understanding of them. In basic research and clinical research projects at ETH Zurich, EPFL and Swiss universities and hospitals, huge volumes of personal data are generated. Information on a genetic level flows together with clinical data and information from biobanks.

But how can we evaluate all this information securely and meaningfully, so that each individual patient can profit from improved preventive measures, drugs and therapies? How can the data be made available to society so that - for example - rare diseases can be detected earlier without

disproportionate costs? The excellent research conducted at Switzerland's research institutions is constantly bringing forth new results and new methods that make our country stand out on the international scene. But the challenges that face researchers in our tertiary institutions and hospitals are immense: they have to be able to analyse their data meaningfully. Data exchange and interoperability are essential for progress to be made, and they have to be guaranteed. Data storage has to be secure, data quality cannot suffer in the process, and ownership rights have to be clarified.

The Swiss Academies of Arts and Sciences are committed to illuminating the topic of personal health from different perspectives and with scientific transparency. The Swiss Personal Health Network was formed in 2014, in

which all the important stakeholders are represented. This network is intended to ensure that progress made in the molecular life sciences and in IT is made accessible to our universities and industry, where it should help to promote research and innovation. The aim is to prevent researchers from duplicating the efforts of others, and to avoid the dead-ends of regional data graveyards. Instead, we want to provide the basic data needed for future cutting-edge research and a better health provision in Switzerland.

Institutions and top researchers alike have recognised the leading role played by the Swiss Academy of Medical Sciences (SAMW). In collaboration with the Swiss Institute of Bioinformatics (SIB), the SAMW will be responsible for overall coordination of this network from 2017 to 2020. The knowledge of all the academies and competence centres can be brought together within the framework of this national funding initiative. The expertise of this network encompassing 100,000 people has precisely this responsibility: bringing projects and stakeholders together across existing boundaries to form a single network. Especially with such a 'personal' topic as personalised medicine, we have to be able to count on the total of our collective knowledge.

Since 1 January 2016, Maurice Campagna has been the President of the Swiss Academies of Arts and Sciences.

Valérie Chételat



14 September 2016

Living together

Experts discuss how communities can profit from civic initiatives on demographic change
[University of Fribourg](#)

13 and 14 September 2016

Climate protection and energy efficiency

Clean-tech innovators - from scientists to investors - are meeting under the motto 'Building Tomorrow'
[Kursaal Bern](#)

8 October 2016

Powered exoskeleton race

A world first: at the first-ever Cybathlon, paraplegic pilots will compete on parallel tracks in six demanding disciplines
[ETH Zurich](#)

12 to 14 October 2016

At the limit

This annual dialogue on science will discuss the benefits and risks of scientific frontiers
[Academia Engelberg](#)

Until December 2016

Mediaeval factory

This exhibition for children aims to explain the underrated creativity of the Middle Ages
[Espace des inventions, Lausanne](#)

Until February 2017

If you rest, you rust!

Muscles, sinews, fasciae: this exhibition takes a closer look at the human motor system
[Anatomical Museum, Basel](#)

Until May 2017

What's the point?

Every month, the 'Banques publiques' organise discussions on topical science issues
[Musée d'histoire des sciences, Geneva](#)

Letters to the editor

Shouldering one's responsibilities

Horizons was right to discuss the liability of researchers with regard to the use of their discoveries (Editorial, Horizons 109, June 2016). The classic response to this issue used to be that they weren't responsible for what others (industry, governments) did with the results of scientific research. Although this may seem reasonable, it appears, however, to be falling shorter and shorter of meeting the exponential rise of science's potential to change and to 'disrupt'. Sufficient ethical con-

sideration (including in relation to social justice) must be given to foreseeable progress, and not just *a posteriori* but also prior to it happening. As with the editorial at hand, it's important to recall that "even research freedom has its limits", even if not everyone is pleased to hear it.

Jean Martin (Echandens, Vaud), former cantonal physician and member of the National Advisory Commission on Biomedical Ethics.

Scientists shouldn't believe

I find the question "Should we believe in parallel universes?" misplaced in a science magazine

(Horizons 109, June 2016, p. 8). Scientists aren't supposed to believe; they're supposed to analyse, formulate and validate hypotheses and theories using evidence and experimentation. Neither interviewee says anything else. Martin Rees says, "we should surely be open-minded about the possibility of many universes", and Carlo Rovelli, "maybe the multiverse idea will one day give us a serious testable prediction". Neither argues that they do or don't exist. Scientists shouldn't believe or invite others to do so. Nor should a research magazine.

Rolf Kickuth, (Gaiberg bei Heidelberg, Germany)

A networker to lead the Academies

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Claudia Appenzeller-Winterberger is the new Managing Director of the Swiss Academies of Arts and Sciences. She aims to strengthen the existing network between the four academies and their

two centres of excellence, and also to expand it by bringing in many stakeholders from across science and society. She was previously the Deputy Head of the Start-up and Entrepreneurship Division of the Commission for Technology and Innovation (CTI) and Managing Director of the Association of Swiss Scientific Olympiads.

Linking up biobanks

With its BioLink initiative, the SNSF wants to improve the network joining collections of biological samples. Researchers from all disciplines can apply for funding for IT systems. Their applications must be based on original, unique and timely scientific questions whose investigation critically depends on the networking of biobanks. The launch was announced in July 2016. Applications must be submitted by 23 September 2016.

Initial 'Investigator Initiated Clinical Trials' approved

The SNSF has approved the first nine Investigator Initiated Clinical Trials (IICT) on topics that are not normally the focus of research in the pharmaceutical industry. A total of CHF 12.6 million is being provided. Most of the studies will last between four and five years and involve between 100 and 400 patients. A total of 75 applications were submitted, testifying to the great interest in this special programme. A second call for the IICT programme will be launched in August 2016.

Call for proposals for the 'Sustainable economy' NRP

The National Research Programme 'Sustainable economy: resource-friendly, future-oriented, innovative' (NRP 73) has a new website. Interested researchers can submit their pre-proposals by 26 September 2016.

Gottfried Schatz's last lecture

The biochemist Gottfried Schatz, formerly the President of the Swiss Science and Technology Council, died in 2015. He was no longer able to give his last lecture, on the current unhealthy growth of knowledge. Its manuscript has now been published in the series 'Swiss Academies Communications'. He argues that less knowledge and more science should be taught in our kindergartens, schools and universities.

Plant breeding beyond regulation



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In the factsheet 'New plant breeding techniques for Swiss agriculture - significant potential, uncertain future', the Swiss Academies of Arts and Sciences analyse new, precise techniques for genetic alterations in the light of Swiss genetics legislation. The authors are from the Forum for Genetic Research and conclude that there is no scientific reason for the strict regulation of plants cultivated in this manner - as long as safety is guaranteed.

François Baumgartner elected new deputy director of the SNSF

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The Executive Committee of the Foundation Council of the SNSF has appointed François Baumgartner as its new deputy director. In recent years he worked at the Federal Statistical Office as deputy director, interim director and head of the 'Health and Social Affairs' division. On 1 September 2016 he will succeed Angelika Kalt, who became director of the SNSF in April 2016. François Baumgartner has a PhD in geophysics and a master's degree in public administration.

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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.

“Whoever invests the most work becomes the project leader, regardless of where they are in the world”.

Alice Williamson page 14

“Physics can be simple and beautiful”.

Chenkai Mao page 24

“For me, the academic world is a means to an end”.

Jakob Zinsstag page 36