

البحث

研究

연구



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Limited printed edition  
in English

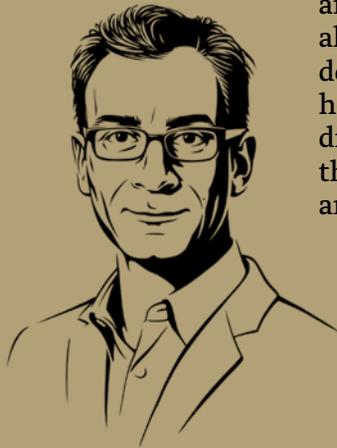
## Multilateral science

These days, one scientific study out of twelve comes from China. The growth of scientific production in Asia is unprecedented, and it has already upset the world's research scene.

In this quest for knowledge, advantages abound under authoritarian systems of government. In particular, they allow for the rapid implementation of enormous nationwide programmes, such as personalised medicine and cloning in China, the 'creative economy' in South Korea, or the gleaming new technological institutes in Saudi Arabia.

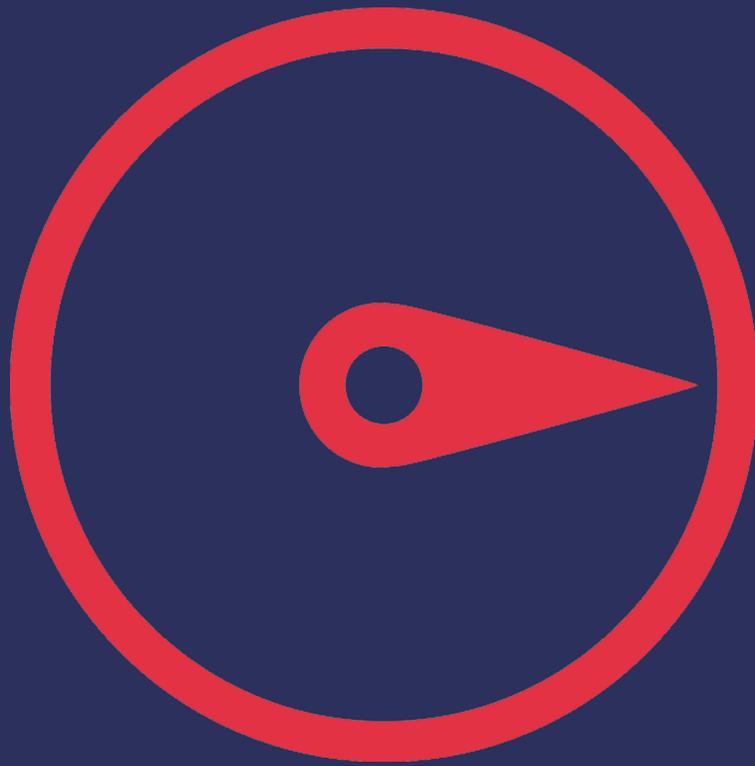
All these science-hungry countries are investing heavily in R&D. They are also all developing strategies to increase their competitiveness. Some offer more flexible regulations for life science research. Others focus on applied research by bringing together public institutions and private actors, or by putting money on the table not only to attract researchers from the world's best universities, but also to encourage those same universities to open satellite campuses. With so many new models around, the West may find its own research support policies confronted, or even influenced.

The world's new science powers are still focusing greatly on applied research, largely neglecting the humanities and social sciences, and sometimes stifling critical studies. This utilitarian approach is alarming. The challenge "We will clone a human before you!" - laid down by a Chinese researcher following a sumptuous dinner - shows how the new world order of science is being reshaped by ideas diametrically opposed to our own ethical considerations. Faced with this situation, our response should not be one of disdain, but one of anticipation: what will a global and multilateral science mean for us?



Daniel Saraga, chief editor

# horizons

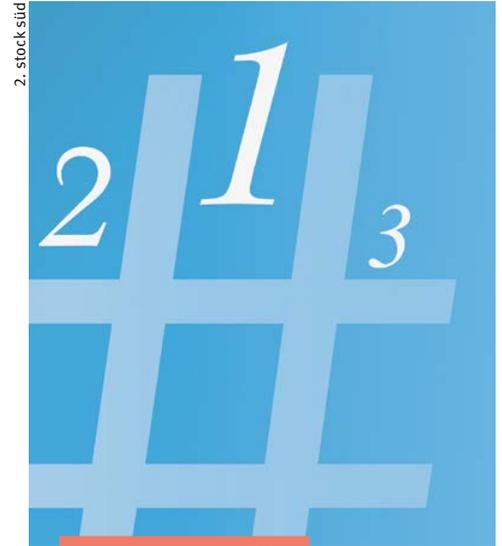


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Courtesy of KAUST

Focus: Eastward bound



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Knowledge and politics

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Image: 2. Stock süd

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Image: 2. Stock süd

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## Between life and death

Are they asleep, or lying in a mass grave? In Henry Moore's 'Shelter drawings' of 1940/41, we are shown Londoners in the city's Underground stations seeking refuge from Hitler's bombs during the Blitz. They're gaunt, ashen and packed tightly together. But these drawings offer little sense of 'shelter', exuding instead the aura of a sepulchre.

"Since metro systems first opened, they have been associated with death", explains Benedikt Tremp, who is doing his doctorate at the University of Lausanne through the 'Mediality' National Centre of Competence in Research (NCCR). Using literary and iconographical sources, he is investigating forms of aestheticisation of this modern means of transport. Its societal status has been ambivalent ever since it rose to popularity at the end of the 19<sup>th</sup> century and it has changed whole cities in the process. Celebrated by its adherents as a symbol of progress, denounced by its opponents as a sign of social self-destruction, the metro system opened up a new space for the imagination: the act of moving under the ground.

Wartime images such as those by Moore emphasise this dichotomy and are emblematic of contrary experiences. Whereas in London the considerable depth of the Underground did indeed save many lives, the U-Bahn in Berlin, for example, often became a death trap. "The lines often lay right underneath the asphalt, meaning that bombs could easily make them cave in". *hpa*

Image: Tube Shelter Perspective: The Liverpool Street Extension, Henry Moore, 1941. Reproduced with the permission of The Henry Moore Foundation

# Is glyphosate carcinogenic?

Glyphosate is the world's most widely used herbicide. While it's important in controlling weeds, its possible effects on humans are hotly debated among scientists.

Valérie Chételat & Binliam Ghezai (photomontage)



## Yes

says the environmental health researcher Christopher Portier

**H**ow strong is the evidence that humans are more likely to get cancer when widely exposed to glyphosate? This question centres on three issues: finding evidence in humans, finding evidence in laboratory animals and finding evidence of a molecular mechanism by which glyphosate might cause cancer.

Some 26 cancer studies have been carried out on humans who have been exposed to glyphosate formulations. Most of them found no connection. Nine of these studies examined non-Hodgkin lymphoma. Four case-control studies, when pooled, showed there to be an association between this cancer and glyphosate, as did two other case-control studies. The studies of higher quality adjusted for multiple exposures to other pesticides but still demonstrated an association, with the length of exposure increasing the strength of the association. However, these studies had certain limitations that made it impossible to rule out bias or other confounding factors. The conclusion we must draw is that glyphosate formulations are associated with non-Hodgkin lymphoma in humans, but there is only limited evidence of causality.

Five laboratory studies were carried out on mice, and nine on rats. All five of the mouse studies displayed increased tumour growth in at least one site. Three studies showed growth in kidney tumours, which rarely occur in mice; two studies showed an increase in hemangiosarcomas (a cancer arising in the blood vessels); and two studies also showed growth in malignant lymphomas. With the exception of growth in a few non-malignant tumours, none of the rat studies showed any effect. The conclusion is that glyphosate causes various tumours in laboratory mice.

“There is evidence of a mechanism by which glyphosate causes cancer”.

Christopher Portier

As to the molecular mechanism, publicly available data demonstrates that glyphosate and glyphosate formulations cause DNA damage in human and animal cells as well as in laboratory animals, but so far not

in bacterial cells. In two studies, glyphosate formulations also induced DNA damage in the blood cells of exposed humans. In human and other cells, glyphosate and glyphosate formulations have been shown to induce free oxygen radicals that are capable of damaging DNA. The conclusion is that there is indeed evidence of a mechanism by which glyphosate causes cancer.

From all this information, it is reasonable to conclude that, at sufficient levels of exposure, glyphosate and glyphosate formulations are probably carcinogenic to humans.

Christopher Portier is the former Director of the US National Institute of Environmental Health. He lives in Switzerland and wrote the ‘Open letter: Review of the Carcinogenicity of Glyphosate by EFSA and BfR’ to the European Commission that was signed by 95 scientists from around the world.



# No

says Jose Tarazona  
from the European  
Food Safety Authority

**T**he European Food Safety Authority (EFSA) has recently reviewed the toxicological profile of glyphosate and proposed new toxicological reference values for risk assessment. The EFSA did not confirm the recent classification of glyphosate as probably carcinogenic by the International Agency for Research on Cancer (IARC).

The IARC considered there to be “limited evidence in humans” for an association between glyphosate and non-Hodgkin lymphoma, while for the EFSA the evidence was insufficient to support such a classification. As the evidence from studies in humans alone had been insufficient for concluding that glyphosate is carcinogenic, the assessment of evidence in laboratory animals was key, and led to the different conclusions of the two bodies.

Significant trends in reports on industry-sponsored studies have been observed by the IARC. The EFSA searched the recent, large database of animal carcinogenicity studies in its entirety, but found no significant differences between control and treatment groups in the studies that were valid. Reviewing the biological relevance

of the incidences observed, the EFSA noted that the statistical trends were the result of bias, driven by secondary toxicity at excessively high doses, or chance results not related to glyphosate treatment.

“The lab results don't show a dose-response”.

Jose Tarazona

It is well known that excessive toxicity can affect the carcinogenic responses in bioassays. Such toxicity can cause effects such as cell death with associated regenerative cell proliferation. This can lead to tumour development as a secondary consequence, and is unrelated to the intrinsic potential of the substance to cause tumours at lower, less toxic doses.

The observed incidences were within the historical range observed in untreated animals. The laboratory results did not show a dose-response, and remain unconfirmed by equivalent studies at similar or higher doses. Therefore, besides the

absence of statistically significant differences with the concurrent controls, the observed tumour incidences also lacked biological relevance.

The EFSA also concluded that glyphosate is unlikely to cause DNA damage, as has been confirmed by a large number of studies showing no effect. However, effects were reported for glyphosate formulations containing other ingredients, and the EFSA's assessment of a surfactant frequently used in these formulations revealed some concerns. This led the EFSA to recommend carrying out further assessments regarding the possibility of DNA damage being caused by formulated products.

Jose Tarazona is the Head of the Pesticides Unit at the European Food Safety Authority (EFSA) and vice-chairman of the EU Scientific Committee on Health and Environmental Risks.



**Ewha Womans University, Seoul.** Photo: Keystone/Agence VU/Juan Manuel Castro Prieto

# The Asian frontier

As the West watches on, Asia is winning back the world's top minds with modern infrastructure and liberal ethics.



# The shifting sands of science

Research infrastructure in Asia is catching up with the West. From here, the main challenge for the region is to manoeuvre research out of rigid policy and into higher quality.

By *Mohammed Yahia*

In 2014, India became the first country to place a probe into orbit around Mars on the first attempt. A year later, Tu Youyou became the first Chinese Nobel Laureate in Physiology or Medicine. And Saudi Arabia has recently opened a 20-billion-dollar university focusing on science and technology. But just a few decades ago, these countries were still a long way from playing in the top science league.

Since the Renaissance, the West has been dominant in science and research, producing the bulk of humanity's knowledge in the meantime. In the past two decades, however, we have seen a dramatic shift in the science and research landscape. The East – especially Asia – has seen a sharp rise in research and technology, and this is driving its economic success.

“There is clearly a keen understanding in the leadership circles [in China] that science leads to innovation, which is seen as the best recipe to raise the income level of Chinese people”, says Pascal Marmier, CEO of Swissnex China, an outpost aimed at connecting Switzerland with the world's innovation hubs.

Neighbouring Singapore and India have both also set up ambitious national strategies to turn themselves into knowledge-based economies. Singapore has just announced an increase of 18% in its R&D budget for 2016 compared to 2011 – 2015. Using its huge income as the world's biggest oil exporter, Saudi Arabia drew up a plan in 2008 to become an Asian leader in science by 2030 and thereby shift the country away from its complete economic reliance

on oil. It aims to focus on science instead, and over the past five years has invested billions in cutting-edge universities and research facilities.

“To really become a research powerhouse, there must be more curiosity-driven research”.

Peter Edwards,  
director of the Singapore-ETH Centre

All these countries have strong support from top government officials to promote science and technology. According to a forecasts by Battelle, combined public and private spending R&D in Singapore equated to 2.7% of GDP in 2014, while China reached 2%. Five years ago, Qatar pledged 2.8% of its GDP to science research – for comparison, the US invests 2.8% of GDP in research, while in Switzerland it's 2.9%. “The strategic importance attached to research is indicated by the fact that the National Research Foundation (NRF) answers to the prime minister's office”, says Peter Edwards, the director of the Singapore-ETH Centre, a joint institute launched by ETH Zurich and Singapore's NRF.

## Planned science

While this has allowed countries to jumpstart their science endeavours, it has also created challenges for them. Closely

monitoring research and tying grants to a national agenda can stifle basic, curiosity-driven research. Three years ago, the Qatar Foundation identified a set of ‘research grand challenges’ on which to focus their funding: cybersecurity, water and energy security, and healthcare. Researchers working on other topics have voiced worries that they will lose their funding, and some have seen research proposals refused because they did not meet the country's criteria.

In Singapore, funding opportunities are very much determined by top-down priorities that are based on national economic and strategic considerations and leave little leeway for research without a clear goal. “Even schemes intended to give excellent young scientists a high degree of freedom to pursue their own research tend to go to projects with a very clear use”, says Edwards. “To really become a research powerhouse, there must be more curiosity-driven research.”

The bulk of basic research in China is funded through the government. Priorities are set as part of the country's regular five-year plans, while the private sector works with universities on short-term, applied research projects.

## Changing attitudes

“The challenge is to reconcile the open environment of research with the way of governing and deciding”, says Marmier of Swissnex. “There is a need for a new governance model for funding, education and university governance. This is the innovation that would accelerate the status

of China as a world leader in S&T". Edwards feels the problem is less about funding, and more about attitudes. "From conversations with senior people in universities, I would say that attitudes are changing, with a growing acceptance of a need for more bottom-up, 'blue skies' research".

Real change would need senior policy-makers to be persuaded of the importance of this type of research. Those in Saudi Arabia stress that they are still committed to basic research despite their focus on the industrialisation of research over the next five years. "We know we must invest heavily in this because this is an important component in creating a science culture", says Abdulaziz Al-Swailem, vice president for scientific research support at the King Abdulaziz City for Science and Technology (KACST), which has been advising the government on the country's science strategy.

### Quantity versus quality

Investing in science is paying off. China doubled its R&D spending between 2009 and 2012, and an OECD report released in 2014 projects that China is set to overtake the US as the world's biggest science spender by 2019. But while the number of research papers published in China has mushroomed, their quality has failed to keep up and still remains below world averages (see the infographic "The tiger awakens", p. 14). "The new aspect is that now there are schemes in place to really look at excellence and not only quantity of output", says Marmier.

The lack of freedom of scientific research is also creating an environment that may hinder science pursuit and lead to misconduct. Research in China has been plagued by fabrications and plagiarism. An editorial in *The Lancet* in 2015 blamed this on an academic promotion system that relies heavily on the number of publications. This problem is also felt in Saudi Arabia.

Even Western offshore campuses in emerging economies have sometimes suffered under the censorship of academic freedom. New York University Abu Dhabi has helped to increase research publications in the United Arab Emirates (UAE), but the bulk of the research in question is actually conducted at its New York base. In March 2015, the university was subjected to intense scrutiny when a researcher from its New York campus was banned from entering UAE because he was looking into the working and living conditions of migrant labour in the country. These are delicate issues that the government does not want to be discussed.

"Singapore is very different from China in terms of transparency, dealing with fraud, plagiarism and the like", says Artur Ekert, director of the Centre for Quantum Technologies in Singapore. He also stresses that his country offers greater academic freedom than its neighbours. "I am sure there are various research-related ethical issues that Singapore has to deal with but, to my knowledge, they are no different from those in Europe or the US".

### Bringing science home

To be sustainable, this growth in science needs manpower and expertise, and it has to be able to attract highly cited international researchers. Graduate student enrolment in China rocketed from 280,000 in 2000 to 1.6 million in 2011 as the country rapidly expanded its education system. China, India, South Korea and Saudi Arabia now make up the majority of expatriate students studying in the US, with China alone having over 300,000 students there. A scholarship programme in Saudi Arabia has seen hundreds of thousands of students travel for graduate studies overseas in recent years.

"China's leadership circles have a keen understanding that science leads to innovation".

Pascal Marmier,  
CEO Swissnex China

Now, the challenge is to have attractive facilities and grants to lure these researchers back home, and also to acquire foreign, high-calibre expertise. In China, "there is a very large talent programme that offers large grants to either returnees or foreign experts interested in research", says Marmier. China and South Korea are now the countries attracting the largest number of researchers from the US, and they are experiencing an overall 'brain gain' as a result.

Saudi Arabia is trying to attract highly cited researchers by offering lucrative packages and excellent facilities. "We need to work with advanced research institutes to learn from them", says Al-Swailem. Singapore is also sending talented students to study at the best overseas universities through government scholarships. These come with a requirement for them to return and work in their country for a certain number of years, adds Ekert. The

'Create' programme of its National Research Foundation provides a research ecosystem in collaboration with renowned universities such as ETH Zurich, MIT, Technische Universität München, Cambridge University and UC Berkeley.

The real challenge is to convince more young people to pursue science careers and to increase home-grown expertise. "This is a real problem. Despite producing excellent graduates and providing many opportunities to do a PhD, it is remarkably difficult to recruit Singaporean doctoral students", says Edwards. Upon graduation, they prefer to take up secure, well-paid jobs instead of pursuing postgraduate studies for several more years. Locals are often a minority among doctoral students.

In Saudi Arabia, KACST is trying to reach more people and increase their interest in science by translating science texts into Arabic. "We want to create knowledge and make it available for all parts of society", says Al-Swailem. "A large part of the Kingdom is young people, and they are hungry for science. We are learning from our mistakes to continue to build positively".

Mohammed Yahia is a science journalist and the editor of *Nature Middle East*. He is based in Cairo.

### Partnerships with Switzerland

Four Asian countries – China, Japan, South Korea and India – figure among the seven scientific-cooperation priority countries designated by the Swiss State Secretariat for Education, Research and Innovation. In 2015 the Swiss National Science Foundation approved a new series of joint projects with South Korea as well as Brazil and Russia, and launched a programme with the National Natural Science Foundation of China. "Korea has great potential", says Jean-Luc Barras, head of international cooperation at the SNSF. "We are trying to align bilateral cooperation support opportunities with the needs of researchers".

# The tiger awakens

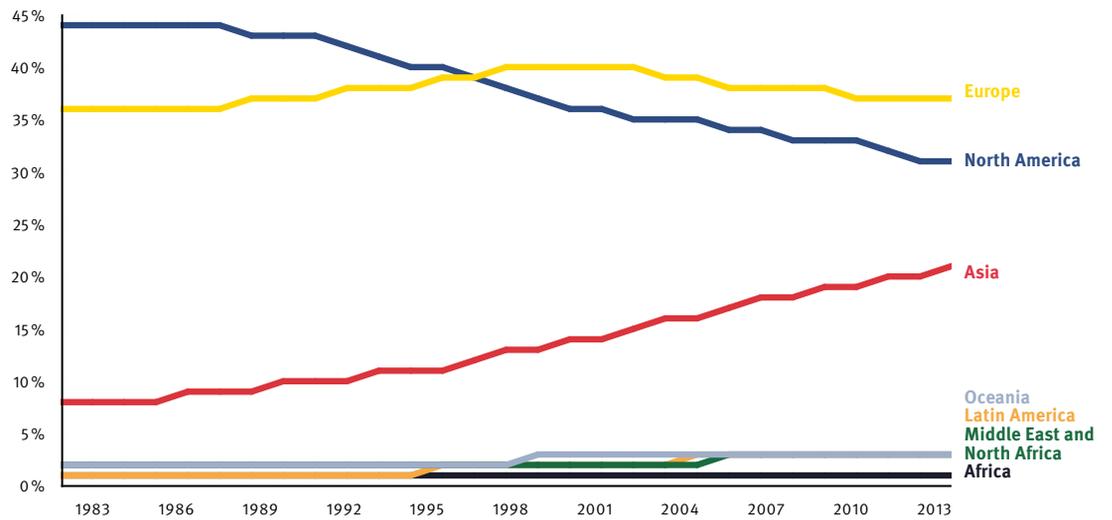
The West still dominates world research, but globalisation continues at strength, especially in Asia. China has already upset the established order.

## Asia's rising power

The proportion of scientific articles involving Asian researchers has almost tripled in three decades, reaching 21%. The proportion of European research overtook that of North America sometime around 1995 but has since lost its momentum. The annual growth rate in emerging regions (Asia, Africa, Latin America) is 8%. The total volume of publications has also tripled, standing now at 2.4 million articles per year.

Method: total occurrences of an institute in co-author lists. Source: Thomson Reuters (SCI, SSCI, A&HCI). Data analysis: SBFI.

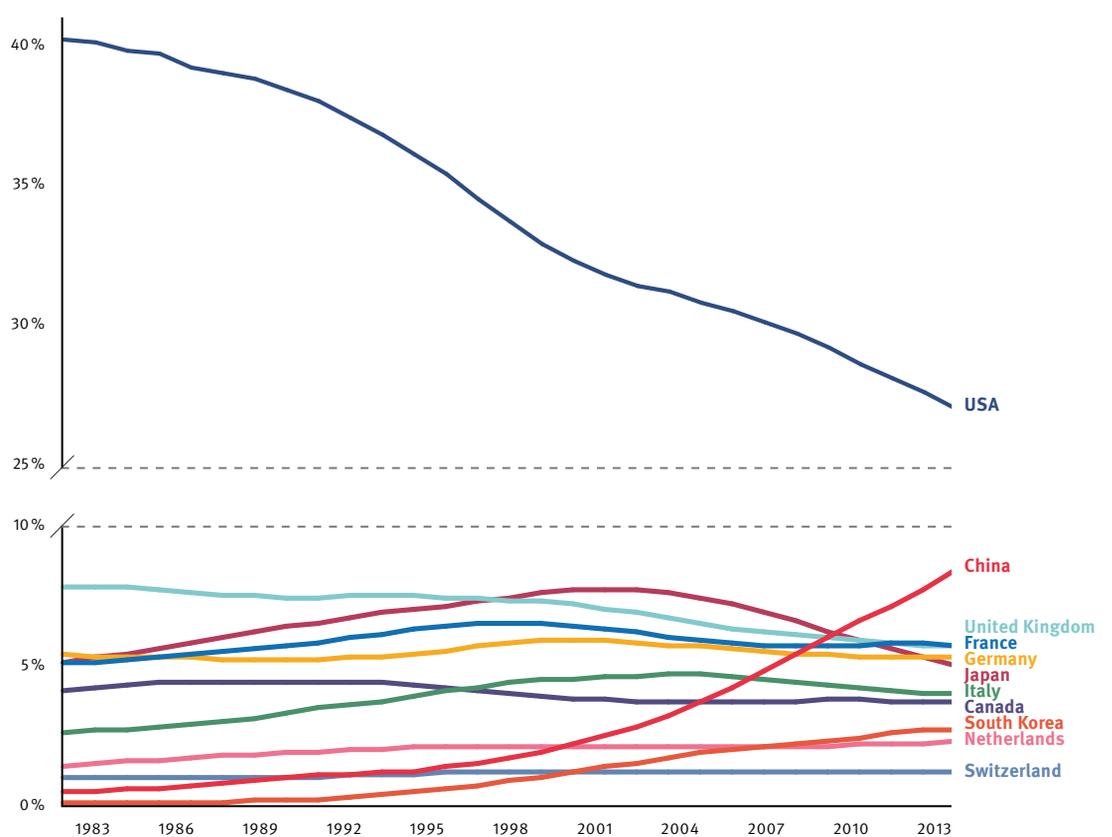
Proportion of world scientific publications



## Fall of the American Empire

The contribution of the US to world publications has fallen from 40% to 27% in three decades. China has displayed spectacular growth, rising from 1% to 8%. Other countries, such as South Korea, Taiwan, Brazil and India are also producing more. Switzerland's contribution remains very stable.

Proportion of world scientific publications



## Western quality

The US, the Netherlands and Switzerland produce research of the highest order of impact. Emerging countries are below the global average (100 points), but have made very good progress, particularly China, which has risen from 30 to 71 points since 1981.

Since 2007 Switzerland has been publishing the greatest number of scientific articles per capita (3.9 articles for every 1,000 inhabitants), ahead of Scandinavia and, by a length, the US (2.2). Asia is relatively unproductive: China (0.16) and India (0.04).

Method: 'impact' measures the number of citations per published article, adjusted across fields. Figures: 2009–2013 average.

### Publication impact

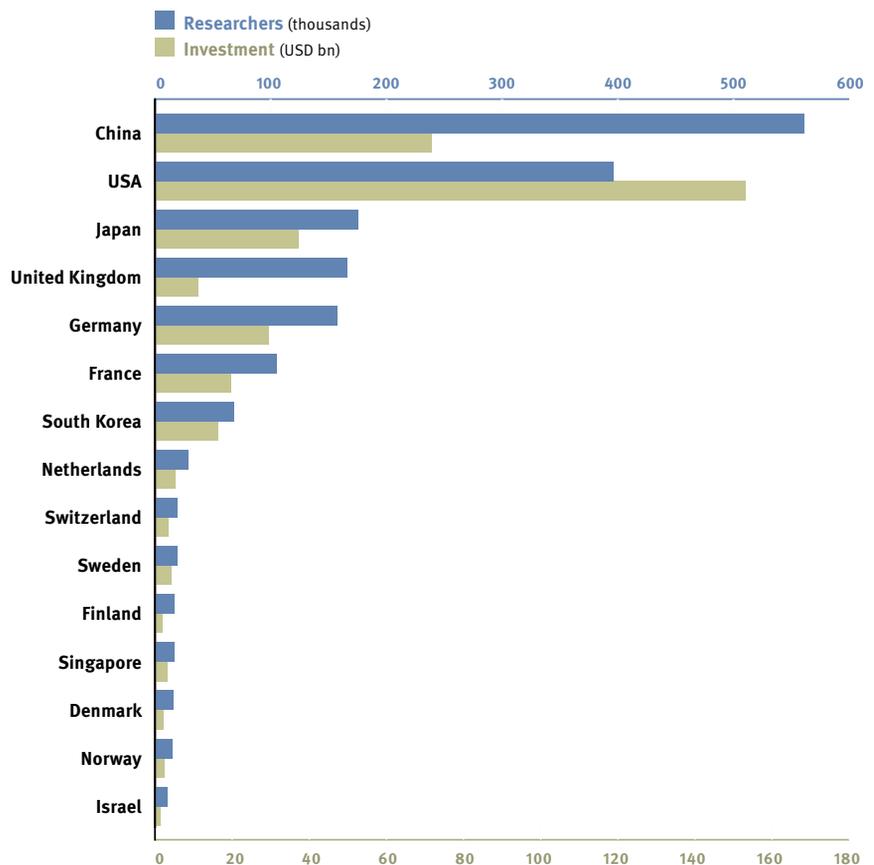


## The two great powers

The US government spends the most on R&D, injecting 153 billion US dollars per year, some five times more than Germany and twice that of China. But China has more researchers than the US: more than 1.4 million. South Korea and Singapore lead the emerging countries.

Method: number of researchers (FTE) active in R&D outside the private sector; government spending on R&D (including in specialised universities). Figures: 2012 or 2013.

### R&D: researchers and public investment



## South Korea

# Reining in the 'chaebol'

South Korea's mighty conglomerates dominate research and development. But at what cost to innovation?

By Mark Zastrow

**W**hen South Korea's President Park Geun-hye swept into office in 2012, she promised to reform the economy. The enormous conglomerates that had long driven the nation's development were struggling to innovate and were stifling entrepreneurship. In response, Park pledged to boost start-ups by building a 'creative economy'.

The policy centrepiece is the regional centres where the conglomerates join and work together with local industry and research institutions with a view to nurturing start-ups and investing in them. Since 2014, the government has established 17 such centres, which it hopes will spur growth in sectors ranging from smartphones to smart farms and from shipbuilding to fashion.

South Korea's commitment to the technocratic path has made it the world's number one spender in terms of research and development as a proportion of GDP. "The investment is pretty unparalleled", says Christian Schneider, head of the Swiss Science and Technology Office in Seoul.

But what really sets South Korea apart is how it spends it: the bulk goes through the conglomerates, or 'chaebol'. Park is bidding to reposition and leverage these pillars of the South Korean economy, but the enormous influence they wield on research will not disappear anytime soon.

## The rise of the chaebol

The chaebol have formed the backbone of Korea's economy since the days of Park Chung-hee, the military dictator who rose to power in the coup of 1963 - and father of the current President Park. He built an economy around the family businesses that he favoured, many of them now global brands like Samsung, LG and Hyundai.

But it was not until the late 1980s that the chaebol began to play an out-sized role

in research and development. Often, it took the form of creating universities and in-house laboratories from scratch. For example, it was a steel company that founded what would become the nation's top engineering university, Pohang University of Science and Technology. Samsung followed suit by establishing the Samsung Advanced Institute of Technology (SAIT), an internal lab reminiscent of Bell Labs.

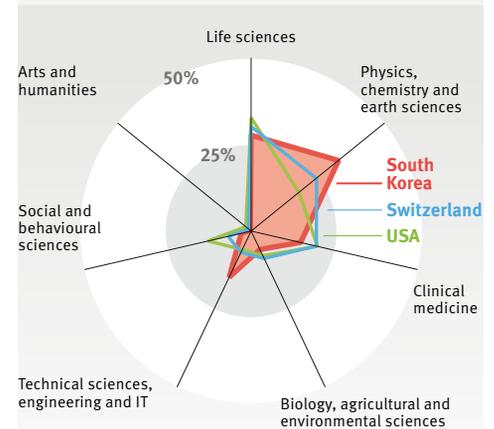
"It was very visionary to build a central corporate research lab in the classical sense", says Ogan Gurel, the chief innovation officer at the Seoul-based start-up incubator Campus D.

Today, the conglomerates are shifting funds to support basic research in universities, says Gurel, who steered SAIT's efforts in this direction as a division leader until 2015. "The scientists apply to Samsung for funding as if it were the government", says Schneider. "It's really a lot of money, and they use it for basic science".

This approach creates unique opportunities for academics to conduct research that has a direct link to the market, says Bernhard Egger, a computer scientist at Seoul National University (SNU). Egger knows both sides of this industrial-academic nexus: he earned his PhD at SNU, the nation's top research university, and then joined SAIT in 2008. There, he helped write the compiler for the company's reconfigurable processor - a low-power chip that decodes video and music in its smartphones. Later, he returned to academia as a professor at SNU, where he still collaborates with Samsung researchers and currently leads one of five research groups funded by Samsung.

What will become of this project is still unknown to Egger. "I think Samsung doesn't know yet either", he says. "So this really is research". But he notes one possibility: last December, Samsung announced

## Research profile



Breakdown of publications according to field of research. Source: SBF

it was jumping into the race to develop self-driving cars. "I get the chance to join projects that actually have an impact on the industry, that have some real product behind them", he says.

## A remixed economy

Instead of dismantling the chaebol, President Park is trying to convince them to help start-ups by providing facilities, training and capital. For example, in Daejeon, the region's Creative Economy and Innovation Centre is located on the campus of the nation's top technical university. The resident conglomerate is SK Telecom, the nation's largest wireless carrier, and it shepherds projects started by students, to cite just one of many examples.

"The scientists apply to Samsung as if it were the government".

Christian Schneider

Critics say these creative-economy centres have yet to bear fruit and note they have failed to yield the desired amount of investment. Many economists argue it will take much more drastic measures to eliminate the chaebol's asphyxiating dominance.

But that has not stopped South Korea from exporting the model to other developing nations eager to copy it. They are willing to pay, too: Saudi Arabia and Brazil have already penned agreements with Seoul to emulate its creative economy.

Based in Seoul, Mark Zastrow is a freelance science journalist and has written for Nature, New Scientist, Nova and Retraction Watch.

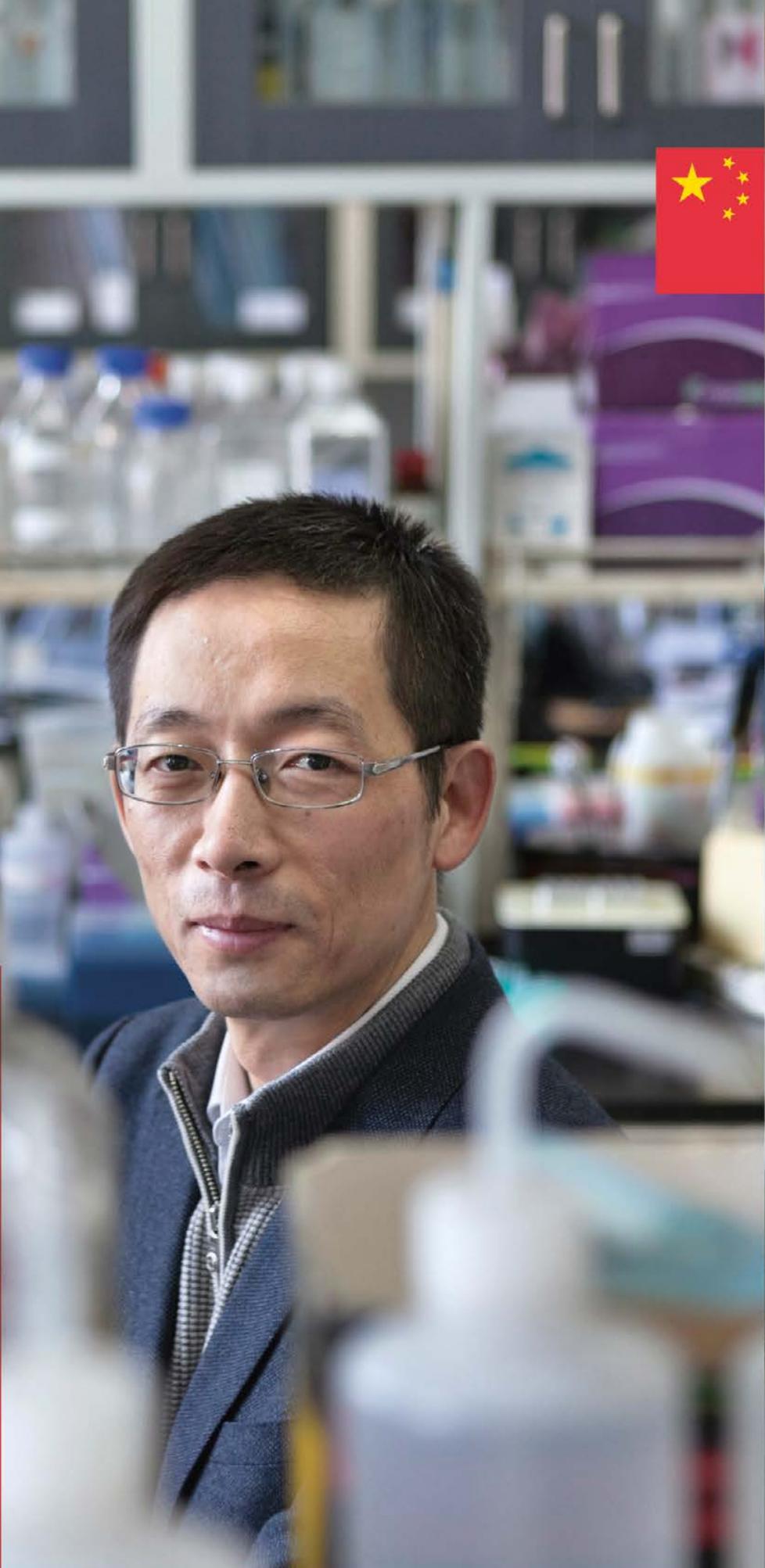


## Going east

In 2002 when Bernhard Egger graduated from ETH Zurich, he saw his classmates going to America for their PhD studies. "I thought it might be more interesting and challenging to go east instead of west". But why Korea and not, say, China or Japan? In addition to its friendly, hard-working image, Egger saw one practical advantage: its rather simple alphabet.

Now firmly rooted in South Korea with his wife and two children, he is comfortable bridging divides, whether within an industry or across continents. He collaborates with a colleague at ETH Zurich, allowing students to join research exchanges. And his work with Samsung keeps him grounded. "I like to do things that are not just vapourware, but something that is actually out there and works", he says. "Coming to Korea has allowed me to do that".

Photo: Aaron Choe



### From Princeton to Beijing

Yigong Shi had everything a scientist could ask for when he was researching the structure of proteins at Princeton University. In fact, just a handful of grants from the US National Institutes of Health meant he could tell his post-doctoral researchers not to bother applying for fellowships.

But China continued to be the land of opportunity for Shi, even when he was considering the prospect of a Howard Hughes grant to the tune of 10 million US dollars. And so, in 2008, he returned to Tsinghua University in Beijing, of which he became vice-president in 2015. He is a symbol of China's ambitions in biomedical sciences, and its ability to gather the brains needed. Life can be difficult. Air pollution is a particular problem, he says. But the abundance of hard-working graduate students and great facilities make it a researcher's dream. "For career development, you can't think of a better choice than returning to China", he says.

Photo: Andrew Wong



### More Saudi Arabian women in science

Suzana Nunes studied at the University of Campinas in Brazil. Her journey took her to Germany for over 12 years before she decided to join the nascent King Abdullah University of Science and Technology (KAUST) in 2009.

She is now Associate Dean of the Division of Biological and Environmental Sciences and Engineering and is passionate about empowering women to pursue careers in science. The majority of her research group are women, and she wishes to attract more Saudi Arabian women to chemistry and engineering. She is also setting up initiatives to attract high school students to science and to help promote science to young people.

Photo: KAUST

People's Republic of China

# Beijing's research gambit

China aims to reverse its brain drain by offering researchers ample salaries, lab animals and infrastructure. But clean air and Internet freedom are not included.

By David Cyranoski

Over the past two decades, China has lived through the most impressive science boom in modern history. What was once a scientific backwater is now the world's second ranking nation by the number of scientific papers published. It is even poised to snatch the top spot from the United States. Furthermore, all those papers, especially in such fields as physics, chemistry and genomics, are increasingly appearing in top-tier journals.

It is not just publications. China has also sent a probe to the Moon and more recently launched a satellite that may give it the edge in the global quest to identify dark matter. China, it seems, is ready to compete at the forefront in most fields of science and technology.

The boom has been driven by the determined efforts to reclaim the Chinese brains cultivated abroad. The 1000 Talents programme, launched in 2008, has been the most successful of these efforts. It has a number of components, including a salary and housing allowance that can easily surpass 100,000 US dollars and generous research funding, says Cong Cao, a science-policy researcher at the University of Nottingham's Ningbo campus, himself a recent returnee. "It's just the opportunities", he says.

Yigong Shi (see portrait), vice-president of Tsinghua University, says the salaries of top researchers in China, while still below the equivalent levels in the United States, are growing rapidly and the equipment there is usually better too. The human resources are also a draw, because it is easy to attract large numbers of hard-working students. Although many top students pursue graduate studies in the United States, some choose to stay in China. "They are more motivated and spend more time in the lab. As a consequence, their research is even stronger", says Shi.

## Internet lock-down

But China has faced an uphill battle in recruiting the best. Positions in the United States and Europe are still considered more prestigious. In the early years of the 1000 Talents programme, many scientists maintained their affiliations outside of China and spent most of their time abroad, treating their positions at home almost as part-time jobs that were merely a source of extra income or of graduate students. As a countermeasure, China launched the 'Young Professionals' plan within the 1000 Talents programme, ensuring that PhD students would have to come back to work full-time.

But this push to retrieve foreign-trained scholars has created tension, especially in cases where young, inexperienced scientists earn salaries ten times greater than the heads of neighbouring laboratories whose comparable experience was 'home-grown'.

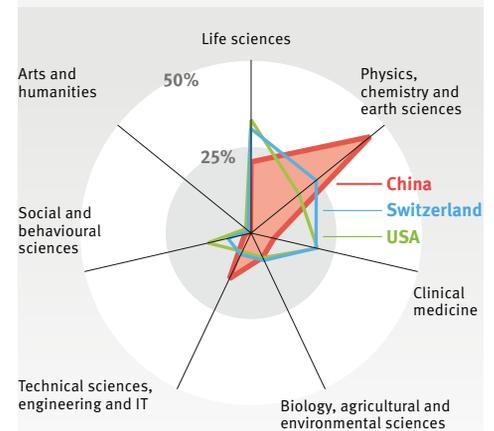
There are other obstacles to regaining brains. Shi says some scientists turn down offers because of the air quality - especially in Beijing where pollutants sometimes reach hazardous levels. Some potential returnees balk at China's administrative heavy handedness and obsession with quantitative metrics.

Many scientists also hesitate to work in China because of the restrictions on the use of the internet. Most notably, the government blocks access to Google Scholar, which is used by academics across the planet to find and stay on top of cutting-edge research. "The impact on second and third tier universities is especially hard, because they may not have well-stocked libraries", says Cao.

## Liberties without ethical concerns

But China does also have some freedoms. The absence of an animal rights movement is one example. Chinese scientists have in fact had a field day applying new

## Research profile



Breakdown of publications according to research field. Source: SBF

gene-editing techniques to animals. In 2015, they produced lap-sized mini-pigs, 'super-muscled' pigs and dogs, and are working on an assortment of primates engineered to be models of certain diseases such as autism. Some researchers famously used the new techniques to modify the genome of a human embryo. And recently, a local government unveiled plans for the world's biggest cloning factory, which will breed cattle, dogs and race horses.

"Researchers are given a greater degree of latitude in China".

Yigong Shi

These efforts might have met with resistance in the West, but in China, scientists can move forward quickly. Economics also drives this, says Xingxu Huang, who returned from a six-year postdoctoral stint at Baylor College of Medicine in Houston and now leads a group at Shanghai Tech University. His plans, i.e., genome engineering in large animals such as pigs, goats and monkeys, are "more feasible in China than in the United States because the animals are cheaper and more accessible".

The government even provides incentives to entrepreneurship. "All this exemplifies what scientists can do in China", says Shi. "Whether it's starting a business or doing research with stem cells or primates, researchers are given a greater degree of latitude".

Still, there is a way to go. When asked what is holding back science in China, Cao says, "the shortage of talent is the biggest issue".

David Cyranoski is the Asia-Pacific correspondent for Nature.



Shenzhen University, Building of Science and Technology. Photo: Chloeklein/Dreamstime.com

## Saudi Arabia

# Pumping money into science

Saudi Arabia wants to become a leading research nation, and has recently established a multi-billion dollar university. But can science be built from scratch?

By Mohammed Yahia.

Some 150 kilometres from the city of Jeddah and off the shore of the Red Sea, a brand new research institute has sprung up in the deserts of Saudi Arabia. It was created to nudge the rich oil country into becoming a knowledge economy by means of science.

The King Abdullah University of Science and Technology (KAUST) was inaugurated in 2009 - a dream of the late King Abdullah who wanted to create a high-tech university to propel scientific research in the country. KAUST is a combination of graduate-level university and research institute and the first co-education facility in Saudi Arabia. Seed funding of 20 billion US dollars has helped furnish it with cutting edge laboratories, which in turn have started to attract leading scientists from around the world. In a short time, it has become one of the leading research institutes in the Arab world.

Unlike neighbouring Qatar and the United Arab Emirates, who opted to attract offshore campuses of established Western universities such as New York University and Weill Cornell Medical College, Saudi Arabia chose to build a university from scratch and to model it after leading private universities in the West.

## Funding inspired by ETH and EPFL

“KAUST is really an experiment, a catalyst to do new things. If they are successful, they will be adapted by others, if not, they won’t”, says Jean Fréchet, who left his position at the University of California, Berkeley, to join KAUST as a vice president for research shortly after its inauguration. Today, KAUST is home to 901 students - nearly 40 percent of whom are women.

One of the founding models used when building KAUST, Fréchet explains, was that

of ETH Zurich and EPFL, which receive direct funding from the Swiss federal government. So scientists are getting recurring allowances for their research without having to wait for grants to come in first. “We have both models at KAUST; we depend on grants but also have what we call baseline funding. People really like this model because they know that year in year out they can conduct highly ambitious research and do not have to wait for grants to be allocated.”

“If we cannot create a hunger for science then we will not succeed”.

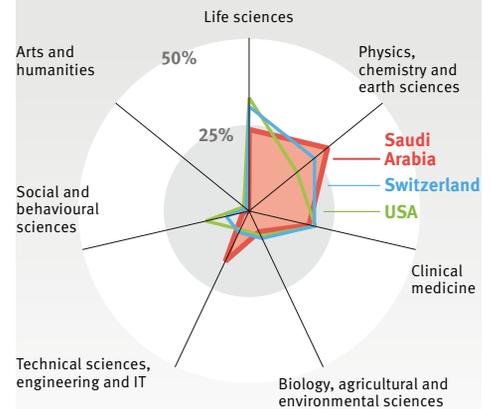
Abdulaziz Al-Swailem

The combination of generous funding, advanced facilities and visionary goals has attracted well-established scientists from around the world. Jean-Lou Chameau, the current president of KAUST, is the former president of Caltech, while the founding president Shih Choon Fong was the president of the National University of Singapore.

Suzana Nunes, Associate Dean of the Biological and Environmental Science and Engineering Division at KAUST, says: “When I applied to KAUST, I very much liked their assurance that the university would give you the freedom and support to be as good as you can be. The core laboratories offer the possibility for students to be trained but also to work with excellent scientists at the same time”.

Fréchet stresses that they are wary of growing too fast and that their ultimate goal is to recruit faculty members who will

## Research profile



Breakdown of publications according to research field. Source: SBF

conduct high-level research and be committed to the goal of the university: “We don’t want people to come here as tourists, we want them to come here as contributors”.

## Part of a bigger plan

KAUST is a part of Saudi Arabia’s bigger plan to boost the country’s science output. The Kingdom put together a national science plan that started in 2009. It extends into 2030 and is divided into five-year periods with clear deliverables. The first stage, which ended in 2014, was to build a complete infrastructure in the Kingdom to promote and support science in all universities and research institutes.

“We also worked on making sure the research being conducted is of high impact and quality and will have an effect both regionally and internationally”, says Abdulaziz Al-Swailem, Vice President of Scientific Research Support at the King Abdulaziz City for Science and Technology (KACST), the institute responsible for putting together the country’s science strategy. According to Nature Index, the science output of Saudi Arabia has grown over the past two years to surpass all other states in the Middle East except for Israel.

Al-Swailem recognises that one of the biggest challenges faced by KACST is to create a science culture within the population. Over the past few years, KACST has taken the initiative to translate top science publications and books into Arabic. “We want to create knowledge and make it available for all sectors of society. If we cannot build science within society and create a hunger for it then we will not succeed”.

Mohammed Yahia is a science journalist and editor of Nature Middle East. He is based in Cairo.



**Administration building, KAUST.** Photo: Courtesy of KAUST

INTERVIEW

“We must encourage international co-author networks”

Alain Herzog



Dominique Foray of EPFL has studied the career paths of 4,666 doctoral students from two specialised universities. The results show that holding a PhD from another institution increases productivity.

**What methods did you apply?**

Working with my colleague Fabiana Visentin, we tried to isolate the effect of the mode of recruitment of doctoral students on their scientific productivity between 2000 and 2008. This was measured by the number of publications. We wanted to examine the influence of two factors on the productivity of a doctoral student: having come from another institution

and having a supervisor with an external research network.

**What was the result?**

Postdocs recruited externally are more productive than those recruited internally. The most prolific come from other institutions with which their supervisor maintains ties, particularly co-authorship ties. They are 10% more productive than students coming from a university completely outside of the professor’s network, and 16% more than local students who stayed put after finishing their PhD.

**How do you interpret this?**

It shows the role played by social and professional relationships, particularly for recruiting good postdoc students, something that is often a difficult task. A professor’s network can help in selecting good candidates.

**What are the consequences for elite universities?**

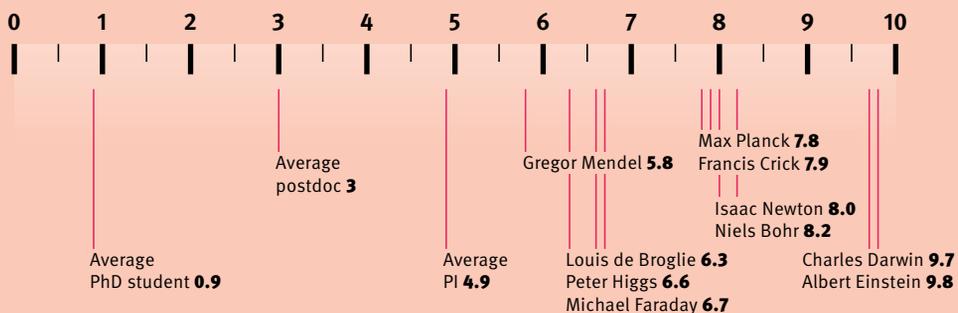
Our results are interesting for institutions, such as EPFL, that deploy global marketing strategies for recruiting talent. Whilst it’s good to have open doors and to be able to double-check the authenticity of unknown certificates, it’s also important to encourage researchers within an institution to develop their external co-author networks, particularly in recruitment countries. Some American universities employ this strategy; they hire Chinese researchers on the basis of the quality not only of their work but also of their networks. These researchers and their connections in China can prove useful when it comes to taking on yet more new postdocs.

INFOGRAPHIC

A new index

After the h-index and the i10-index, we now have the L-index which also sets out to measure researcher impact. It standardises the number of citations according to

the age of each publication as well as the number of co-authors, before calculating the logarithm. In this diagram we see the L-index of typical and atypical researchers.



AV Belikov et al., F1000Research (2015), 4:884

NEWS

A more transparent peer review

The journal Nature Communications will begin publishing the peer review history of submissions. Authors must, however, consent to the disclosure of comments made by peer reviewers. A similar model is already used in the journals European Geosciences Union, Biomed Central and EMBO.

A prize for more reliable science

The first prizes to promote more rigorous research in political and social sciences were awarded at the end of 2015. One of the winners of the Leamer-Rosenthal prize had tried to reproduce old results (without success however), others had conducted meta-analyses in a transparent manner, and some had been teaching the principles of reproducibility. The initiative hopes to promote scientific culture and also to promote solid, verifiable results.

Emphatic articles

Scientific articles include ever greater numbers of positive qualifiers, says a Dutch study of all the articles in the PubMed database published since 1974. In 2014, more than 17% of abstracts contained one or more terms from a list of 25 positive words (‘robust’, ‘innovative’, ‘promising’), equating to a nine-fold increase over the last 40 years. “Apparently, scientists see their results optimistically”, say the authors of the study. “But we need to verify whether this perception corresponds to reality”.

Lab chimps retire

The US National Institutes of Health (NIH) are to send the last of their 50 chimpanzees to sanctuaries. The NIH already retired 310 of its laboratory primates in 2013, keeping around 50 on standby for emergency research.

Ghost writing in Swiss universities

Hundreds of students are employing professional ghost-writers for their coursework. A bachelor thesis costs circa CHF 3,500 if written by a university graduate. The practice was uncovered by a Swiss TV programme in January 2015 and involves hundreds of students every year. Several universities are now taking legal action.

For more news, go to the new portal supported by the SNSF: [www.sciencegeist.com](http://www.sciencegeist.com).

# 2113

## RESEARCH IMPACT

# What if we let social media rate research?

With citation indexes being routinely questioned, 'alternative metrics' could gain ground as a new indicator of research success. But can they be trusted?  
*By Roland Fischer*

**W**hat were the most successful research publications of 2015? It's a seemingly harmless question, but until recently, no one would have asked it. People have been measuring research painstakingly for decades, but the impact quantifiers used were almost always based on citations. These are notoriously slow to assess, as it can take months or even years for the first citations to surface.

But at the turn of this year, reports were coming in everywhere about the '10 most-talked about science stories of 2015' or the 'Findings that caused a stir in the (social) media in 2015'. This didn't happen by chance. The London-based company Altmetric had sent out a report at the end of the year that included a list of the top-100 publications. In these days of digital tidbits and 'listicles', this science hit-parade was a welcome arrival to those working in the media.

Altmetric is currently the most successful at offering so-called alternative metrics, or 'altmetrics' for short, hence the name of the company. These metrics go one step further than just adding up citations, by including all sorts of other kinds of freely available success indicators for research articles. They especially cover social networks. In other words, they count the numbers of downloads, tweets, Facebook entries, blog posts and media reports.

Altmetrics are supposed to be able to measure the scientific and societal impact of a research publication more precisely and more comprehensively. They're also allegedly swifter at proving the success of a research publication. If people tweet about a new research article, for example, a discussion will get off the ground far quicker than in a specialist journal.

### A digital press review

But there's more. While altmetrics might provide an alternative to established indicators such as the impact factor and the number of citations, they could also offer relief to the peer-review system that's under so much strain these days. In a manifesto of 2010, the pioneers of the 'alternative metrics' movement, headed by information scientist Jason Priem, cheekily suggested that "With altmetrics, we can crowdsource peer-review". Their idea is that large numbers of amateurs - joined by a healthy number of professionals - could use clicks and shares in their social networks to decide whether a research article is of interest. If evaluated and analysed properly, these clicks could function along the lines of an implicit peer-review process.

This approach is interesting because there are indeed far more peers for research publications than just the select few who are currently asked for their opinion.

(continued on page 28)

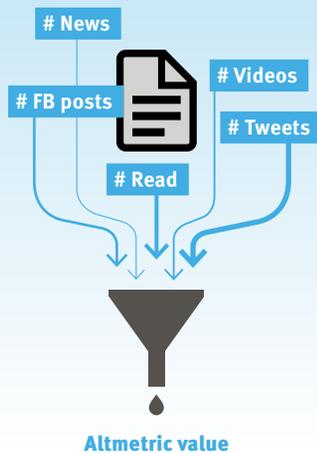
# The top Swiss research of 2014/15

What study has had the biggest impact? Our analysis shows that two different methods offer different results.

## New: Altmetric

### Altmetrics

The impact of an article is measured by the (weighted) number of **mentions** in the **media** and on the **Internet** (Twitter, Facebook, etc.).



- 1** **Ebola Virus Disease in West Africa – The First 9 Months of the Epidemic and Forward Projections.**  
 New England Journal of Medicine, 22.09.2014  
[Altmetric: 1352](#)  
*News: 57, tweets: 701, FB posts: 232*  
[Citations: 301](#)
- 2** **Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990 – 2013: a systematic analysis for the Global Burden of Disease Study 2013**  
 The Lancet, 12.12.2014  
[Altmetric: 1181](#)  
*News: 34, tweets: 950, FB posts: 76*  
[Citations: 104](#)
- 3** **Business culture and dishonesty in the banking industry**  
 Nature, 19.11.2014  
[Altmetric: 1177](#)  
*News: 70, tweets: 596, FB posts: 36*  
[Citations: 11](#)
- 4** **67P/Churyumov-Gerasimenko, a Jupiter family comet with a high D/H ratio.**  
 Science, 10.12.2014  
[Altmetric: 1135](#)  
[Citations: 21](#)
- 5** **Photonic crystals cause active colour change in chameleons**  
 Nature Communications, 10.03.2015  
[Altmetric: 1116](#)  
[Citations: 11](#)
- 6** **Recovery of large carnivores in Europe’s modern human-dominated landscapes**  
 Science, 19.12.2014  
[Altmetric: 1105](#)  
[Citations: 43](#)
- 7** **A prudent path forward for genomic engineering and germline gene modification**  
 Science, 19.03.2015  
[Altmetric: 977](#)  
[Citations: 47](#)
- 8** **Biological insights from 108 schizophrenia-associated genetic loci**  
 Nature, 22.07.2014  
[Altmetric: 820](#)  
[Citations: 436](#)
- 9** **Mind-controlled transgene expression by a wireless-powered optogenetic designer cell implant**  
 Nature Communications, 11.11.2014  
[Altmetric: 809](#)  
[Citations: 426](#)
- 10** **Evidence for interstellar origin of seven dust particles collected by the Stardust spacecraft**  
 Science, 15.08.2014  
[Altmetric: 782](#)  
[Citations: 18](#)

## Ebola, bankers and 3D printing

The ranking of Swiss articles according to their Altmetric score for 2014/2015 reflects the general trend in popular topics. Biomedical fields are clearly dominant, and physics also snatched a top place. All the other disciplines are in the ‘also ran’ category. One exception confirms the rule: third place in the cumulative rankings went to ‘Busi-

ness culture and dishonesty in the banking industry’ from Ernst Fehr’s research group at the University of Zurich – which is not surprising, given the current zeitgeist.

It’s striking that the impact factor clearly applies here. In the upper regions of the chart we primarily find articles from the top journals such as Nature and Science. This

isn’t surprising because they do a lot of media work to advertise themselves. What’s interesting are the differences between the channels, as shown by our detailed analysis (available online). On Facebook particularly, less prominent publications can still succeed. Its highest-ranking paper is ‘No scientific consensus on GMO

## Traditional: number of citations

1

### Planck 2013 results. XVI. Cosmological parameters

Astronomy and Astrophysics, 01.10.2014

[Altmetric: 12](#)

[News: 1, tweets: 1, FB posts: 0](#)

[Citations: 697](#)

2

### 2014 ESC/EACTS Guidelines on myocardial revascularization

European Heart Journal, 28.08.2014

[Altmetric: 81](#)

[News: 2, tweets: 73, FB posts: 7](#)

[Citations: 450](#)

3

### Biological insights from 108 schizophrenia-associated genetic loci

Nature, 22.07.2014

[Altmetric: 820](#)

[News: 45, tweets: 334, FB posts: 30](#)

[Citations: 436](#)

4

### Ebola Virus Disease in West Africa – The First 9 Months of the Epidemic and Forward Projections.

New England Journal of Medicine, 22.09.2014

[Altmetric: 1352](#)

[Citations: 301](#)

5

### A hole-conductor-free, fully printable mesoscopic perovskite solar cell with high stability

Science, 18.07.2014

[Altmetric: 92](#)

[Citations: 290](#)

6

### SWISS-MODEL: modelling protein tertiary and quaternary structure using evolutionary information

Nucleic Acids Research, 09.04.2014

[Altmetric: 1](#)

[Citations: 289](#)

7

### Planck 2013 results. XXII. Constraints on inflation

Astronomy and Astrophysics, 29.10.2014

[Altmetric: 110](#)

[Citations: 234](#)

8

### Comprehensive molecular profiling of lung adenocarcinoma

Nature, 09.07.2014

[Altmetric: 129](#)

[Citations: 232](#)

9

### Growth of CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> cuboids with controlled size for high-efficiency perovskite solar cells

Nature Nanotechnology, 31.08.2014

[Altmetric: 3](#)

[Citations: 209](#)

10

### Organohalide lead perovskites for photovoltaic applications

Energy & Environmental Science, 29.04.2014

[Altmetric: 1](#)

[Citations: 177](#)

## Citations

The impact of an article is determined by the number of **published articles** that **cite** it.



safety' by the ETH Zurich researcher Angelika Hilbeck. It's followed by papers on Ebola and early history, but also by tips about how to finish your PhD. It's here that we get the biggest mixed discussion between amateurs and experts, whereas on Twitter, a nerd's paper breaks the pattern: 'Open labware: 3-D printing your own lab equipment'.

Kathrin Altwegg scored a hit with a paper about the discovery of oxygen on the Chury comet. But she'd never heard of alternative metrics until she was told of her success. She laughed about it, but was happy for her work to be noticed beyond the confines of her own field. It certainly acts as an encouragement, she says. Just behind Altwegg in the rankings was

Michel C. Milinkovitch from the University of Geneva with his paper on chameleons changing their colours. He'd known about altmetrics for longer, but he was still a little surprised to see how widely his article had been shared. "Of course I'm also happy if my results reach a broader public". But his main task, he insists, is to produce good science.

## Method:

The analysis considers articles published between July 2014 and June 2015 in which at least one Swiss institution participated.

► For more extensive data: [www.snf.ch/Ho\\_altmetrics](http://www.snf.ch/Ho_altmetrics)

“At present I don’t see how altmetrics could replace the old methods”.

Euan Adie, founder of Altmetric

“At the moment, altmetrics aren’t measuring research quality at all”.

Stefanie Haustein, information scientist

If everyone could somehow be drawn into the quality control process, then the peer-review idea would also become more efficient and less prone to mistakes. It’s already a fact that scientists are very active on social media channels. Twitter is especially popular among researchers. A survey in early 2015 among members of the American Association for the Advancement of Science (AAAS) showed that 47 percent of them use social media in order to inform themselves about research or research results.

Euan Adie, the boss of Altmetric, put it like this: “Today, scientific publications are already being subjected to critical discussion in blogs and similar channels. A new system could establish itself here that is better able to identify substandard research”. But he also adds: “Altmetrics are a complement to citation analyses and peer reviews. At present I don’t see how they could actually replace the old methods”.

Adie is more concerned about documenting the impact of research above and beyond the realm of science and scholarship - it’s a kind of digital press review. “Our index measures how much attention a paper has received. It’s not an indicator of quality”, says Adie. Meanwhile, Stefanie Haustein, an information scientist at the University of Montreal, has been dealing intensively with altmetrics for several years and has arrived at the same opinion: “At the moment, altmetrics aren’t measuring research quality at all”. And she even allows herself to indulge in a little heresy: “To say social media equals social impact is simply not true”. This challenges the notion that altmetrics are somehow able to offer an elegant measurement of the social impact of a paper.

#### Competing measurements

So the basic question arises as to just what altmetrics actually measure. Do they measure something that’s relevant, or do they merely measure the specific volume of something that’s readily available and can be quantified by automated means? Thanks to the 2013

DORA initiative, which made manifest the general mistrust regarding the use of the classical impact factor as a quality indicator, the wheels have begun turning in the world of research politics. It seems as if the result won’t involve turning away from quantitative evaluation systems, but instead will be a move to more complex methods - such as altmetrics. A British report on the state of science evaluation back in 2015 spoke already in its title of a ‘metric tide’.

Deciding what criteria and methods should be used to evaluate the quality and impact of research is probably only going to get more complicated for the research community in future. And also more complicated for those in charge of research policy. Because metric methods are never simply objective indicators: they’re also always policy levers. They create incentive systems that can subtly transform the research landscape. So should research really be available on social media channels? What about the many research results that might be of high quality, but are less suited to the hectic everyday concerns of social media?

In a recent publication, Stefanie Haustein has raised several questions about the relevance and robustness of these new evaluation methods. She showed that scientific publications have a rather low-level presence on digital channels - while 21.5 percent of papers get a tweet, less than five percent are shared on Facebook and only two percent are mentioned in blogs. Against this we have to consider the 66.8 percent that are cited at least once in the traditional manner.

These new metric methods are still largely a kind of black box. We need to examine them better in order to understand what is being measured by them, and how the old indicators relate to the new - especially when it comes to the 64-million-dollar question of whether altmetrics should be used to substitute the old methods, or to complement them.

Roland Fischer is a science journalist in Bern.

# “Solve the problem with Brussels!”

Gerd Folkers, the new President of the Swiss Science and Innovation Council (SSIC), would like to increase the influence of this prestigious body. In political terms, much of what is at stake for scientists lies in international relations. *By Urs Hafner*

**Prof. Folkers, you're taking up a position with a lot of prestige ...**

... are you sure?

**Yes: a lot of prestige but little impact. The voice of the SSIC is barely heard these days – the Federal Council certainly isn't listening.**

I agree.

**How do you want to change this?**

With shuttle diplomacy. I'll be on the spot in Bern one day a week, where I'll be speaking with people in the civil service, in the SNSF and in parliament, about our general 'work in progress' in matters of science policy. I want to hear their assessments and their opinions. I want to take their temperature, as it were. We have to find a common language. The problems on the table are there for all to see: financing growth, economic pressures, falsification of data and fraud, getting young scientists onto the career ladder, and getting more women into academia ...

**The SSIC has long been demanding an improvement in career opportunities for young scientists, for example.**

There are problems that can't be solved definitively because the context changes so quickly. We have to put these issues back on the table, time and again. There's nothing else we can do about it, like the fight against cancer or the issue of inoculation. And then there are complex problems to which the SSIC can only offer a nuanced answer: "Not only do you have to do this or that, but you also have to take into consideration and weigh up the ethical, economic and legal dimensions".

**Do politicians want to hear advice like that?**

They have no choice. But there are also more clear-cut cases: Yes, we should introduce pre-implantation diagnostics. Yes, Switzerland should participate in the European ELI super-laser. The SSIC works on scientifically ascertainable truth. It doesn't determine science policy; it's the politicians who have to make the decisions. I hope that our parliamentarians will increasingly ask us for advice. But to achieve this, we have to become far more visible.



“I hope that our parliamentarians will increasingly ask us for advice”, says Gerd Folkers, the new President of the SSIC. Photo: Valérie Chételat

**If you could advise the whole Federal Council on the action they should take, what would you say to them?**

To be quite brazen about it, I'd say: think before you act. But in all seriousness: there's no single piece of general advice I would give the Federal Council.

**But what would be your priority?**

Maintaining international relations. Scientific findings don't keep to national boundaries. Knowledge flows globally. So in this, my advice would be: solve the problem with Brussels! But this is as trivial as it is urgent.

**The majority in parliament doesn't see things like that.**

Then I'd have to say this: does it make sense to have to invent everything again here – everything that's already been imagined and invented elsewhere? No. Switzerland mustn't isolate itself. If it does, then it won't profit any more from the knowledge that's gained elsewhere – nor will the outside world profit from us.

**Given the wave of terror attacks, politicians have been focussing increasingly on policing and surveillance. The humanities could**

**explain the root causes of terrorism. Would this be a case for the SSIC?**

Sure. Until now, regrettably, I have hardly read any astute analysis on terror in the newspapers. To be a little provocative: you could simply ask how we should weigh up the threat level against the other internal risks we're facing – such as fatalities in hospitals caused by a lack of hygiene. We need the humanities and social sciences to offer answers here. They can illuminate both sides: the motivation of the terrorists and the reactions of society, which prefers to prioritise security issues.

At the beginning of this year, Gerd Folkers assumed the Presidency of the Swiss Science and Innovation Council (SSIC), a body of fifteen people whose task since 1965 has been to offer support and scientific advice to the Federal Council. Folkers has been a full professor of pharmaceutical chemistry at ETH Zurich since 1994. He was the Director of the Collegium Helveticum in Zurich until 2014.

Urs Hafner is a historian and a science journalist in Bern.

# Switzerland, getting warmer

At the end of the 21<sup>st</sup> century, with the world having continued along its current path, Switzerland is some five degrees warmer than today. Telling us what a warmer future holds in store are a city-dweller, a vegetable farmer, a building contractor and an old-age pensioner. *By Roland Fischer, illustration by Brunner&Meyer*

“If only the electricity didn’t keep cutting out”

“I was in Stockholm recently. Up there, a lot of people actually still live in the old part of town! It’s next to the sea, which is probably why the heat doesn’t build up so much in the narrow streets. I recently read the specialist term for it: the ‘heat-island effect’. It doesn’t even sound so unpleasant. But we couldn’t stand it for any length of time without air conditioning.

“Back home, the friends of mine who can afford it have almost all moved up into the hills around the city or into the new suburbs that have been climate-optimised. And in the summer, they really only come down to the centre after dark to enjoy the night life. In the old part of town, you just find people like me who simply have to live close to the railway station. Despite having my office at home, I still have to travel to meetings on a regular basis. If only the electricity didn’t keep cutting out”.

Catherine, 37, graphic designer, Neuchâtel

“... all the different weather extremes at the same time ...”

“I don’t know how I’m supposed to continue. The farm has been in our family now for eight generations. Just work, work, and don’t blame the weather – that’s what my grandfather always used to say. But those were different times back then in the middle of the 21st century. Climate change still had a positive side for the farmers in the Swiss lake district. The weather was warm, sure, but there was also still enough water.

“Anyway, I’d have given it all up long ago if I didn’t have my faithful customers. They keep telling me that local produce is still needed, and that not everything has to be industrialised. It’s become really difficult because we have all the different weather extremes at the same time. In the spring it’s either too dry or too wet, and the summers are far too hot and dry. You can really only cope if you invest massively in infrastructure and grow more and more of your produce inside, protected from the weather. The banks and corporations would be happy, but it isn’t what my grandfather imagined”.

Jan, 53, vegetable farmer, Murten



## Stories from the future

How will people live 20, 50 or 100 years from now, when Switzerland is warmer? When we ask experts to peer into a distant future, they hold back with their prognoses. But we can still tell stories about how people might be living. These texts ignore issues such as possible societal change or new technologies. And as is usual with science fiction, stories tell us as much about the present as they do about the future. But this is how our experiment should be understood.

It’s to make us think harder about how to plan for the future – which is something we should be doing today.

Our thanks go to ProClim and to the four experts who dared to look into their crystal ball for us: Martin Hoelzle (mountain landscapes and permafrost), Jürg Fuhrer (agriculture), Eberhard Parlow (urban climate) and Marco Pütz (land planning). In the course of this year, the Swiss Academies of Arts and Sciences will present a report offering a scientific view of Switzerland as it comes to terms with climate change.

“We’re not going to run out of work”

“ Let’s get one thing clear: I really can’t complain. It was always obvious that I’d take over the family business and I’ve never regretted my decision. I’ve continued with my father’s expansion strategy. We have to have a strong presence in the mountain regions, because that’s where our expertise is in demand: Bernasconi Civil Engineering – Landscape Protection and Debris Management.

“The business began on a small scale in Splügen, but today most of our work is in the ‘rich’ valleys, where there’s a lot happening – in the Valsertal, around Davos and Klosters and of course in the Engadine. Building dams, securing hillsides. Or occasionally diverting whole rivers, and then offering solutions for flood water management. And dredging stream beds all the time, clearing away mudslides.

Personally, of course, I think it’s a shame that not all towns can afford this infrastructure, and that whole valleys have had to be abandoned. But the permafrost is simply melting away slowly and isn’t going to stop. We’re not going to run out of work”.

Stefanie, 29, building contractor, Davos

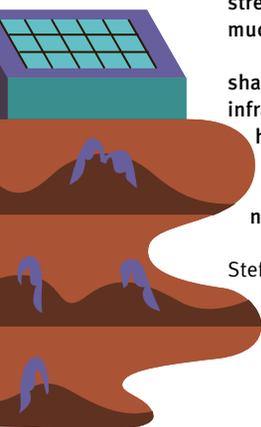


“I wouldn’t have been able to stand it in the city any more”

“ It’s crazy what’s been built here in the last 30 years. But it’s been really well integrated into the landscape – such as the new hospital and shopping complex. It’s not like the concrete monstrosities of years gone by. I like living up here. It’s cool at 1,500 metres and you’ve got all the benefits of living in a special zone like this. Luckily I inherited money at just the right time, when you think of all the super-rich people who are now drawn to the alpine climate. I wouldn’t have been able to stand it in the city any more. But it’s odd to talk of a ‘city’ when you think that the population of the conurbation of Crans-Montana-Randogne (or ‘Cramoran’ as people say these days) recently also reached 15,000.

“I was always fascinated by architecture. And it’s crazy how timber construction developed in the second half of the 21st century, after the concrete crisis. I live in one of these elegant high-rise buildings with a pleasant indoor climate. It’s a bit too close to the forest, though. Last year, the forest fires almost reached us. And it’s also a shame the swimming pool has had to stay empty for the last five years. To be honest, I think that’s a bit extreme. After all, the rich people over in Randogne water their lawns even in the heat of high summer”.

Leo, 71, retired building technician, Crans-West



# Net, bugs and rock 'n' roll

He has sold his own paintings on the Internet, launched a number of websites and opened for Lenny Kravitz. We meet the biologist Marcel Salathé, one of the world's rare experts in digital epidemiology. *By Sophie Gaitzsch*

**O**ur first question to Marcel Salathé was: Are you a pioneer in digital epidemiology? His circumspect reply was, “Hmm, more like somebody who started to work in this field early on”. Salathé is a 40-year-old biologist from Basel who uses new methods of digital communication to study illnesses and their propagation. When he talks about himself he shows typical Swiss modesty. Yet he still wins the respect of his peers. “Marcel was one of the first to see Twitter as a source of health information”, says Andrew Read, a former colleague at Pennsylvania State University. “Many people saw him as crazy. He’s always thinking about the next new idea, and whether he dares to enter early”.

Following eight years spent in the United States, where he attended the University of Stanford prior to Pennsylvania, Salathé joined EPFL in the summer of 2015 and set up its digital epidemiology laboratory. At his new office within Geneva’s Biotech Campus, his reserve has been replaced by an American enthusiasm for his research field. “People love talking about their health concerns on Facebook and Twitter, making it an inexhaustible supply of information for scientists. Another example is the ability to localise mobile phones, which helps us to track population movements during epidemics. These new data flows are rapid, but above all global. Hundreds of millions of people who do not have access to traditional health systems now have a smart phone”.

## Hashtag swine flu

One of Salathé’s latest pieces of research uses Twitter to analyse the secondary effects of HIV treatment. He has also worked on the effects of pro- and anti-vaccination messages during the swine flu outbreak.

“The idea of using digital tools to improve health has only entered its primary phase. In the long term, care will be fundamentally changed, becoming more intelligent and more efficacious”. Salathé is not one to hesitate when it comes to experimenting with these new tools personally. He shows off his smart watch with its fluorescent orange strap. “It measures the number of steps I take during the day, the number of calories that I burn. I realised that this would influence my behaviour. And it’s evident on days when I haven’t been very physically active: just before going to bed, I start running up and down the stairs like a maniac!”

Salathé will now move on to his project entitled PlantVillage, which is designed to help farmers diagnose plant illnesses by sharing and commenting on photographs posted online. When he joined EPFL he also brought with him an overflowing optimism for mass online open courses, or MOOCs. He is the father of two children of three and six years and lives near Morges, where he feels at home well off the beaten path. His peers also describe his profile as ‘atypical’. He is the son of a police officer and an office worker and chose to begin his studies in the field of biology at the University of Basel by using a process of “elimination”. “Everything else seemed boring. I was an anxious teenager, and nature was one of the few places where I could find calm”. He eventually found the topic to be “incredibly inspiring” before soon discovering a second area of interest: web programming.

## Painter, programmer and biologist

Salathé left university and set up an online sales start-up before returning to study: and all the while he was working as a programmer. “At the end of the 1990s, everybody was an autodidact! This experience

Valérie Chételat





“I envy those scientists who spend all of their energy on a single pursuit”.

gave me a mental freedom which continues to guide my work today”. He has since launched other Internet projects, and has just published a manual entitled *Nature in Code*, which links programming and biology. “Marcel hopes to have an impact”, says his former colleague Read. “To do this, he is ready to carry out projects outside of his academic position, by launching a company or an app”. He’s an ambitious person then? “Yes, but in a nice way”.

Salathé had the opportunity to conduct new experiments during his doctoral studies at ETH Zurich in the 2000s. According to his supervisor Sebastian Bonhoeffer, Salathé stood out thanks to his “exceptional” ability to concentrate and to having published a dozen articles. He put 1,000 of his paintings up for sale on the Internet, setting the price himself as a function of demand. Each canvas has a number between one and 1,000, and all are painted using the same template. This idea was well-received particularly by the media in a number of countries. “Marcel has always had a refined sense of what works and what doesn’t in the digital world”, says Bonhoeffer. “That’s why he’s been on television to debate what is and what isn’t art!”

#### **Exiting the comfort zone**

During the same period, Salathé played with a rock group from Basel called *Phébus*. The group has been relatively successful, having signed with the British record label EMI, and even having opened for Lenny Kravitz. “It was a funny experience”, he laughs, as he is now more interested in classical music despite continuing to write his own songs. “Today, I am mainly trying to spend every minute of my free time with my family. And this summer, I will try to go trekking. I am also always looking for

someone who would like to accompany me on a journey across Switzerland. For anyone who is interested!”

So he wears the caps of scientist, entrepreneur, author and musician. Can he manage them all? “I envy those scientists who spend all of their energy on a single pursuit. Being active in a number of different research fields sometimes leads you to think that you lack depth in a number of them. But given that modern science is interdisciplinary, becoming involved in areas outside of one’s comfort zone is also an asset. After all, why choose one approach over another?”

Sophie Gaitzsch is a journalist based in Geneva.

#### **A multi-talent**

40-year-old Marcel Salathé is a biology professor at EPFL. He studied at the University of Basel, holds a PhD from ETH Zurich and conducted post-doctoral research at the University of Stanford before being appointed assistant professor at Pennsylvania State University. He is an expert in digital epidemiology, has launched his own websites and apps (*Netzfaktor*, *PlantVillage*), played in a rock group, and sold 800 paintings on the Internet. He is married and the father of two children.

# Sausages and cancer: what's in a warning?

Tobacco, glyphosates and sausages are all carcinogenic... “probably”. But what does that really mean? And what does it tell us about WHO’s risk-communication strategy? *By Florian Fisch*

It's long become a ritual. At regular intervals, the World Health Organization (WHO) classifies chemicals and food-stuffs as carcinogenic - most recently, it was the sausage. The headlines automatically follow. ‘Beware of the sausage’ was the comment of the *Neue Zürcher Zeitung*, the main German-Swiss daily. Then passers-by on the street are asked for their opinion. “I don’t pay any attention to studies”, one of them told the Swiss TV programme ‘Puls’. And an irritated butcher asks: “I’d like to know just how much a study like that costs, and what the use of it is”.

As expected, the meat industry didn’t take much pleasure in the news. But it’s an open question as to just how big an effect WHO warnings have on public health. What’s certain is that they sow much confusion. After the sausage warning, the US monthly *The Atlantic* described WHO as ‘confusogenic’ and said, “they are terrible at communicating their findings”. Michael Siegrist, Professor of Consumer Behaviour at ETH Zurich, is looking into how risks are communicated. He agrees with *The Atlantic*. “WHO isn’t tasked with scaring people. It’s supposed to inform them”.

## An unequivocally low risk

Informing people is also exactly what WHO would like to do. It runs a specialised cancer agency called the International Agency for Research on Cancer (IARC), whose goal is “to identify the causes of cancer so that preventive measures may be adopted and the burden of disease and associated suffering reduced”. They have thus far investigated over 900 different suspect factors, the best-known examples being smoking and passive smoking.

A specialist group analyses all the studies published on factors that cause cancer, and classifies these factors according to five categories. The first is ‘carcinogenic to humans’ and includes tobacco, ultraviolet rays and asbestos. The most recent addition

was processed meat products. ‘Probably carcinogenic’ is the category assigned to red meat and the herbicide glyphosate (see “Is glyphosate carcinogenic?”, p. 8). Apart from many ‘not classifiable’ agents, most factors are placed in the ‘possibly carcinogenic’ category, which includes radio waves and aloe vera extract. The only substance classified as ‘probably not carcinogenic’ is caprolactam, a chemical used in the production of nylon.

“WHO has to get to grips with the current literature on risk communication”.

Michael Siegrist

So are sausages and tobacco equally dangerous? No, writes WHO in a list of frequently asked questions: “The IARC classifications describe the strength of the scientific evidence about an agent being a cause of cancer, rather than assessing the level of risk”. However small the risk, if it’s unequivocal, then it comes into the top category. In another of the FAQs, there is mention of the Global Burden of Disease Project, which attributes 34,000 cancer deaths worldwide to diets high in processed meat. This is almost insignificant in comparison with the millions of deaths from tobacco.

## A lack of guidelines

“Assessing the credibility of an effect is the first step in assessing risks, and a very significant one too”, explains Béatrice Lauby-Secretan, a scientist at the IARC. The important work on weighing up this effect is postponed by WHO until a later date. Then it works with national health authorities who know the local context. Lauby-Secretan believes that it would be irresponsible to wait for additional information before communicating the results, because

individuals could already start to change their everyday lives by taking the results into consideration.

WHO thus leaves it up to journalists to interpret this information for the general public. Heinz Bonfadelli, a former professor at the Institute of Mass Communication and Media Research at the University of Zurich, thinks that this is unwise. “I find it problematical when WHO doesn’t contextualise the information it gives to the media, but instead refrains from giving guidelines for action”. He suspects that WHO avoids doing this so as not to come into conflict with different interest groups.

Bonfadelli does admit that “Risk communication is always a difficult business”. All the same, there are methods that could create less confusion. For example, WHO ought to plan ahead when informing the media “and consider how its information



WHO's confusing cancer warnings serve sausage makers a dish of unwelcome food for thought. Photo: Keystone/Gian Ehrenzeller

might be distorted". If it completely outsourced its risk analysis, then the national authorities in question could be informed two weeks in advance, for example, and could prepare the information to be passed on to journalists.

### The damage of relative risks

Siegrist isn't convinced that this would help. "It's not just the consumers. Even the authorities themselves in some cases are unable to deal with risks". He believes that the problem lies squarely in communicating relative risks. WHO wrote in its media release that eating 50 grams of sausage per day can increase the risk of bowel cancer by 18 percent. "This information is completely useless. As a consumer, I need absolute figures in order to be able to assess a risk". According to the Cancer League in Switzerland, some 4,100 people develop bowel can-

cer every year. If meat consumption were reduced across the country, this number could sink to less than 3,500.

Communicating relative risks has tangible side effects, says Siegrist. "It has an impact on perceptions and leads people to worry more. Even absolute figures can seem more threatening if they are accompanied by relative figures". People are probably becoming dulled to all these threats. Siegrist believes that a need for public attention drives organisations like WHO to insist on keeping relative figures in their media communication.

WHO itself doesn't know whether these cancer warnings really have any impact. According to Lauby-Secretan, it would be extremely complicated to try and carry out a global analysis of behavioural change or of cancer rates. "We do know that after our press release, sales of processed meat

went down noticeably in several countries". But for Siegrist the consumer behaviour specialist, the situation is quite clear: "If WHO wants to communicate seriously with the general public, then it has to get to grips with the current literature on risk communication".

Florian Fisch is a science editor at the SNSF.

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G. Gigerenzer et al.: Helping doctors and patients make sense of health statistics. *Psychological Science in the Public Interest* (2008)

V. Bouvard et al.: Carcinogenicity of consumption of red and processed meat. *The Lancet Oncology* (2015)

# For some, it's an up-hill battle

We are not all equal when it comes to viral infections. Some people end up out of action for weeks, whilst others recover spontaneously. Individual genetic variations may shed light on this phenomenon.

By Marie-Christine Petit-Pierre

**T**hanks to Angelina Jolie, everybody now knows about the mutations to the BRCA1 and BRCA2 genes that cause breast cancers 1 and 2. We know that these mutations lead to a significant increase in the risk of both ovarian and breast cancer. This situation also illustrates the health impact of individual genetic variations.

Our sensitivity to bacteria, viruses and fungi is also influenced by our genes. Pierre-Yves Bochud, a visiting doctor at the infectious diseases service of the Vaud University Hospital (CHUV), is working as part of a team tracking the influence of individual genetic variations on immune system responses in patients infected with certain microbes. In particular, they are looking at hepatitis C.

## Avoiding ineffective treatment

A genetic variation in interferon-lambda (IFNL) 4 leads to a shortfall in the immune response, reducing the organism's capacity to fight against the virus, and even to respond to treatment correctly. "Whilst everybody produces the anti-viral protein IFNL 3, only a few people also produce IFNL 4". It should be a complementary weapon in the fight against the hepatitis C virus, but it's not. In fact, "it's as if the immune system burns out and runs itself into the ground, no longer capable of fighting the virus", says Bochud.

"Having detected the genetic variant means treatment regimes can be personalised, including in terms of their duration. For example, a person who doesn't produce IFNL 4 can have weeks cut from their prescription", he says. Having improved on previous efforts, the current treatment

is effective in 90% of cases but it has also continued to be somewhat expensive at CHF 50,000 - 200,000 per patient. Now a quick screening test costing around CHF 100 helps decide which patients will receive treatment.

Treating hepatitis C can cost up to CHF 200,000.

Genetic variations in IFNL 3 and 4 also play an important role in our defences against cytomegalovirus, an endogenous virus that leads to serious illnesses in immunosuppressed patients, such as those with advanced AIDS or with transplanted-organ rejection. "We can give a prophylaxis to risk patients", says Bochud.

## Predicting risk

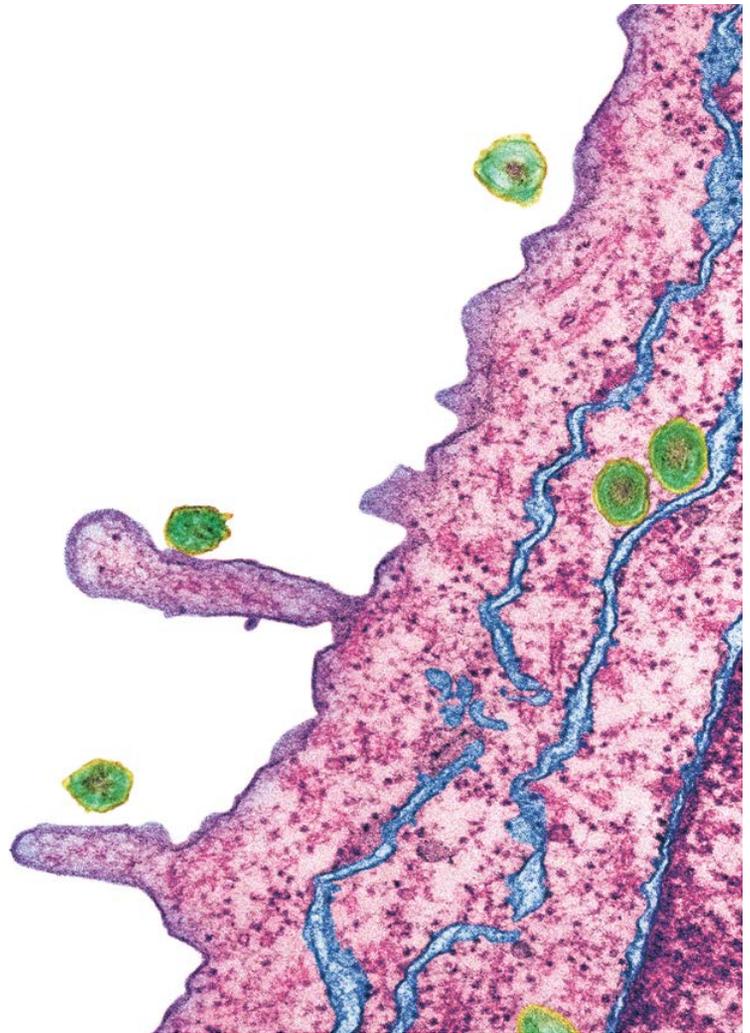
The same kind of mechanism is found in the gene PTX3, the variation of which leads patients to become more sensitive to pulmonary aspergillosis. This fungal infection can affect patients with leukaemia

following intensive chemotherapy. In these cases, we can predict risk and improve the personalised management.

Jean Villard, head of the national reference laboratory for histocompatibility at the University Hospital Geneva (HUG), thinks that this research can also be applied to preventative medicine. When asked if we can envisage the correction of undesirable variants using genetic therapy, he says, "no, because it's generally clusters of genetic variations that are implicated. It's therefore very difficult, if not impossible to identify them all and then to establish the relations among them, some of which may protect us whereas others make us more vulnerable to certain diseases".

Marie-Christine Petit-Pierre is a freelance journalist.

A. Wójtowicz et al.: PTX3 polymorphisms and invasive mold infections after solid organ transplant. *Clinical infectious diseases* (2015)



The hepatitis C virus, seen here in green attacking liver cells, has to reckon with a different defence mechanism in every host. Photo: Keystone/Science Photo

Library/Thomas Deerinck, NCMIR

## Super-resistance in sewage sludge

It's like an arms race. Every time the pharmaceutical industry develops a new antibiotic, resistant bacteria soon emerge. Their resistance develops quicker when antibiotics are taken for too short a time, or in dosages that are too small. Likewise, sewage plants are ideal breeding grounds for resistant bacteria, because the antibiotics found in waste water are highly diluted.

A research team led by Philippe Corvini, a professor at the School of Life Sciences FHNW in Muttenz, has discovered precisely how a bacterium in sewage sludge protects itself from a commonly used antibiotic, the sulfonamide group. What's particularly interesting about this recently discovered mechanism is that it doesn't just make the bacterium resistant to the substances: it even lets it feed off them.

The researchers have decoded how the bacterium breaks down the antibiotic Sulfamethoxazole, and they've determined what genes and enzymes are involved. When the substance is broken down, certain intermediary products emerge - benzoquinone and hydroquinone - that the bacterium can utilise as part of its normal metabolic processes.

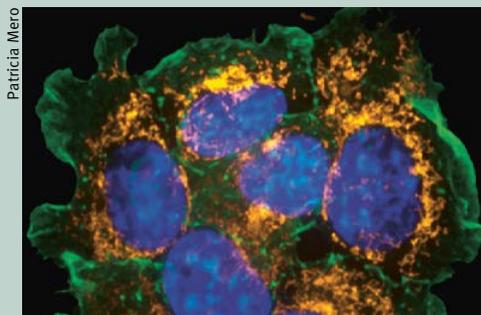
In addition, this micro-bacterium possesses a classical resistance mechanism. One enzyme that is usually blocked by sulfonamides is changed so that it is no longer completely obstructed. "This combination of the two mechanisms could be a kind of super-resistance that we would rather not see spread further", says Corvini.

Knowledge of these mechanisms and the enzymes involved in them could help us in future to develop better antibiotics, able to evade this form of resistance. *Angelika Jacobs*

B. Ricken et al.: Degradation of sulfonamide antibiotics by *Microbacterium* sp. strain BR1 – elucidating the downstream pathway. *New Biotechnology* (2015)



Bacteria resistant to antibiotics grow especially well in sewage sludge.



Certain genes in the cell nuclei (blue) are indispensable to cancer cells.

## Tracking down cancer's weak spots

The new molecular biological tool Crispr is enabling scientists to make quick, precise interventions in living cells. But for as long as the application of this 'gene scalpel' to the optimisation of the human genome continues to be intensely debated, its main use will continue to be for research purposes. And it has already allowed scientists in Canada to screen five different types of cancer cells systematically for genetic weaknesses.

In the course of their work, these researchers have disabled almost every one of the 20,000 human genes individually *in vitro* and then observed the growth of the genetically altered cells. Where the cells continue to reproduce to the same degree, the gene removed is regarded as dispensable. But where growth slows or even stops, the scientists classify the suppressed gene as vital for life.

Almost 1,600 genes were shown to be essential for all the cell types studied. But above and beyond these fundamental biological processes, the scientists have also identified almost 2,500 additional genes that are only necessary for the growth of individual cancer cell types.

"In future, the fight against cancer should target these specific characteristics precisely", says Michael Aregger, an SNSF-funded researcher at the Donnelly Centre in Toronto. For example, if we succeed in producing agents that can paralyse a gene needed only by bowel cancer cells for their growth, then a long-standing medical dream could come true: being able to combat cancer cells with a tool that has no side effects because it does not damage healthy cells. *Ori Schipper*

T. Hart et al.: High-resolution CRISPR screens reveal fitness genes and genotype-specific cancer liabilities. *Cell* (2015)

## Make hay while the sun shines

The productivity of grasslands plummets during arid summers. If the land is regularly used for grazing instead of being mown, the losses are even greater. This has been proven by a study on extremely dry summers in the Swiss Jura mountains that has been carried out jointly by the Swiss federal research institutes Agroscope and WSL, along with EPFL and three French institutes.

In order to simulate drought conditions, the researchers covered grass surfaces with transparent horticultural tunnels. They compared these with grass surfaces that were exposed to rainfall, and the results were as expected. They confirmed that drought leads to shortfalls in the harvest.

But both grass surfaces were also further divided up into sections where sheep were allowed to graze, and sections that were mown regularly. The yield from the open grass that was grazed upon was roughly 15 percent less than for the grass that was mown. And when the grass was arid, this loss of biomass was twice as great. "In contrast to earlier studies on aridity, we have for the first time compared two realistic agricultural practices in Switzerland", explains Agroscope's Claire Deléglise, the principal author of the study. Her study compared five grazed surfaces with three mown surfaces.

Extremely arid summers could become a more common occurrence in Central Europe. The present results are only valid for conditions in the Jura, says Deléglise, "But there are plant-physiological models that are being used to calculate the general impact of climate change on agriculture, and our results are helping to calibrate them". *Stéphane Hess*

C. Deléglise et al.: Drought-induced shifts in plants traits, yields and nutritive value under realistic grazing and mowing managements in a mountain grassland. *Agriculture, Ecosystems & Environment* (2015)



The researchers use greenhouse tunnels to simulate very dry summers.



**The oil industry has been using continuous processes for decades – as shown here in the Collombey refinery in the canton of Valais. But chemists are still having difficulty in applying its advantages to the production of drugs.**

Photo: Luca Zanier by Keystone



# Towards a mobile drugs lab

Pump out pills 24/7 and reduce wastage? Pharmaceutical companies are rolling out the red carpet for continuous manufacturing. We look at why 'flow chemistry' is about to shake up the industry. *By Sven Titz*

**P**roducing pharmaceutical agents continues to be a cumbersome process, like a relay race over hurdles. Production takes place in a long chain of individual steps. One stirrer tank after the next has to be filled, one chemical reaction started after another. Sometimes, these individual steps even take place at different sites, which means production takes even longer still.

But all this could soon change. Because the batch processes that are still the norm are due to be replaced by more modern methods. "Continuous manufacturing" is the magic formula. From now on, production is to become a seamless procedure.

In a long, single stream of reactions, the initial substances are added bit by bit. Control measurements and regular feedback ensure things don't get out of hand. The motivation behind all this is simple. Pharmaceutical companies could be able to develop and produce drugs quicker by using 'flow chemistry', as the procedure is called. It would also require less energy and a smaller volume of starting substances. Altogether, it's claimed that costs could be reduced by up to 30 percent. Several companies are now working on bringing these new production techniques onto the market - from Pfizer and GlaxoSmithKline to Novartis and Lonza.

## Flowing fully from start to finish

Researchers at the Massachusetts Institute of Technology (MIT) and Novartis set themselves an ambitious goal back in 2007. Together, they wanted to develop the first-ever drugs production factory to be fully devoted to continuous manufacturing. In 2012, an experimental plant was completed at MIT. All steps were fully integrated, from the chemistry to the cleaning and the coating of the tablets. Team leader Bernhard Trout from MIT is firmly convinced of the potential of this concept. "We can produce any drug, and do it more efficiently and with less waste", he claims. That experimental plant at MIT is currently being used

as a model for developing viable industrial plants for drugs production. And the MIT spin-off 'Continuous Pharmaceuticals' in the USA is working on this too.

## More efficient production needed

The oil industry has already demonstrated the benefits of continuous manufacturing. The techniques have been used in oil refineries for decades now - notably for the production of synthetic materials. Ten years ago, the idea was taken up by other sectors. Dwindling profits and greater competition in the pharmaceutical industry helped to raise awareness of a need to make production more efficient and more flexible.

"There's no limit to the spectrum of products".

Roger Marti

Flow chemistry isn't just limited to pharmaceuticals. "There's no limit to the spectrum of products that can use it", explains Roger Marti, a chemist at the School of Engineering and Architecture in Fribourg. You can produce both basic chemicals and complex fine chemicals on a large scale. Even polymers and nanoparticles are possible.

## Indispensable miniaturisation

In order to apply continuous manufacturing to drugs production, reaction systems had to be miniaturised, because in the pharmaceutical industry, especially at the development stage, the volumes involved are much smaller than in the oil industry. "From a chemistry perspective, miniaturisation also has its advantages", says Marti. "For example, reactions can be carried out at higher temperatures than used to be the case".

So researchers have designed special little pipes and micro-reactors in which the reactions take place, and which are often made of steel, glass or plastic. And they didn't just design new reaction vessels, but



**A standardised mini-factory fitted to a transport container. This is the vision of the European research project 'F3 Factory'.**

Photo: INVITE GmbH

also new components for mixing or heating substances, because when shrunk down to a mini-format, standard components could fail.

#### Assembling micro-reactors

One typical example of this miniaturisation is the FlowPlate MicroReactor developed by Lonza. These micro-reactors are made in four different sizes, allowing a flow volume of between just a few millilitres and half a litre per minute. They can be combined in a modular system, meaning they can be adjusted to different volume requirements. According to Lonza, they can be used to develop new chemical processes in the lab and then afterwards transform them into a production line.

Lonza says the modular design saves space and can lower production costs. Furthermore, it offers secure reaction conditions, even for highly reactive or poisonous starting substances. The process yield could conceivably be increased, says Lonza, if quick mixing processes, efficient heat exchange and precisely controlled reaction times could be integrated. Lonza has already tested different reaction types successfully: liquids with each other, liquids with gases, oxidation, and with bromine or chlorine, for example.

#### Standardised container modules

Industry relies on modular systems. If pharmaceutical companies want to make use of continuous manufacturing on a large scale, they will find it advantageous to employ modules in which chemical substances can be produced for a broad variety of active agents. This would also

speed up supply. For this, they need flexible units that can facilitate the transfer of laboratory processes to the pilot and production phases. This can mean a leap from just a few millilitres to several cubic metres per year.

“We can produce each drug more efficiently and with less waste”.

Bernhard Trout

This is why the EU research project ‘F3 Factory’ developed practical modules oriented to the standardised size of containers: six metres long and 2.4 metres high and wide. Forty modules can fit into a single container. In this research project, for example, such modules were used to produce chemical intermediates for a test drug to treat cancer.

The EU project was run by a large consortium from 2009 to 2013, and its modules are now being further refined at the INVITE research centre in Leverkusen, run jointly by Bayer Technology Services and the Technical University of Dortmund. Lots of minor changes are being made there. They’re working on the regulation technology and on preparing the active ingredients for the drugs. “Our centre isn’t called ‘INVITE’ for nothing”, says Thomas Bieringer, a former managing director of INVITE. “We are a public-private partnership, and we invite external partners to develop and try out new continuous procedures”.

#### Tricky crystals

Several obstacles still have to be tackled. “Some of the chemical processes can block the reaction channels”, says Bieringer. This can happen when the chemical reactions produce solid substances. Then the researchers have to try and alter the reaction conditions – such as by employing feedback loops. If this works, then they will be able to recognise the danger of a blockage in good time and prevent it.

Flow chemistry’s full potential for the pharmaceutical industry is yet to be realised. Scientists in various places are working on adding crystallisation to continuous production processes, which would help them to produce drugs in tablet form. But they also have to make these new processes safe enough for them to be accepted by the authorities. And all this will take time. But it could soon become normal for the tablets on our bedside table to be made in a mini-refinery.

Sven Titz is a science journalist. He lives in Berlin and writes regularly for *Neue Zürcher Zeitung*, *Tagesspiegel* and *Welt der Physik*.

Carl-Jürgen Bautsch



The BIQ House in Hamburg generates energy from the algae biomass in its façade.

## Fuel from sunlight

For a long time, engineers have been trying to copy biological photosynthesis. Their aim is to use the energy of the sun to separate energy-rich hydrogen from water. This would enable us to produce fuel for engines or fuel cells. Artur Braun's working group at Empa has taken a step closer to artificial photosynthesis.

Braun is a biophysicist working on photo-electrochemical cells in which the semiconductor iron oxide is combined with proteins derived from cyanobacteria. Now his team has used X-rays to help them succeed in measuring the physical processes occurring between the biomolecules and the semiconductor. "We can see the cell's physical reactions on the surface in detail", he says.

Such experimental proof shows that two different strategies of artificial photosynthesis can be united: on the one hand we have the biochemists who put their hope in using biological molecules, and on the other hand we have the engineers who are recreating the biological system with inorganic materials. Braun's photo-electrochemical cell is thus comparable to the cell made by the solar pioneer Michael Grätzel of EPFL. "Our hybrid of animate and inanimate matter generates more hydrogen than pure iron oxide", says Braun.

Measuring these processes on the boundary between biomolecules and iron oxide is necessary in order to further the exploitation of biological energy systems that can regenerate themselves. In Lausanne, Grätzel supports Braun's strategy: "Their work with iron oxide and bacterial proteins has a promising future", he says. *Stefan Stöcklin*

A. Braun et al.: Biological components and bio-electronic interfaces of water splitting photoelectrodes for solar hydrogen production. *Chemistry – A European Journal* (2015)

## Depicting a single virus

Biologists dream of being able to image individual molecules. Researchers at the University of Zurich have come one step closer to this goal with the help of innovative technology. Using electron holography, they have been able to visualise a single virus with an unparalleled level of precision.

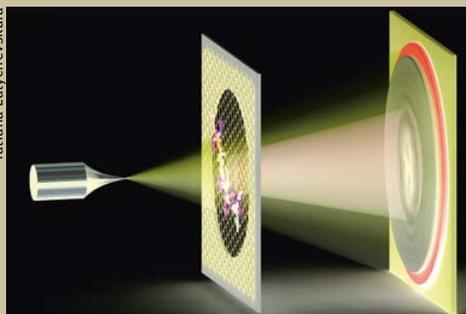
In order to develop better drugs, it is imperative to know the details of the spatial and chemical structure of individual biomolecules. Traditional technologies such as nuclear magnetic resonance, X-ray crystallography or electron microscopy only allow us to decipher the average structure of many biomolecules. Thanks to electron holography, the team in Zurich has been able to display a single tobacco mosaic virus with a resolution of one nanometre.

This technology makes use of the fact that electrons behave like waves according to quantum mechanics. If you irradiate a molecule with electrons, they partially warp the wave in question. The warped part of the wave then overlaps with the unaltered part on a detector and creates a pattern – a so-called hologram. This technology does not use any lenses, thereby excluding the danger of distortion and making sharper pictures possible. Furthermore, the low energy level of the electrons means they barely do any damage to the molecule being investigated.

"Electron holography has the potential to make even sharper pictures, possibly making every single atom of a biomolecule visible", says Jean-Nicolas Longchamp, the main author of the study. This could allow us to examine precisely how drugs dock with their target in our bodies. *Leonid Leiva*

J.-N. Longchamp et al.: Low-energy electron holographic imaging of individual tobacco mosaic virions. *Applied Physics Letters* (2015)

Tatiana Latychevskaia



Electron holography illuminates details on a nanometric scale.



The goal: less soot in exhaust fumes.

## Putting oxygen in your motor

When we talk about 'green' transportation, we tend to think about electric or hydrogen vehicles. But whilst we're waiting for tomorrow's world, combustion engines can and must be continually improved. A number of studies have looked at improving the formula of today's fuels, particularly so-called 'oxygenated' diesels. "When combusted, these fuels release far fewer particles and less soot than traditional diesels", explains Stefano Iannuzzi of ETH Zurich. The other side to this coin is that they are not compatible with the engines currently on the road, particularly because they evaporate at temperatures greater than 42° C.

Iannuzzi has been studying oxygenated diesels of the group OME, which are ethers obtained from natural gas. With his team, he was able to quantify the formation of soot during OME combustion using analytical tools such as spectrometers. Among the fuels tested by the team, it was the blends of OMEs and conventional diesel that stood out. "The more that the OMEs in the mixture are oxygenated, the less they released soot during combustion", he says. The results speak for themselves: a commercial fuel with 5% oxygenated diesel reduces soot formation by almost 30%.

Nevertheless, these tests were conducted under laboratory conditions, and not in engines. Iannuzzi is now conducting new tests using single cylinder engines, hoping to see whether the blends will work well under real conditions. *Fabien Goubet*

S.E. Iannuzzi et al.: Combustion behavior and soot formation/oxidation of oxygenated fuels in a cylindrical constant volume chamber. *Fuel* (2016)

# Where village chiefs are also judges

Many people are fleeing from South Sudan. But Martina Santschi, a social anthropologist at Swisspeace, often travels there to do her research - despite all the dangers involved. She wants to find out how the new state can make use of existing social structures.



“Everyone asks about safety. And yet at the beginning, it was the dry season that I found most deadly - when the streams have dried out, all the trees are stretching their withered branches into the heavens and the ground is riven with gaping wounds. The first time I experienced it, I asked myself: can I really cope with this for a long period of time? I grew up on a farm in a village by Lake Thun. I love green, luscious meadows. But on the other hand, I did soon notice similarities between the Bernese Oberland and South Sudan. For example, cows are very important to my family. And cattle-breeding is also very important in my place of research. The societal significance of the cow plays a role in my scholarly work.

“And yet I’m not actually looking into the dairy industry or cattle-breeding. I’m investigating how existing social structures can interact with the creation of statehood in a new nation, South Sudan, which only became independent on 9 July 2011. It is the youngest country in Africa. I visited South Sudan for the first time in 2007 as part of my doctoral research in

social anthropology at the University of Bern. It was still part of the Sudan back then. I’ve since been back repeatedly. I twice spent eight months in South Sudan to do research for my doctorate. For other projects, I go back for shorter periods of time. I’m especially interested in traditional authorities, local governance and arbitration courts.

## Establishing harmony

“Arbitration courts settle concrete disputes - and this is where cows come into it. It often happens that people quarrel over dowries. ‘You still owe me a cow for my daughter’ is a typical accusation you hear from the father of the bride. Those affected then hand in a complaint to the village chief, who calls up other members of the court. Witnesses are questioned and everyone is allowed to take part in the discussion. It can take several hours. I find it very impressive, because it’s not the village chief who makes the decision at the end. It’s more about establishing harmony, about finding a compromise. It’s rare that anyone is locked up after committing



an offence, except in the case of serious crime such as murder. It's interesting as a researcher to observe how, despite years of civil war, systems of governance and arbitration procedures have continued to function in spaces that otherwise seem to be a legal vacuum and are supposedly devoid of state authority.

### Risk factors in uniform

"I carried out interviews in South Sudan, accompanied by an interpreter. I had a satellite phone with me in case of emergency. To be sure, South Sudan is a conflict region - but I'm not reckless. I make sure I'm well-informed before I travel anywhere. When I'm in towns, I spend my nights in secure accommodation. Out in the countryside there's a greater degree of social control, and I can sometimes set up my tent or live in simple guest houses. I've been in a critical situation perhaps two or three times. Armed men in uniform can be unpredictable, and that's a risk factor. And on one occasion I came down with malaria despite having taken prophylactic medication.

"What's important is being able to place trust in my contacts and my interpreter. Mareng Chuor translated for me during my first field trip. I lived with his family. We soon broke the ice - one morning, my host family noticed that I was wearing one black sock and one blue sock. We laughed out loud, and Mareng said: 'It's nice to see you're only human too'.

"And what's the result of my research? Perhaps the realisation that there are local institutions that function very well, and that play an important role in local governance. External bodies like the UN agencies and NGOs often focus on laws at the national level, paying less attention to their concrete implementation and the impact they have. At first glance, passing a new land law might seem a sensible thing. But in practice, this can prove disadvantageous to poor people who can't afford the official registration fees. It can mean they lose their land".

Recorded by Christian Weber.

A new member of the arbitration court is elected at the village meeting in Mangartong in Aweil East County in South Sudan (top). Martina Santschi, her interpreter Wyiual Lam and the off-road vehicle that they and their colleagues have just pushed through a river near Yua (left).

Photos: Martina Santschi and Rachel Gordon



A new ice age begins in the disaster film 'The Day after Tomorrow'. This fictional scenario seems to heighten

## The upside to the end of the world

Disaster films and science-fiction stories can go one step beyond entertaining us: they can also help shape our values.

*By Susanne Leuenberger*



the audience's awareness of climate change. Photo: Keystone/Everett Collection

**T**he Antarctic wasteland stretches out endlessly before us on the movie screen. For several minutes, the aerial photography explores the sublime beauty and the terrors of this icy world. Only then do human figures appear in the picture. We see a team of scientists, drilling into the ice core. The palaeontologist Jack Hall is one of them. When an ice floe breaks off suddenly and a gap opens up between the ice core and the scientists, Hall jumps over the chasm to save the samples before leaping quickly back again. He risks his life for research – and for the survival of humanity.

The scientist Jack Hall is the hero of Roland Emmerich's disaster film 'The Day after Tomorrow' from 2004. The movie cost 125 million US dollars to produce,

and for long stretches it shows computer-animated scenes of a world frozen in ice. It's one of very few Hollywood blockbusters to have taken the dangers of climate change as its main topic. The dramatic climate scenario of this commercially successful film had an impact that was felt way beyond the cinemas. The hype surrounding 'The Day after Tomorrow' prompted real scientists to take to the media, assuring everyone that the new ice age it conjured up was merely an improbable, purely fictional scenario.

Whether fictional or real: these images of a world ravaged by storms and floods and a flash-frozen world had a major impact, as has been proven by existing reception studies such as the Yale Project on Climate Change Communication. After

seeing the film, audiences were measurably more aware of climate change than they had been before.

#### **Fiction sensitises us to reality**

The cultural studies expert Alexa Weik von Mossner has seen this action movie innumerable times already. "Not because I find the plot particularly successful. It uses a lot of clichés". She works at the Department of English and American Studies at the University of Klagenfurt and is investigating how narratives of catastrophe and post-apocalyptic tales are used to talk about climate change; in films, in literature, and also in non-fictional formats such as climate documentary films. Her conclusion is this: "Fictions such as Emmerich's 'The Day after Tomorrow'

# “Here the brain seems not to differentiate between fiction and reality”.

Alexa Weik von Mossner

can help to sensitise a broader public to the risks of climate change”.

Von Mossner's next monograph will be published soon. In it, one of the works she subjects to narrative analysis is the novel 'The Road' by Cormac McCarthy, which won the Pulitzer Prize in 2007. The novel tells of a father and son who struggle to reach the coast in a post-apocalyptic America. After a catastrophic event, not described in detail, the sky is overcast with a dark fog, the Earth is barely populated any more and it has cooled down almost to freezing. Von Mossner looks at the literary text and its later film adaptation by John Hillcoat to see how these two media deal with their respective possibilities for telling a narrative set in a devastated world, and how they make it perceptible to the senses. Von Mossner works with the concept of 'embodied cognition'. This takes as its starting point the idea that cognition is bound to emotions and physical sensations.

## Narratives and neurology

Von Mossner complements her narrative analysis with findings from neurological research into the emotions. Different experiments suggest that the action and scenarios experienced while watching films in fact stimulate the same areas of the brain as the real thing would. “The brain seems not to differentiate between fiction and reality”. Fiction can therefore heighten our consciousness of risk, and sensitise us to possible future scenarios.

This interdisciplinary approach to fiction is rather new, but it could set a precedent. Literary scholarship and film studies used to be moulded by psychoanalysis and social criticism, but for some years now they have been drawing closer to

neuroscience and have started to investigate the cognitive and emotional dimensions of fiction.

However, the incorporation of neurological findings into film-studies literature isn't always simple, because it means bringing together different research traditions. Von Mossner is aware of this. She sees a need for 'translation services' between cultural studies and cognitive research: “The analysis of a whole film sequence has to be broken down into measurable factors”. Nevertheless, taking neurological findings into account allows you to prove the impact of fiction on 'real life' - which is an important complement to pure content analysis of film and literature.

## Emotional mechanisms

Robert Blanchet is also of this opinion. He is based at the Department of Film Studies of the University of Zurich, where he is researching into the emotional impact of films. In his project 'The Medium of Love', he investigates what it means to feel empathy with the characters in a film: “Empathy, in my opinion, is a necessary prerequisite for developing sympathy or antipathy for either a real or a fictional character”. Blanchet is looking into what emotional mechanisms are involved when fans of TV series devote themselves to their programmes' heroes for longer periods of time. He's looking at US series such as 'The Sopranos', 'The Wire' or 'Mad Men'. His research is based on neuro-scientific and socio-psychological findings, while his theoretical assumptions are based on the philosophy of the mind. “It's obvious that not every research problem in the humanities can be backed up empirically, nor does it

have to be”. And yet it often makes sense for someone in the humanities to check whether there are empirical studies that might support or contradict one's own findings. Just like von Mossner, Blanchet believes that, emotionally, people process fictional content and real-life experiences in a similar manner.

Whether it is fictional or real: many other current research projects also support the idea that engaging with disaster scenarios is more than just a pastime. One of these is being run by the media psychologist Matthias Hofer of the Institute of Mass Communication and Media Research in Zurich.

Hofer is currently at Michigan State University, where he is investigating how medially transmitted values and norms can influence social behaviour such as welfare. His results already suggest that people who read newspaper articles about the victims of natural disasters and starving children are more likely to offer help afterwards than those who read holiday reports.

Susanne Leuenberger is a journalist in Bern.

# “I can see no alternative to the multilateral path”

Streams of refugees, global warming, the Euro crisis - it seems we spend our time arguing about our problems in marathon negotiations when we should really be solving them instead. But appearances are deceptive, says the historian Madeleine Herren-Oesch.

*Interview by Anita Vonmont*

**Prof. Herren-Oesch, these days the big international conferences often end without any binding agreement. Declarations of intent seem to be the best they can muster. Will we ever again put our money where our mouth is, like back in 1987 when we agreed on a worldwide ban on the CFC propellants that destroy the ozone layer?**

It's become more difficult to reach really concrete, binding decisions, that's true. Today there are a lot more players involved than there were 30 years ago. It's not just the politicians and diplomats of the West who decide things at the negotiating table. Developing countries and emerging economies are important too, and have to be taken to task. International civil society and its interest groups are also involved in the debate. Regional differences have to be accounted for. So the negotiations are complex, as are the grounds for making decisions. And this makes it more difficult to find a consensus.

**At the climate summit in Paris last December, an agreement was signed by 195 countries, and this was regarded as a success. Is that how you see it too?**

It depends on how you look at it. It's certainly a success in that the different countries were able to agree on ambitious climate goals. But at the same time it's an open question as to just how binding the wording of the agreement is, and whether the signatory states will actually implement what they've promised.

**Can this multilateral path really lead us to our goal?**

I simply see no alternative. In a globalised world, individual players can't be responsible for the problems, nor should they be. Struggling to negotiate the best possible solutions with broad support is the only way forward.



“Europe is an example of how we can deal peacefully with the very different demands placed on us”, says Madeleine Herren-Oesch. Photo: Valérie Chételat

**What's the best way of achieving this? For example, how can the EU countries find their way to a rapid allocation formula for refugees?**

There's no magic formula for this. Such negotiations are difficult and protracted. But even if negotiations at the EU level don't bring about any concrete results, this doesn't mean they've been a failure. Decisions don't depend exclusively on international agreements but develop through political discussions, and these have clearly sensitised many people to the problem. The welcoming culture we've seen in Germany has really impressed me. I was surprised how quickly even the German universities opened up after the arrival of the first Syrian refugees. The Berlin Senate simply overturned the existing study ban for refugees in the space of 14 days! Quite unexpectedly, this has initiated an integration process that's really important, even though nothing was decided at the EU level.

**Do we still need reforms to enable the EU, the UN and international conferences to act more effectively?**

Yes, we do, but those reforms are in part already happening. The big international

players need societal legitimisation. We need to prevent people from being unsettled by complexity and from feeling threatened by the many different levels of action that are open to us. These should instead be seen as an opportunity. For example, Europe is often depicted as if it's in decline, overwhelmed by refugees and on the point of economic collapse. And yet after the end of the Cold War, Europe achieved something that is remarkable when compared with the rest of the world, namely a peaceful political transformation, with a reunited Germany integrated in the EU. Even if nationalistic tendencies and the terrorist threat are cause for concern today, Europe remains an example of how we can deal peacefully with the very different demands placed upon us.

Madeleine Herren-Oesch is a professor of modern general history and is the director of the Institute for European Global Studies in Basel. Her field is Europe's interconnectedness in a global context and, in particular, the history of international organisations.

Anita Vonmont is a science journalist in Basel.

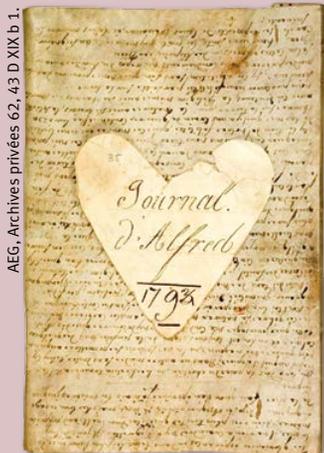
## Mothers' diaries

In the 18<sup>th</sup> century, the Western family underwent a significant change as a new model of maternity emerged. Mothers were given a new educational role, making them emotionally and physically closer to their children, and taking them beyond their primary functions of reproducer and feeder. The change was widely observed across French-speaking Switzerland, as has been shown by Sylvie Moret Petrini in her thesis on family educational practices and writing in the home.

Moret Petrini is a historian at the University of Lausanne, where she has analysed seven education diaries written between 1790 and 1820. The authors of these diaries were young mothers from Vaud and Geneva, whose social origins ranged from the clergy to the upper-middle class and the nobility. The diaries describe their children's development from birth and offer privileged insight into the realm of education at the time, revealing the ideas that were coming into use, as well as the welcome or the reserve with which they were received.

All of the mothers, except one, breast-fed their babies themselves, a practice strongly encouraged from the 18<sup>th</sup> century as part of the fight against infant mortality. In the cases studied, the issue of health was brought to the forefront. "Given this new responsibility - that is, ensuring the child's survival - mothers took to writing down their preferences and their skills", says Moret Petrini. On occasion, many even questioned the prescription of a doctor or the recommendation of a teacher on the basis of their own maternal status and experience. *Marie-Jeanne Krill*

S. Moret Petrini: La plume, instrument d'affirmation de la mère éducatrice, in Danièle Tosato-Rigo (Ed.): *Egodocuments et pratiques sociales (XVIe - début XIXe siècles)*, Etudes de lettres, Lausanne, 2016



This booklet tells us all about little Alfred's progress, from birth onwards.

Valérie Chételat

It. Stella ha anche letto Shakespeare.  
Fr. Stella a aussi lu Shakespeare.  
E. Stella has also read Shakespeare.

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'Also' means the same thing in many languages, but it's used very differently.

## The many lives of 'also'

'Also' is one of the best-loved words in many languages. As a rule, we barely pay attention to how we use these so-called additive particles when we write or talk, even though we make use of them constantly. The ways in which we use the little word 'also' and its foreign relatives 'aussi', 'anche' and 'auch' can be very varied indeed.

This particle appears in written texts less often in French and English than in Italian. The reason for this, says the linguist Anna-Maria De Cesare, is that French and English have other particles that are barely different from 'aussi' and 'also', namely 'également' and 'too'. De Cesare is an SNSF Professor at the University of Basel. Her work there has led her to the surprising discovery that an identical, seemingly irrelevant word in different languages can lead a very varied life. From a corpus of 750,000 words taken from the websites of large daily newspapers in France, Italy and England, she chose 300 examples comprising several sentences for her qualitative analysis. "You have to know the context of the words in order to understand their function". Her work is important for both linguistic theory and for linguistic didactics, she says. "When someone learns a foreign language, you can now draw their attention to its idiosyncrasies with regard to these seemingly unimportant particles", says De Cesare. *Urs Hafner*

A.-M. De Cesare: Additive Focus Adverbs in Canonical Word Orders. A Corpus-based Study of It. anche, Fr. aussi and E. also in *Written News*, in: *Linguistik online*, 2015

## The birth of a popular goddess

She was one of the many gods in the complex Egyptian panoply of deities. In English, her name was 'Mut', or 'mother'. She sometimes appears in human form, sometimes as a lioness with a human head, or as a vulture. She has a temple dedicated to her in Karnak, not far from Luxor, which is a sign of her former popularity. It's thanks to the Egyptologist Michela Luiselli from the University of Basel that we now know how Mut came into vogue. She initially had a political function but then developed a dynamic all of her own that her promoters - the pharaohs and theologians - had not foreseen.

The so-called 17<sup>th</sup> Dynasty enthroned Mut as a spouse of the god Amun-Re during a bellicose period in about 1500 BCE. She was intended to legitimise the monarchy, to stabilise its sovereignty and to embody the unity of Upper and Lower Egypt as a mother goddess in human form with a dual crown.

Already by the 18<sup>th</sup> Dynasty, Mut had become incredibly popular. Broad swathes of the population venerated her in extravagant processions with music, singing and prayers. But at the same time she was feared when in her guise as a lion goddess. In a dark period characterised by plague and famine, people saw in Mut both a threat to be banished and a possible source of longed-for redemption. A goddess created for political purposes had become an ambivalent goddess of the people. *Urs Hafner*

M. Luiselli: Escaping fear and seeking protection. On the role of Mut in New Kingdom personal religion, in: Ch. Zivie-Coche (Ed.): *Le rôle de l'individu dans la religion égyptienne*. Cahiers "Égypte Nilotique et Méditerranéenne", 2016



Daunting deity: a woman here, but crowd-pleasing Mut also manifested herself as a vulture and as a lioness.

# A gift that keeps on giving

The immune system is constantly creating new antibodies. A spin-off company based in Bellinzona is using them to produce antiviral drugs.

Journalist: Florian Fisch

Infographic: ikonaut



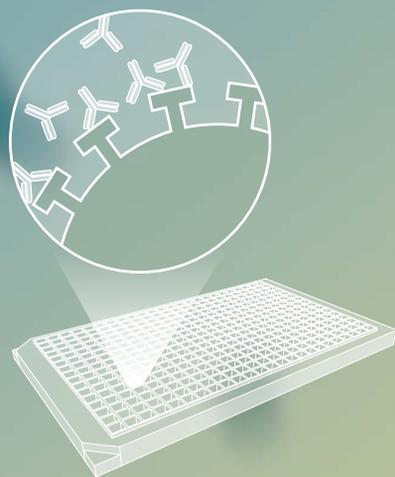
## 1. Survivors produce antibodies

After successfully overcoming an infectious disease – such as the Middle East respiratory syndrome coronavirus (MERS-CoV), which can lead to severe pneumonia – survivors' immune systems develop effective antibodies. Humabs Biomed, a spin-off company of the Istituto di Ricerca in Biomedicina (IRB) in Bellinzona, fishes these antibodies out of the blood of survivors.



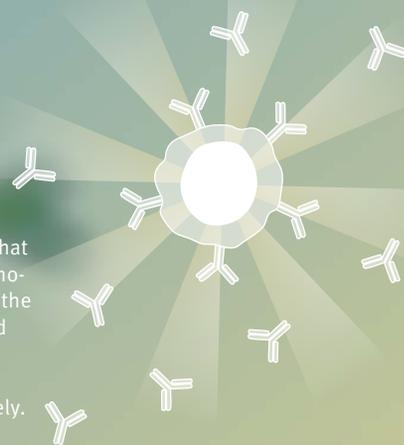
## 3. Good antibodies are selected

Which of the many hundreds of thousands of memory cells actually produce the right antibodies and prevent a virus from flooding the host cells with its DNA? The answer is provided by chemical light reactions in tiny test vessels. If they stay dark, then the antibodies are effective.



## 2. Cells are immortalised

The white blood corpuscles that produce the antibodies (memory B cells) are extracted from the blood. A biotechnical method patented by the IRB renders them 'immortal', after which they can reproduce indefinitely.



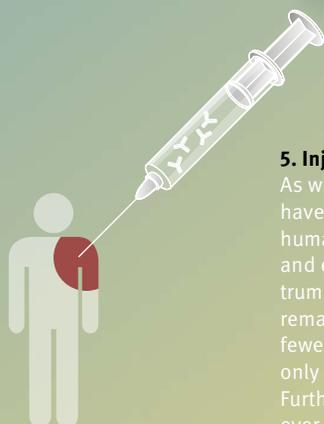
## 4. Production via genetic engineering

The appropriate gene of the victorious blood corpuscle is isolated, adjusted slightly, and then planted in cells from mammals for the purposes of industrial production.



## 5. Injecting antibodies

As with any treatment, this method will have to be subjected to clinical tests in humans in order to determine its safety and efficacy. At any rate, antibodies trump chemical substances, as they remain in the blood longer and cause fewer side effects, because they almost only ever fix themselves to their targets. Furthermore, human antibodies hardly ever provoke allergic reactions.



# Making savings: Parliament should reward risks

By Maurice Campagna

The federal government, the cantons and the local authorities have to save money. Saving money on its own isn't a bad thing. In Italian, it's described as 'clearing away the dead wood to let new wood grow'. Cost-cutting exercises are always a good opportunity to ponder what really matters. Cutting some old things can make space for the new.

Freedom in teaching and research - 'autonomy' - is the basic pillar of the academic world. Our best lecturers and researchers orient themselves according to research topics that are largely determined on an international level.

Little Switzerland always has to ask itself what it can manage, where it

should invest its money best, and whether it might make sense to restructure its portfolio. These aren't easy questions, and the answers to them are full of risks. And yet no approach can be taboo. Japan, for example, recently announced a reorientation of both its humanities and its nuclear fusion research.

So the Swiss parliament is confronted with the fact that, when seen in isolation and on a short-term basis, investment in education and research is a risky business. Despite the acceleration in research processes (thanks to simulations with powerful computers, for example), it's usually still impossible to achieve

concrete results within the space of a single parliamentary term. And it's still even less probable that those results be turned into profitable, practical applications within the same timeframe.

So investing in education and research needs patience. The federal government and the cantons should first and foremost create fertile ground for excellent research, a place where the best support goes to those researchers who have an 'inner fire', regardless of whether their path is long and arduous. If young, motivated researchers are ready to invest their best creative years in their work - often alongside older, more experienced colleagues - then they too are undertaking a considerable risk. This risk should be rewarded by the funding authorities.

Parliament isn't, however, just confronted by the imponderabilities of education and research, it also has to keep an eye on the whole federal budget beyond the timescale of its own political activities. It doesn't help that researchers are often clumsy about marketing themselves when compared with, say, the professionalism of the agricultural sector. But is it really sensible to make harsh cuts in investments that have been planned in education, research and innovation? At a time when we should be investing most in our best minds? Wouldn't the image of our country suffer irreversibly if such cuts were made, especially when they affect young, top-class talent?

Maurice Campagna became President of the Swiss Academies of Arts and Sciences on 1 January 2016.



Valérie Chételat

17 and 18 March 2016

## Political rights for foreigners?

This hot topic will be debated during the 8<sup>th</sup> Aargau Democracy Days  
[Kultur- und Kongresshaus, Aarau](#)

7 to 9 April 2016

## Social change and the media

The annual conference of the Swiss Association of Communication and Media Research (SACM)  
[University of Fribourg](#)

8 April 2016

## Ethical and legal responsibilities in international research

A symposium tackling case studies  
[House of Academies, Bern](#)

Until 10 April 2016

## We eat the world

An exhibition about indulgence, business and globalisation  
[Natur-Museum, Lucerne](#)

5 March until 26 May 2016

## Under the sign of the avant-garde

On the occasion of its 25<sup>th</sup> anniversary, the Swiss Literary Archives are presenting an exhibition entitled 'DADA original'  
[Swiss National Library, Bern](#)

Until 25 June 2017

## Digital dinos: the giants from Kem Kem

An interactive workshop for young people  
[Natural History Museum, Geneva](#)

## Letter to the editor

### We also need 'architects in the natural sciences'

Re: the article "Interdisciplinarity bring university structures into question" (Horizons 107, December 2015, p. 29) on interdisciplinary research

An architect is an all-rounder of sorts in structural engineering. Always interdisciplinary, you're part artist, engineer, energy expert, quantity surveyor, accountant and manager. A passable knowledge of some 15 skilled vocations is a must. Architects are 'dabblers' on a grand scale; they have broad but shallow knowledge.

It seems the natural sciences don't train all-rounders or managers. If they did, they would have solid, basic knowledge of all the important subfields, be more or less fluent in the 'lingo'

and have good leadership skills - without being closely associated with any single field. They would 'stand above' these disciplines, formulating interdisciplinary questions, designing research goals and connecting researchers from the most varied fields (academia, industry and even 'laymen' trained in the natural sciences). They would presumably be able to conjure a highly efficient research symbiosis.

I am convinced the natural sciences need their 'architects': neutral coordinators keeping an overview of things. They could compose interdisciplinary teams and lead them to achieve great things together.

Theo Gmür, architect, 9463 Oberriet

## Correction

### A child gets its name at birth

In "XX, XY, XXY, X and the others" (Horizons 107, December 2015, p.10), the picture caption could be regarded as desirous of precision. Although baptism is strongly associated with the act of name-giving in society, it's normally done shortly after birth. In this context, baptism is primarily an act of entry into the Christian community.

### Missing ingredients

It was incorrect to describe Aldo Steinfeld's project (Horizons 107, December 2015, p. 44) as "... transforming CO<sub>2</sub> into hydrogen", as other ingredients are needed. It should be: "... creating hydrogen and synthesis gas using water and CO<sub>2</sub>". Our apologies for this oversimplification.

## Angelika Kalt is the new Director of the SNSF

SNF/Marco Finsterwald



The board of the Foundation Council has elected Angelika Kalt a director of the SNSF. On 1 April, she succeeds Daniel Höchli, who is leaving the SNSF after eleven years to lead Curaviva Schweiz.

Angelika Kalt has been Deputy Director of the SNSF since 2008. She was professor of geology at the University of Neuchâtel for eight years.

## A good report for the NCCR

The National Centres of Competence in Research (NCCR) have been given an excellent report by the Swiss Science and Innovation Council (SSIC). Their goals are to strengthen Switzerland in strategically important fields by means of long-term interdisciplinary and innovative projects. After the first series of 14 NCCRs was concluded in 2013, the SSIC evaluated their efficacy. The SSIC report states that the NCCRs are pursuing ambitious scientific and structural goals, and it offers a number of recommendations, several of which have already been implemented.

## Brochure on the conclusion of NRP 63

The cells of the pancreas that produce insulin can be replaced by related cells – at least in mice. This is just one result of the National Research Programme ‘Stem Cells and Regenerative Medicine’ (NRP 63). To conclude NRP 63, a brochure has been published to offer an accessible overview of the results. Other research groups, for example, developed cartilage tissue that might one day be able to replace earlobes. A team comprising a medical expert, an ethicist and a legal specialist also investigated the conditions under which stem cell donations might be made.

## Support for 27 open-access books

In the pilot project OAPEN-CH, the SNSF and academic publishers are gathering experience with publishing open-access monographs on the Internet. In the first round of OAPEN-CH, the SNSF supported 27 open-access books. These publications will be accessible on the publishers’ web-

sites, in the OAPEN Library and in an institutional repository. On a longer-term basis these pilot books are intended to be made available via the e-Helvetica platform of the Swiss National Library. All the pilot publications are also available in print format. The complete list is published on [www.snf.ch](http://www.snf.ch). The second round of this pilot project was launched in mid-February.

## A new portal for science policy

Screenshot



Financing research, tackling plagiarism, debating peer review and reforming the world of academic publishing are all topics belonging to the culture of science, which is what Sciencegeist.com is all about. This new portal, supported by the SNSF, offers a collection of news items asking critical questions about today’s research practices. This news aggregator also serves as an archive and an online newsletter at the same time.

## A new president for SCNAT

Christian Flierl/Swiss TPH



At the beginning of this year, the epidemiologist and parasitologist Marcel Tanner assumed the presidency of the Swiss Academy of Sciences (SCNAT). Tanner ran the Swiss Tropical and Public Health Institute from 1997 until mid-2015. Tanner succeeds the Geneva-based astrophysicist Thierry Courvoisier, who was President of SCNAT from 2012 to 2015.

## Switzerland and Russia engage in joint research

In 2015 Switzerland and Russia launched the Scientific & Technological Cooperation Programme Switzerland-Russia. Some 25 projects have been approved in the fields of quantum technology and robotics, the humanities and social sciences, and systems biology and bioinformatics. The SNSF is providing CHF 5.9 million for the Swiss part of the research.

### Horizons

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### The SNSF

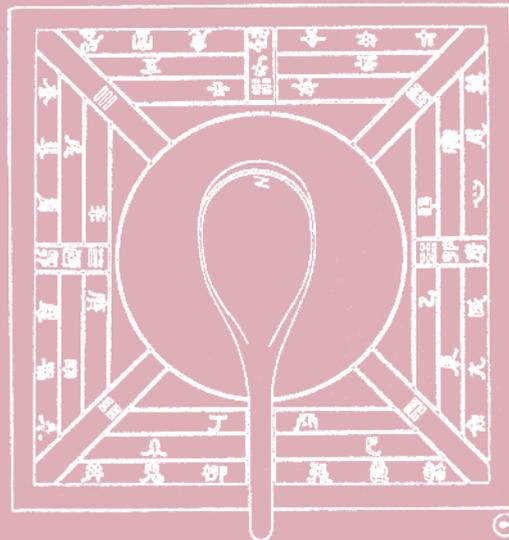
The SNSF is the principal body for the promotion of scientific research in Switzerland. It is mandated by the Confederation to promote basic research in all fields and disciplines and each year distributes some 755 million Swiss francs amongst more than 3,500 projects involving about 8,750 scholars.

### 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.

“Solve the problem with Brussels”.  
Gerd Folkers, page 29

“Risk communication is always a  
difficult business”.  
Heinz Bonfadelli, page 34



The predecessor of the  
compass: a magnetite spoon  
balanced on a bronze plate  
(China, 370 BCE).

Image: Keystone/Interfoto/  
Sammlung Rauch

“In the Bernese Oberland and  
South Sudan, cows are important”.  
Martina Santschi, page 42

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## MAP PIECE

Draw a map to get lost.

1964 spring y.o.



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