*This supplement is under strict embargo until 1800 BST (London Time) Wednesday 19th September*
YOUR CAREER BREAKTHROUGH
Sooner or later?

THE LIVELY LEAGUE
Young universities take on the elite

THE TABLES
Fastest climbers ranked

THE NEW BREED
Standout researchers transform science, from medicine to materials
RISING STARS | NATURE INDEX

THE FAST TRACK

If ideas are the flames burning from the torches of discovery, scientists are the hands that hold them. Creative minds uphold the scientific enterprise.

In recognition of their leading role, Nature Index 2018 Rising Stars profiles 11 up-and-coming researchers in the natural sciences (S10). These scientists are highlighted based on their recent contributions to the 82 journals tracked by the Nature Index, and their standing in the League of Scholars Whole-of-Web ranking, which assesses individuals on their research quality and impact, industry links and co-authorship networks. Their work ranges from analysing peatland and permafrost, to developing wearable electronics.

The researchers have all demonstrated excellence, and the passion, ambition and resilience to rise higher — essential for surviving in academia. As competition for jobs intensifies, researchers are expected to do more earlier in their careers, from publishing high-quality research to achieving impact, attracting funding, teaching, and cultivating international connections.

This supplement also tells the stories of institutions (S26), countries and regions (S20) that have exceeded expectations over the past three years in their contribution to the Nature Index. The ones we have selected as rising stars experienced exceptional absolute and percentage growth in their output of high-quality research, either across the breadth of subjects in the natural sciences, or in specific areas. As always in the Nature Index, our primary quantitative measurement is fractional count (FC) — a metric that accounts for the relative contribution of each author to an article. All FC figures are adjusted to 2017 levels.

A section on young universities explores their progress in the research world, achieved without the years of experience of established competitors (S30). We expect to see more of these high-flying contributors to the Nature Index, in reports of scientific inquiry and the testimonies of social change.

Smriti Mallapaty
Senior editor, Nature Index

The world at their feet
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THE WORLD AT THEIR FEET

These newcomers are making their mark in science across the disciplines.

From cutting the cost of solar electricity to reducing the risk of ovarian cancer, the 11 early- to mid-career scientists profiled here are emerging as leaders in their fields.

They stood out from among 500 scientists assessed using the power of the Nature Index and the League of Scholars Whole-of-Web (WoW) rankings. They are bringing fresh ideas in a range of disciplines, from cognitive neuroscience to geology, and condensed matter physics. Their initiative, curiosity and flexibility have given them an edge in a competitive research environment.

The analysis included active researchers who have published at least one paper in the 82 index journals in 2017, and whose first scientific paper appeared less than 20 years ago, with some even emerging on the scholarly scene in the past six years.

The profiled scientists have shown year-on-year citation growth, and scored exceptionally in the WoW ranking, which identifies the most influential researchers using an algorithm similar to Google’s PageRank. It considers factors such as the quality of a scientist’s output, links to industry, and co-authorship networks.

DEFECT DETECTIVE

A chemist seeks the right material to bring cheap, solar electricity to those without access.

Materials scientist Dane deQuilettes hopes to help transform the world’s energy systems, especially for people who don’t have reliable access to electricity. The postdoc at MIT is using his expertise in the properties of promising materials called perovskites to make it happen.

The performance of perovskites in solar cells rivals conventional silicon, and they promise to be much cheaper to make. While costs of silicon solar cells, which supply 1.7%
of the world’s electricity, have come down, they are not likely to fall low enough to make an impact for the 1.2 billion people globally who don’t have access to grid electricity.

GridEdge Solar is an MIT project, led by deQuilettes, to evaluate different lightweight, flexible photovoltaic materials, and, in a few years, build a pilot line to manufacture them. He thinks perovskites, which can be made into ink-like solutions and printed on rolls of material, similar to newsprint, are a strong contender. The project is funded by the Indian philanthropic organization Tata Trusts.

deQuilettes, who has a background in chemistry, started working on perovskites during his PhD at the University of Washington. Fascinated by their particular crystalline structure, he has studied how single misplaced atoms in perovskites can degrade their properties and inhibit their performance in a solar cell. Before his work, it wasn’t clear why there was so much variation in the quality of perovskite solar cells. deQuilettes revealed the answer in the varying atomic alignment in different regions of the crystalline materials. “Once we understood where the defects were, we could work on a design strategy to remove them and make the performance of the device more uniform,” he says.

“I’m interested in the fundamental physics of how light interacts with materials, but I always come back to, ‘What’s the purpose?’” says deQuilettes. KATHERINE BOURZAC

HEARTFELT REASONER
A cognitive neuroscientist reveals how the body moves the mind.

Sarah Garfinkel studies how beats of the heart, and our awareness of its rhythms, can influence everything from anxiety levels and emotional learning, to sleep quality and racial bias. She’s now one of the world’s foremost experts on the health consequences of interoception, the felt sense of one’s internal organ activities.

As a postdoc at the University of Michigan, Garfinkel studied memory recall among veterans of the Iraq and Afghanistan wars who were suffering from post-traumatic stress disorder. Her study focussed mostly on the brain, but a curious observation led Garfinkel to wonder about the role the heart might play in emotional processing. Why was it that the heartbeats of some veterans remained steady while in the brain scanner reliving their traumatic experiences, whereas the hearts of others raced frantically?

Working with Hugo Critchley, a neuropsychiatrist at the Brighton and Sussex Medical School, she revealed a disconnect between how good people think they are at detecting their own heartbeats and their true accuracy. Garfinkel then showed why that incongruence matters, reporting in 2016 that the less people with autism knew their own hearts, the greater their anxiety.

In another study, she and Critchley found that poor interoceptive awareness among people with depression or anxiety was associated with deficient sleep quality. “This now gives us a target for intervention,” Garfinkel says. “We want to train people to have better precision over their bodily signals.”

Garfinkel is now co-leading one of the first clinical trials of an interoception-directed therapy, evaluating whether a computer training module can help people with autism become more in tune with their heartbeats and thereby reduce anxiety.

Critchley says psychologists had been aware of interoception for more than a century, but its clinical importance had largely been overlooked until Garfinkel’s work. “She reinvigorated this whole field,” he says. ELIE DOLGIN

ELECTRON MICROSCOPIST
A condensed-matter physicist peers deep into materials for industrial applications.

Binghui Ge made his mark with an answer to Richard Feynman’s 1959 challenge: “Is there no way to make the electron microscope more powerful?” Invented in 1931, transmission electron microscopy (TEM) vastly improved the resolution of conventional optical microscopes by using a beam of electrons, instead of light, to reveal nanometre-sized structural features. But Feynman urged researchers to improve the resolution by a hundred times. Drawing on imaging theory, Ge and a team at the Chinese Academy of Sciences’s Institute of Physics developed a method for obtaining structural information less than a nanometre in size, using conventional TEM. They provided the first analytical expression of image distortions that arise in samples of greater thickness and used that to observe individual atoms.

Ge has moved on to the application of TEM to reveal the microstructures of catalysts and thermoelectric materials in unprecedented detail. Recently, he has been exploring the microstructure of thermoelectric materials at multiple scales, with a view to improving their efficiency in heating, cooling and generating power. These materials could be used to convert the wasted two-thirds of heat produced by vehicle engines to electricity.

Ge wants to explore cryo-electron microscopy, a TEM method allowing scientists to image three-dimensional biological molecules without destroying samples. Ge wants to know whether this can improve imaging of non-biological materials that are also susceptible to beam damage, such as metal-organic frameworks, widely used in catalysts. CATHERINE ARMITAGE
FROST SURVEYOR
A physical geographer digs deep in frozen soils to fill gaps in maps.

To Gustaf Hugelius, white space on a map presents a challenge. The modern-day explorer, who as a boy hiked every summer in northern Scandinavia, looks for peatland and permafrost areas of the Arctic and sub-Arctic regions where soils have not been analysed. The gaps in the maps have taken him as far as Siberia, Greenland, and northern Canada.

Arctic peatland and permafrost represent 25% of the Earth’s carbon sink. Global warming is expected to thaw these frozen grounds, releasing carbon dioxide and methane into the atmosphere and accelerating climate change. Yet their potentially crucial role in the carbon–climate feedback cycle is poorly understood, partly due to large gaps in the data.

Hugelius has pioneered the use of high-resolution satellite imagery, calibrated with field samples, to show that northern soils, due to seasonal freezing and thawing, are far more variable and complex in composition than the comparatively simple ‘backyard’ soil types used in climate modelling. Reflecting the diversity in soil composition and, correspondingly, in the decomposition process that releases greenhouse gases, could improve the accuracy of climate models.

The field research is “very demanding”, he says. There are permits to secure; there are the logistics of getting people, equipment and supplies to some of the world’s most remote regions for long stays; and the sheer difficulty of drilling into ice-hard ground for samples. Not to mention the polar bear risk. “You need to be aware of the bears, both for their safety and for ours,” he says.

Poor data sharing has long been a problem for soil research, he says. As manager of the Northern Circumpolar Soil Carbon Database, a dataset of organic carbon stored in soils of the region he studies, Hugelius is helping to fix that, also working with climate modellers so they can better account for uncertainty in the models.

MINI-MOLECULE MANIPULATOR
An organic chemist creates hydrogels made of cost-effective, self-assembling proteins.

Antimicrobial peptides, made of chains of amino acids, are the body’s first line of defence against invading pathogens. These proteins have the geometric quality of chirality, which means they cannot be overlaid on their mirror images, just as a left-handed glove doesn’t fit on a right hand.

Their chirality also determines their biological activity — a quality that pharmaceutical manufacturers have long utilized to create drugs with sought-after properties. The heartburn pill, Nexium, for example, is made from a left-handed molecule. Its predecessor drug, Prilosec, also made by AstraZeneca, included the left and right hands of the molecule pair.

These molecules generally consist of long strings of hundreds of amino acids. Organic chemist, Silvia Marchesan, of the University of Trieste in Italy, has a more refined and cost-effective approach. She works with...
short peptides, only three amino acids long, and switches the chirality of the individual amino acids. “It’s like putting a right-hand finger on a left hand to see what kind of hand we get, and how this new hand behaves differently,” she says.

Marchesan has used this technique to make tripeptides that self-assemble into water-based gels that have intrinsic antimicrobial properties and are biocompatible. The supramolecular structure of the hydrogels allows the potential to switch functions on and off, making them useful as enzyme substitutes, scaffolding in the repair of body tissue, and for the sustained delivery of drugs.

In 2013, Marchesan co-authored a paper, which described combining the self-assembling tripeptides with a common antibiotic. The resulting hydrogel continuously released the drug over six days.

A paper that made the August 2018 cover of Chem describes why Marchesan’s tweaked tripeptides behave differently from their real-world analogues and how the process holds consistent across the scale from single molecule to macroscopic hydrogels, which is important for large-scale production. The next step, says Marchesan, is to refine the lab process into one that can be scaled up cheaply and sustainably. CA

CANCER SLEUTH
A marine biologist turns molecular epidemiologist to tackle ovarian cancer risk.

It’s hard to study marine biology from landlocked Vermont. So, as an undergraduate, Melissa Merritt left to spend a semester investigating the reproductive abilities of corals along the Great Barrier Reef in northeast Australia. Within a few years, though, Merritt had to give up ocean studies due to problems with sea sickness, and went into cancer research. Her grandmother had ovarian cancer and Merritt decided to devote herself to elucidating risk factors and genetic drivers of the gynaecological disease.

For her PhD and postdocs, Merritt trained in cancer epidemiology and molecular biology at institutions across Australia, the United States and the United Kingdom — gaining experience and a dual scientific background that made her “very adept at formulating important research questions”, says molecular epidemiologist Marc Gunter, a former mentor from Imperial College London.

In 2015, for example, Merritt helped develop a methodological approach for evaluating the risk of dietary factors in cancer. It is now being used to study the links between foods and tumours of all kinds, and has also shown that coffee intake helps lower a woman’s risk of developing endometrial cancer.

In what Merritt considers her most “significant finding”, she showed in a recent study that women with locally invasive ovarian cancer have approximately a 30% lower risk of dying from the disease if, after their diagnosis, they take aspirin or a nonsteroidal anti-inflammatory drug like ibuprofen.

Now a faculty member of the University of Hawaii Cancer Center in Honolulu, Merritt has secured funding to explore whether hormone-altering chemicals found in many products affect a woman’s chances of developing endometrial cancer — a project that will harness Merritt’s skills in basic lab science and epidemiological data analysis. ED
By geological standards, the timescales that Taylor Schildgen studies are short. She is trying to determine how climate transforms the Earth’s surface over thousands of years. Her work uses a new technique to date landforms, by measuring the presence of rare isotopes known as cosmogenic nuclides. The proportion of these isotopes in rock samples allows geologists to estimate their age and rate of change over millennia.

In 2017, Schildgen published a paper, with postdoc, Stefanie Tofelde, considering the influence of global climate variations on river terraces in the Argentinian Andes. The researchers examined 100,000-year cycles of glaciation and interglaciation. They found that during colder and wetter periods, the increased flow of water and sediments cut deep slits in the valley. The basins filled back up with sediment during drier, warmer periods. Nearby river channels closer to the mountains responded similarly, but over cycles of 21,000 years.

These studies could offer clues about what parts of the landscape will be sensitive to the sudden changes in climate we are experiencing, says Schildgen. The results have “big implications for things like flood hazards and water management,” she says.

Occasionally, Schildgen’s work takes her further back in time. In July 2018, she co-authored a paper in Nature, refuting assumptions about the link between global climate and erosion. She established that there was insufficient evidence to suggest that the onset of glacial–interglacial cycles several million years ago accelerated erosion in alpine regions.

Schildgen traces her fascination for rocks back to a vacation to Yellowstone National Park as a teenager. After completing her PhD in geology at MIT in 2008, she took a postdoctoral position in Germany due to the shortage of academic positions in the United States. “Part of me feels guilt for having left the US because I received such good training there,” she says. “But the reality of my situation is that I have been extremely well supported in Germany.” — Smriti Mallapati

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**MATERIALS MAESTRO**

A computational physicist delves into the complex structures of organic materials.

Due to their abundance and low cost, organic molecules make excellent building blocks for flexible nanoelectronic devices. But achieving the properties needed to replace inorganic semiconductors, such as silicon, demands an intimate understanding of how the molecules interact at the nanoscale.

Sahar Sharifzadeh employs computational modelling to find intuitive ways of describing these molecular interactions, which could facilitate the development of organic materials whose electrical conductivity can be controlled with exquisite precision — a characteristic of semiconductors.

Sharifzadeh has used this theoretical approach to show that the arrangement of molecules in an organic crystalline material strongly influences how it responds electronically to light — an insight that could improve the efficiency and longevity of organic solar cells. Her computational analyses have also been applied to understanding the structures of promising inorganic materials.

In 2017, she simulated free-standing,
one-atom-thick sheets of boron, known as borophene. Researchers have only recently grown the two-dimensional material on silver, but have not been able to isolate it in its freestanding form. Like its close relative graphene, borophene promises exceptional properties, including strength, flexibility and electrical conductivity. Sharifzadeh’s calculations predict that borophene’s optical and electronic properties could be precisely adjusted by stretching or compressing the material.

Sharifzadeh, whose family moved to the United States from Iran when she was eight, started out studying electrical engineering and computer science at the University of California, Berkeley, but the physics courses she took in that degree captured her imagination. Her PhD on condensed matter physics at Princeton University led to a two-year post-doctoral project on nanoscale materials at the US Department of Energy’s Lawrence Berkeley National Laboratory in California. She set up her lab at Boston University in 2014.

She is modelling not just the behaviour of molecules, but that of the high-achieving scientist who is also the mother of a one-year-old. Aware that many young women fear the two roles are incompatible, she’s happy to be seen doing both. CA

**MOTION TRACKER**
*A biophysicist develops microscopes to peer into living tissue samples.*

As a summer intern at the private foundation Brain and Spine Institute (ICM) in Paris, Olivier Thouvenin helped develop an imaging technique for monitoring the neural circuitry in zebrafish larvae. But the method lacked the spatial resolution to tease apart connections between neurons at the single-cell level, which frustrated the young biophysics master’s student.

So for his PhD at the Langevin Institute — two kilometres away on the edge of Paris’s famed Botanical Gardens — Thouvenin worked on improving an existing high-resolution tissue-imaging tool called full-field optical coherence tomography (OCT). He added a dynamic time element to the otherwise static picture-taker, and with that, Thouvenin says, “we could see things that were moving inside the sample.” Thouvenin used his upgraded OCT technique to track the movement and metabolism of subcellular organelles and other structures inside living retina tissue from mice and monkeys.

Last year, he returned to the same ICM lab as a postdoc, with the microscope he designed in tow. Working with neuroscientist, Claire Wyart, he showed in as-yet-unpublished research that cerebrospinal fluid in zebrafish larvae moves in both directions through the backbone, as in humans. Flow disturbance could result in spinal curvature defects, in fish and people.

About to start his own lab back at the Langevin Institute, Thouvenin is also thinking about how to make a bigger societal impact through research. “He’s a very generous and open-minded person,” Wyart remarks. Currently, most commercial OCT instruments used for diagnosing eye diseases and other health problems cost €30,000 (US$34,800) or more, which makes them inaccessible for many hospitals in developing countries.

Thouvenin hopes to bring the price down by using three-dimensional printing, cheap optical parts and a smartphone as a camera. “I’m building a prototype,” he adds, one that should cost less than €1,000. ED

**FOREST MODELLER**
*An ecologist applies mathematical modelling to forest management.*

Giorgio Vacchiano started his career establishing the impact of climate change on forests, but is now finding ways of using forests to mitigate climate change.

His PhD thesis linked the high mortality of a hardy tree species in Italy’s southwestern Alps to drought. The finding set the foundation for an influential paper, published in 2013, presenting strong evidence of the effects of climate change on forest coverage over a span of 20 years. A co-authored paper in *Nature Climate Change* in 2017 reviewed more than 600 studies and found overwhelming evidence of the role of climate change in the increasing frequency and magnitude of fires, droughts and pests.

Vacchiano’s interest in conservation prompted him to study forestry, but he now believes in managing forests for multiple purposes. In Italy, he has pioneered the use of modelling for forest management. Using tools to simulate dynamics under different conditions allows estimation of, for example, how quickly trees will grow after a thinning, or how many trees are needed to stop rocks falling from a slope. These tools offer forest managers a more accurate and reproducible basis for decisions, he says. Vacchiano spent 15 months working on forest modelling with the European Commission before landing his current position at the University of Milan in 2017. He considers himself lucky. “There are a lot of brilliant young researchers who can’t find research work in this country.”

Vacchiano’s current research focuses on optimizing forest management to mitigate climate change, including harvesting timber to replace more carbon-intensive materials such as concrete for building and fossil fuels for energy. CA
**CHALLENGER STATES**

These six countries have experienced the highest absolute and percentage increases in their contribution to the Nature Index since 2015. While China is making waves among the traditional scientific powers, the other five nations are disrupting lower-tiered research strongholds.

**QUALITY GROWTH**
Assessed on their contribution to high-quality research in the natural sciences, all six countries have upped their pace of production since 2015. Iran stands out for its 30.7% increase in fractional count (FC), from 66.87 in 2015 to 87.43 in 2017. China is on a scale of its own, accelerating 22.6% from an FC of 7,412.96 in 2015 to 9,088.90 in 2017, just under half that of the world leader, the United States.

**SECTOR STARS**
Not all sectors appear equal, and not all sectors rise together. In Austria, in the past three years, a higher proportion of corporate institutions (23/28) than academic institutions (18/26) have increased their article counts in the Nature Index. Norway’s growth has been more evenly spread across all four sectors.

**SUBJECT STRENGTHS**
National acceleration is often driven by research specializations. Iran and Brazil excel in the physical sciences, and Norway in Earth and environmental sciences. This is not the case in the Czech Republic. While scientists in the country favour chemistry, their fractional count (FC) has swelled in the three other fields.

**REGIONAL CLIMBERS**
This graph shows the five administrative provinces, counties or states with the most institutions in each country. In China, Beijing remains the centre of knowledge production in the natural sciences, but Jiangsu, Guangdong and Shandong have a higher proportion of rising institutions. Other regions that rise high above the tide are Styria in Austria, Oslo in Norway and Tehran in Iran. Rising institutions had a higher article count in 2017 than in 2015.

*Merged with Nord-Trøndelag in January 2018 to form Trøndelag*
**NORWAY**

R&D SPENDING (% GDP, 2015): 1.93%
RESEARCHERS (FTE, 2015): 30,632

TOP RISING INSTITUTIONS (2017):
1. University of Oslo (FC: 65.58)
2. Norwegian University of Life Sciences (FC: 8.62)
3. University of Tromsø - The Arctic University of Norway (FC: 15.97)

**CZECH REPUBLIC**

R&D SPENDING (% GDP, 2015): 1.93%
RESEARCHERS (FTE, 2015): 38,081

TOP RISING INSTITUTIONS (2017):
1. Czech Academy of Sciences (FC: 86.84)
2. Masaryk University (FC: 21.97)
3. Silesian University in Opava (FC: 5.24)

**BRAZIL**

R&D SPENDING (% GDP, 2015): 1.28%

TOP RISING INSTITUTIONS (2017):
1. Ministry of Science, Technology, Innovation and Communication (FC: 17.16)
2. Federal University of Minas Gerais (FC: 12.90)

**IRAN**

R&D SPENDING (% GDP, 2013): 0.25%
RESEARCHERS (FTE, 2013): 11,961

TOP RISING INSTITUTIONS (2017):
1. University of Tabriz (FC: 3.60)
2. Yazd University (FC: 3.09)
3. Damghan University (FC: 3.27)
DISCOVERY RELIES ON STRONG SUPPORT STAFF

A lack of trained administrators is holding African scientists back.

The global research funding system is becoming increasingly complex and competitive. Scientists need to demonstrate quality, relevance, impact and innovation, while meeting the highest standards of integrity and ethics, managing intellectual property issues and publicizing their work.

To help them succeed in this demanding environment, scientists in the global north have something that those in the global south lack: comparatively well-resourced support structures with trained research management and administration staff, who assist with planning, developing, managing and sustaining their research pursuits. Higher-education institutions in the global south would benefit from similar investments in strong, multi-skilled research support.

Many regions are struggling to compete with the global scientific powers. Africa, for example, has some 700 universities serving more than 1.2 billion people. The region has the lowest investment in research and development, the lowest number of researchers per capita and a comparatively low, albeit growing, share of global scientific publications.

Just as the most talented athletes need good coaches to take them to stardom, gifted scientists in the region need well-trained support staff to help them shine.

IN SHORT SUPPLY

In 2014, the 55 countries that make up the African Union adopted a 10-year strategy for science, technology and innovation. They recognized the critical role of science in the socio-economic development and growth of the continent, and stressed the importance of turning universities into centres of excellence.

But progress has been slow. The top country in terms of spending on R&D, South Africa, is still below 0.8% of GDP and showed slightly decreasing spending over the past five years.

Universities in Africa are increasingly dependent on international sources of funding for research. Funders in the global north are also recognizing the value of collaborating with researchers in low- and middle-income countries. They offer geographical advantages in certain fields, talented researchers, access to important data sets, knowledge of the developing world context, and insight into new markets. Among others, the United Kingdom Newton Fund, the United States National Institutes of Health, and the European Union Horizon 2020, have committed millions of dollars in grant funding for collaborative research with Africa and other regions in the global south.

RESEARCH REPRESENTATION

In 2017, institutions in Africa contributed to 0.2% of the paper authorship in the 82 journals that make up the Nature Index. Their contribution to high-quality research in the natural sciences, measured by fractional count (FC), was far exceeded by institutions in North America, Europe and Asia Pacific.

To capitalize on these opportunities, universities need to invest in skilled research support teams. Well-trained professionals can instil confidence in potential partners that research funds will be spent efficiently and responsibly.

But, such professionals are in short supply on the continent. The majority of universities in Africa typically rely on senior professors to provide part-time guidance on research administration, while expecting them to maintain teaching and research obligations. There is therefore a general lack of capacity in African universities to support and develop research, and no obvious career pathway or professional qualification to allow for the recruitment and development of research management and administration personnel.

ON COURSE

Over the past decade, several initiatives have sought to create a research support system in Africa and other parts of the developing world. These have been supported by the Association of Commonwealth Universities, as well as international funding bodies, including the World Health Organisation and the Wellcome Trust. Existing professional associations for research and innovation managers, such as the Southern African Research and Innovation Management Association (SARIMA) and WARIMA in West Africa, have been strengthened through capacity development interventions, with new associations created in Central (CARIMA) and East Africa (EARIMA) and the Caribbean (CabRIMA).

In 2017, a consortium of institutions led by Stellenbosch University in South Africa, and co-funded by the EU Erasmus+ programme, launched the first professional academic qualification programme for research management and administration in the global south. The project, known in short as StoRM, will develop a post-graduate diploma course and a master’s degree curriculum, as well as a mechanism for formal recognition of professionals in the field. It will also promote exchange between administrators in Europe and southern Africa.

Universities also need to invest more in this area to support their scientific stars. For example, they could allocate indirect costs recovered by grant income to support structures. Many universities in the global south are developing strategies to become research intensive. Providing optimal research support will help create thriving and sustainable scientific communities, and improve innovation and impact from research in the developing world.

David Langley is chief partnerships officer at New Model in Technology and Engineering, UK.

Therina Theron is senior director of research and innovation at Stellenbosch University, South Africa.
In 2016, Griffith University launched the Australian Research Centre for Human Evolution, which contributed to the recent discovery of the oldest fossil of modern humans outside Africa. **Bianca Nograday**

Southeast University (SEU) has long been a science hub in China. It was once part of Nanjing University, but split away in 1952. Today, its historical strengths in chemistry and physics have powered its growth in the Nature Index, with its output nearly doubling over the past three years. Publications have included research on atom-thin memory storage devices and graphene-based electronic tattoos that can monitor heart rates.

One of the university’s most widely read papers in 2017, however, was in the life sciences: a fruit fly study that investigated the neuronal circuitry that drives flies to either sleep or have sex. Neurobiologist, Yufeng Pan, and his colleagues at the MOE Key Laboratory for Developmental Genes and...
Human Disease observed that sleep deprivation caused male fruit flies to more often sleep rather than mate, whereas female fruit flies seemed impervious to fatigue.

Pan credits recruitment of a large number of foreign researchers — including through China’s Thousand Talents Plan — for SEU’s growth. Though research in life sciences only began at SEU in the past decade, he thinks the recruitment trend will continue with the recent creation of a joint institute on neuron morphology with the United States-based Allen Institute. The university has 925 doctoral supervisors.

The Chinese Academy of Sciences spans a network of more than 100 research institutes across China — and its affiliated university matches its scale. Headquartered in Beijing, the University of Chinese Academy of Sciences (UCAS) sprawls across four campuses with five satellite branches in other cities, including Shanghai and Chengdu. It counts more than 15,000 instructors and 7,210 doctoral supervisors on staff, with more than 45,000 graduate students.

UCAS is the latest iteration of China’s first graduate university in science, founded in 1978. Still regarded as China’s best graduate school, UCAS began to admit undergraduates in 2014.

The university has shown remarkable growth in its output of high-quality research: from 2015 to 2017, its fractional count increased 51% from 101.95 to 255.65, the largest rise of any institution globally. The pace of growth is sustained across all fields tracked by the index, and contrasts with a 3.4% decline in the output of CAS over the same period. MZ

The National Center for Atmospheric Research (NCAR) in Boulder, Colorado, was founded in 1960 to assist researchers in their studies of atmospheric and climate science. The aim was to provide faculty members with resources no single university could afford. Those resources now include the NCAR-Wyoming Supercomputing Center, the Mauna Loa Solar Observatory in Hawaii, and two aircraft for geoscience studies.

These facilities have contributed to NCAR’s rise in prominence in the Nature Index, with a 58.8% increase in its contribution to journals in Earth and environmental sciences between 2015 and 2017.

Growing interest in collaborative research has brought NCAR to the fore, says Gerald Meehl, who heads its climate change research section and is among its top authors in the index. He also attributes the institute’s success to a high percentage of eager young researchers. “We’ve got a crop of young project scientists who are pretty active,” he says.

More than half of NCAR’s funding — US$173 million in 2017 — comes from the United States National Science Foundation, with additional funding from other federal agencies interested in weather and geo-sciences, including the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, and the departments of defence and energy. NCAR has approximately 494 scientists, postdocs, and engineers on staff. NEIL SAVAGE

Founded in 1724 by decree of Peter the Great, the Russian Academy of Sciences (RAS) is the world’s oldest scientific research network, and represented the height of Russian science through the era of the Soviet Union. But after the Cold War, the institution struggled with budget cuts as state funds shifted towards universities. In 2013, parliament implemented reforms to the institution, seeking to bring it under control of a federal agency that reports directly to President Vladimir Putin. Critics said the move threatened the academy’s independence.

However, RAS has rebounded in the Nature Index — especially in chemistry, where its output has risen by more than 50%, from a fractional count of 44.21 in 2015 to 66.73 in 2017. In October 2017, an all-RAS team demonstrated a more sustainable 3D printer that uses a material derived from cellulose, the bulk material in plant walls.

Valery Rubakov, a theoretical physicist at the RAS Institute for Nuclear Research in Moscow, says the value of RAS is more recognized today than five years ago. But he warns that if the architects of the 2013 reform continue to exert control, “the system of RAS institutes is in danger of complete destruction.” RAS’s budget in 2013 was 60 billion roubles (US$887 million), and it employed 46,955 researchers in 2016. MZ

The 140-year-old Western University in
Ontario, Canada, has 12 faculties with 1,396 full-time staff and a research budget of more than Can$225 million (US$172 million) in 2017. The university’s fractional count has increased by 40% in the Nature Index from 2015 to 2017. Its output in the physical sciences has doubled, with noticeable growth in chemistry and the life sciences. Researchers during this period have contributed to numerous papers on emerging materials, astrophysics, and the brain regions controlling behaviours such as paying attention.

John Capone, vice-president (research), attributes the rise to the university’s significant investments in areas such as neuroscience, materials science, wind engineering and medical research. In 2013, for example, the university invested more than Can$20 million in clusters of research excellence focused on cognitive neuroscience and musculoskeletal health.

Western University has also secured private and public partnerships, particularly in areas of research with higher equipment and infrastructure costs. Overall, it has invested more than Can$400 million in infrastructure, including biomedical imaging and high-performance computing facilities at The Brain and Mind Institute. BN

**UNIVERSITY OF CALIFORNIA, IRVINE**

**UNITED STATES | 2015 FC: 125.68 | 2017 FC: 162.5**

University of California, Irvine (UCI) is North America’s top rising star in the Nature Index, achieving 29.3% growth in its fractional count over the past three years, with increases in all fields.

Founded in 1965, UCI is one of the younger schools in the state’s university system, but has come into its own thanks to an emphasis on building research facilities with advanced equipment, such as the recently opened Irvine Materials Research Institute that includes a state-of-the-art transmission electron microscope.

UCI has also invested in recruitment. “We attract really top-notch faculty,” says Sorosh Soroshsian, director of the Center for Hydro-meteorology and Remote Sensing in UCI’s engineering school. The university’s strategic plan, released in 2016, set a target to recruit 250 new faculty members by 2021, welcoming 57 in 2017 alone. That’s a continuation of a hiring plan to recruit a few senior professors and several junior faculty, particularly if they span different departments. Recent high-profile hires include tissue bioengineer Kyriacos Athanasiou, and cognitive scientist, Zygmunt Pizlo, who uses computational modelling to simulate how humans perceive three-dimensional shapes from 2D images.

The university has more than 2,100 research faculty. Its funding for fiscal year 2017 was US$378 million. NS

**TU DORTMUND UNIVERSITY**

**GERMANY | 2015 WFC: 23.40 | 2017 WFC: 41.82**

Located in Germany’s industrial heartland, TU Dortmund University has made fast friends in the 50 years since its establishment. Collaborations have ensured its position among Germany’s top rising stars in the Nature Index, almost doubling its fractional count (FC) since 2015, with even faster growth in chemistry from an FC of 11.86 to 25.59 in 2017. The partnerships have been facilitated by a combination of strong researcher networks, university strategy and a changing grant environment.

In 2012, TU Dortmund joined a €28 million (US$32 million) initiative, funded by the German Research Foundation, to explore the science of solvents. Chemists, physicists and engineers from 50 research groups in seven institutions are part of the fundamental science project to advance green chemistry, medical technologies, and photovoltaics.

Gabriele Sadowski, a chemical engineer and TU Dortmund’s vice president of research says researchers have also strengthened collaborations across borders and with industry. Physicists from the university are working with colleagues from Russia to improve semiconductor science using the power of electron spin. The university is also part of a joint venture with the pharmaceutical company, Bayer, developing innovative drug-delivery technologies at the chemicals manufacturing centre of Leverkusen.

The university has a faculty of 2,300 and a 2017 budget of €330 million, including third-party funding. ANJA KRIEGER

**HUNAN UNIVERSITY**

**CHINA**

**PHYSICAL SCIENCES FC 2015: 4.5 | 2017 FC: 23.46**

Located in the city of Changsha in central China, Hunan University (HNU) has seen remarkable growth in physical sciences, with its output in the field increasing more than four-fold in the index between 2015 and 2017, easing declines in chemistry.

Yet HNU’s predominant strengths remain chemistry and materials science. It has two state-funded key labs — China’s elite national laboratories — one for vehicle design and manufacturing, and one for biosensing and data-driven chemistry analysis. The latter accounts for roughly half of HNU’s research in the index.

Chemist, Xiaodong Duan, of the biosensing lab says that increased support from the central Chinese government has contributed to HNU’s standing, as well as university policies that have sought close collaborations with China’s elite national laboratories.
with top scientists abroad. In 2017, he and UCLA’s Xiangfeng Duan published a paper in Science demonstrating a method for producing super-thin semiconductors with intricate structures just a few atoms thick.

Hunan has 1,950 faculty, of which more than 1,400 are professors. MZ

### Fudan University

**China**

**E&E SCIENCES 2015 FC: 5.67 | 2017 FC: 18.40**

Fudan University in Shanghai is a member of the elite C9 League — nine schools sometimes referred to as China’s Ivy League. The designation comes directly from the Chinese government, and accords it extra resources and funding. This has been key in luring international researchers, and getting more Chinese researchers who studied overseas to return.

As the government pushes to clean up China’s dangerously polluted air and mitigate the effects of climate change, Fudan is helping lead the way. The government’s push has given the university many opportunities, says environmental chemist Zhen Ma, whose particular focus is on practical solutions.

Fudan’s output in Earth and environmental sciences more than tripled in the index between 2015 and 2017. Work led by Kan Haidong of Fudan’s School of Public Health published in 2017 showed that exposure to fine particulate matter less than 2.5 microns in diameter (PM2.5) is linked to blood inflammation and the production of stress hormones, increasing cardiovascular risk.

The university’s output in Earth and environmental sciences is set to grow further: in April 2018, it opened a department for atmospheric and oceanic research. MZ

### University of Oslo

**Norway | 2015 FC: 43.46 | 2017 FC: 65.58**

Every five years, the Research Council of Norway offers national research institutions generous ten-year grants to set up centres of excellence in key research areas. The University of Oslo (UiO) has won 17 of the 44 centres since the programme’s launch in 2003. Nine centres are active, covering subjects ranging from solar physics to multilingualism and Earth dynamics.

Four centres have been in Earth and environmental sciences, where the university’s growth in the index has been particularly strong. UiO’s contribution to the authorship of any institution globally, from 3.12 to 12.66. Its papers in the journals tracked by the index are in chemistry and physics.

Among them, analytic chemist, Fengli Qu, has co-authored a flurry of articles on efficient catalysts for the large-scale production of hydrogen, which has promise as a clean source of fuel and long-term storage reservoir for renewable energy. In the past few years, QFNU has transformed itself from a traditional teaching university to a comprehensive research university, says Qu. One of the most effective policies for improvement, he says, has been the introduction of bonus incentives for research. The university has more than 700 professor positions. In 2002, it expanded to a second campus located in Rizhao, on the Yellow Sea — a city known for its sustainability and adoption of solar water heaters in every new building. MZ

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**MARTIN LUTHER UNIVERSITY HALLE-WITTENBERG**

**Germany | 2015 WFC: 18.81 | 2017 WFC: 29.18**

Martin Luther University Halle-Wittenberg was established in 1817 as the largest university in Germany’s state of Saxony-Anhalt. The Nazi regime and subsequent politicisation of academia in East Germany took a toll on the university’s faculty and programmes. After the fall of the Berlin Wall, MLU emerged as a medium-sized university, with around 340 professors among its faculty in 2017, offering the panoply of science subjects. Its research and teaching budget in 2017 was €205 million (US$238 million), excluding third-party funding.

MLU’s rise in the Nature Index has been driven by its chemistry output: between 2015 and 2017, its contribution to articles in this field almost tripled. To Wolfgang Binder, dean of the faculty of natural sciences, MLU’s interdisciplinary approach of connecting physics, chemistry and biology has laid the groundwork for this success.

MLU’s Institute of Chemistry conducts research on subjects ranging from nano-structured and self-healing polymers, to the role of protein misfolding in Alzheimer’s and Parkinson’s diseases, and liquid crystals used in flat-panel displays (LCDs). In 2016, MLU chemist, Carsten Tschierske and his team, in collaboration with Trinity College Dublin, published research on materials that could make liquid-crystal technology faster and more energy-efficient.

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**QUFU NORMAL UNIVERSITY**

**China | 2015 FC: 1.21 | 2017 FC: 12.66**

The city of Qufu has a long history of scholarship: it is the hometown of Confucius.

Qufu Normal University (QFNU) is just coming into its own as a presence in the index. In the last three years, it has seen its fractional count multiply by the largest factor of any university globally, from 1.21 to 12.66. Its papers in the journals tracked by the index are in chemistry and physics.

Among them, analytic chemist, Fengli Qu, has co-authored a flurry of articles on efficient catalysts for the large-scale production of hydrogen, which has promise as a clean source of fuel and long-term storage reservoir for renewable energy. In the past few years, QFNU has transformed itself from a traditional teaching university to a comprehensive research university, says Qu. One of the most effective policies for improvement, he says, has been the introduction of bonus incentives for research. The university has more than 700 professor positions. In 2002, it expanded to a second campus located in Rizhao, on the Yellow Sea — a city known for its sustainability and adoption of solar water heaters in every new building. MZ
GREEN SHOOTS

While many of the top institutions have benefited from centuries of steady scientific activity, these younger contenders are reaching for the sky. Established as universities after 1988, they have made significant progress in contributions to 82 high-quality journals over the past three years. We profile six of the leading young institutions.

**HOMI BHABHA NATIONAL INSTITUTE**

India | FC 2015: 29.84 | FC 2017: 50.20

**SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY**

China | FC 2015: 15.7 | FC 2017: 67.6

**INDIAN INSTITUTES OF SCIENCE EDUCATION AND RESEARCH**

India | FC 2015: 79.01 | FC 2017: 98.21

India’s Department of Atomic Energy (DAE) created Homi Bhabha National Institute (HBNI) in 2005 to advance the country’s capabilities in nuclear science and engineering. Named after Homi Jehangir Bhabha, considered the father of India’s nuclear programme, the university was formed from 10 DAE institutions focusing on nuclear physics and mathematics. Among them is the Variable Energy Cyclotron Centre in Kolkata, which houses India’s first major accelerator for peering inside the atomic nucleus. In 2016, an 11th member, the National Institute of Science Education and Research in Bhubaneswar, became part of the university.

HBNI has increased its contribution to papers in the index by 68.2% since 2015, and is the top-ranked rising star in India in the physical sciences. Papers cover theoretical investigations into subatomic particles, from neutrinos to mesons. Researchers at the institution have also contributed to work on harnessing the Sun’s heat to halve the fossil-fuel consumption of existing coal-fired power plants, and the use of molecular assemblies to prevent amyloid build-up in the body, a hallmark of many diseases including Parkinson’s. HBNI received 15 million Indian rupees (US$212,000) in grants and subsidies in 2016–2017, and has 1,042 research faculty. *SMRITI MALLAPATY*

**SOUTH OF SCIENCE AND TECHNOLOGY**

Southern University of Science and Technology (SUSTech) is positioned for success in Shenzhen, a city often referred to as China’s Silicon Valley. Between 2015 and 2017, funding at SUSTech increased from 153 to 600 million yuan (US$87.8 million), largely from the Shenzhen government and National Natural Science Foundation of China. With the city’s support, SUSTech is also building the country’s most advanced cryo-electron microscope laboratory for revealing the structure of biomolecules.

Shenzhen’s investments are yielding results. Since 2015, SUSTech has more than quadrupled its contribution to the Nature Index — making it the top rising star under 30, with strengths in chemistry, and rapid growth in the physical sciences. Among its top index contributors is Xumu Zhang, who has a chemical reaction named after him. Some 90% of the university’s 300-strong faculty have overseas experience, with the majority of courses taught in English. SUSTech has enlisted 60 staff members through China’s national Thousand Talents Plan, which offers incentives to Chinese professors, trained abroad, to return to China.

The university also has policies that encourage high-quality work, such as a meritocratic appraisal system that makes it easy for researchers to identify promotion opportunities, and deters nepotism. *SARAH O’MEARA*

**INDIAN INSTITUTES OF SCIENCE EDUCATION AND RESEARCH**

Starting with two institutes in 2006 in Pune and Kolkata, there are now seven Indian Institutes of Science Education and Research (IISER), with two set up in 2015 in Berhampur and Tirupati, on the central-eastern coast.

The IISERs were established to bring high-quality science teaching and research under one roof. It was an unusual model for the country. University faculty, burdened with teaching loads, poor funding and limited infrastructure, did not engage in research, while the elite research institutes did not teach. “The IISERs have the right combination of both components,” says Soumitro Banerjee, a physicist at IISER, Kolkata.

The Indian government now recognizes several IISERs as Institutes of National Importance, a designation given to institutions that play a role in developing highly skilled individuals, which affords them additional funding. Collectively, the institutes have increased their contribution to science tracked by the index by 24% since 2015.

The mandate to balance teaching with research has engaged undergraduates in research, some publishing results by completion of their master’s degree. The IISERs’ research budget was 6.3 billion Indian rupees (US$89 million) in 2016–2017. *T.Y. PADMA*

**IS UNDER 30**

All under 30 years old, these universities are the top 15 among the under thirties in the Nature Index, ranked by their growth in fractional count (FC) 2015–2017. Their success has been achieved largely without the advantage of time, though some have inherited a head start from predecessor institutions.
DAEGU GYEONGBUK INSTITUTE OF SCIENCE AND TECHNOLOGY
SOUTH KOREA | FC 2015: 6.73 | FC 2017: 13.99

Located in Klosterneuberg, just outside Vienna, researchers at the Institute of Science and Technology Austria (IST Austria) are encouraged to explore their curiosities, far from the fixation on impact. Established by the federal government in 2009 to focus on basic research, "the institute values science for its own sake and not its potential to bring immediate benefit," says biologist, Fyodor Kondrashov, who runs a research group that uses an array of tools — mathematical modelling, bioinformatics data, and experiments — to study evolution.

The graduate-only university, which is organised into research groups with no departments, encourages students to be collaborative and broadminded, says Kondrashov: students spend the first year rotating among groups to find the best fit for their interests.

Researchers have thrived in the intellectual environment, more than doubling their contribution to the Nature Index since 2015, with the life sciences accounting for two-thirds of this output. Among IST Austria's most prolific teams are those determining how immune cells move and change shape, how plants adapt to changing environments, and how neuronal networks process information.

IST Austria supports 700 staff, and 142 PhD students. The Austrian government committed €290 million (US$336 million) for its first 10 years, with researchers securing an additional €100 million in third-party funds. Gemma Conroy

KING ABDULLAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
SAUDI ARABIA | FC 2015: 88.42 | FC 2017: 109.98

Situated in South Korea's manufacturing centre, Daegu Gyeongbuk Institute of Science and Technology (DGIST) was established in 2004 to boost Daegu's economy through innovation. Four years later, DGIST expanded into a university, supporting 234 researchers addressing societal challenges in six key research areas, including emerging materials, green energy and medical robotics.

The university encourages commercial partnerships, and has 11 start-ups developing technologies such as rehabilitation exercise devices, robots that work on building maintenance, and a fire-retardant insulation material.

With three other national institutes advancing science across the country, in Daejeon, Gwangju and Ulsan, DGIST president, Sang Hyeok Son, says the university stands out for its interdisciplinarity: roboticians team up with life scientists, while solar energy specialists work with materials scientists.

DGIST's contribution to articles tracked by the index has doubled over the past three years to a fractional count of 13.99 in 2017. Chemistry accounts for more than half of its overall output. In 2017, for example, DGIST researchers developed a high-resolution imaging technique to analyse living biological samples without chemical pre-treatment, which could be applied in medical diagnosis and drug screening. Gemma Conroy

A researcher at the Convergence Research Center for Wellness, Daegu Gyeongbuk Institute of Science and Technology, in South Korea, demonstrates a robot that can walk and run.
PREDICTING SCIENTIFIC SUCCESS

Even sophisticated, data-driven models of academic careers have trouble forecasting the highs and lows.

SMRITI MALLAPATY

When Frank Wilczek was a graduate student in his early twenties, he published work on the forces holding quarks together that later won him a Nobel Prize.

At the other end of a career span, John Fenn, a retired analytic chemist in his seventies, developed the award-winning technique for analysing large proteins using mass spectrometry.

From early starters to late bloomers, the timing of a researcher’s career high is largely dependent on chance. This was the conclusion of a 2016 study, in which researchers developed a mathematical model to describe publication and citation trends based on the records of thousands of people.

Every piece of work is just as likely to be your highest impact paper as the last, says study co-author Dashun Wang at Northwestern University’s Kellogg School of Management in Evanston, Illinois. “To be a successful scientist, you should just keep drawing the lottery and hope for the best.”

Sophisticated new models are using vast data sets to help elucidate the process of scientific discovery, and how it will evolve — including at the level of individual careers. As the volume of this information expands, the resulting algorithms and their predictions will improve.

But, in searching for predictable patterns, and a formula for detecting rising research stars, scientists are finding that success is inherently unpredictable, says Daniel Larremore, a computer scientist at the University of Colorado Boulder.

These models are also beginning to reveal the flaws in the research system and point to ways of correcting them. “Through reverse engineering, we can help create a fairer system that nurtures talented people, no matter their ethnicity, gender or location,” says Roberta Sinatra, a network and data scientist at the Central European University in Hungary, and first author of the 2016 study.

BETTING ON THE BEST

Researchers have had limited success in finding quantitative and objective ways of predicting a scientist’s future performance based on their past merits.

Earlier efforts typically involved statistical checks of single or collected metrics to see how well they correlate with reality. In 2007, for example, Jorge Hirsch, a physicist at the University of California, San Diego, published a paper on the predictive power of a popular measure he had invented for determining the scientific impact of an individual — the $h$-index. Hirsch observed a correlation between a researcher’s current and future $h$-index.

Several years later, a group led by computer
scientist, Daniel Acuna, now at Syracuse University, developed a formula to estimate an individual's future $h$-index based on several variables, including number of articles, publication in prestigious journals and years since first paper. It accounted for 66% of the variability in the $h$-index of some 3,000 neuroscientists five years later. But some scientists argued that the cumulative nature of the $h$-index overstated its predictability.

Now, mathematicians, network scientists, and physicists are bringing new tools to the challenge. They are creating simple models of the rules of human behaviour, in the same way that the Standard Model explains the existence of the Higgs Boson.

These models exploit rich and accessible long-term data generated about scientists and their scholarly endeavours — from publications and citations, to funding sources, collaborators, mobility, institutional affiliation, ethnicity and gender. But a formula for spotting rising research stars is still elusive. In detecting career trends, the models are also revealing predictive limits.

CHANCE DISCOVERY

Those who study the trajectories of scientific careers had long assumed that researchers were at their most creative early in their careers. Sinatra and Wang’s 2016 study proved otherwise. They found that a constant and unique value known as Q, derived from an individual’s long-term citation and publication record, could determine the number of citations that their best paper would achieve, but the timing of that paper was anybody’s guess. The higher a researcher’s Q factor, the higher the impact of their paper.

In a recent study covering a shorter publication window, Wang and Sinatra showed that a career high is typically characterized by a slew of several highly cited papers. “All of an individual’s best works tend to happen within that hot streak,” says Wang. And while most scientists will experience such a creative burst, it will probably only happen once in their career.

A 2017 study by Larremore also deconstructed the fast-early-peak, slow-slump pattern of productivity. In an analysis of more than 2,000 computer scientists and 200,000 publications, he found that while the researchers’ collective publication trajectory followed the rise–fall pattern, it could only explain the productivity of one in every five scientists.

Paper citations don’t always follow a reliable pattern either, which makes it difficult to predict career trajectories based on them. Some papers lie dormant for many years before gaining citation traction. A 2015 citation analysis of 22 million articles spanning more than a century found that there are many examples of such ‘sleeping beauties’. Among them is a 1955 paper by Eugene Garfield on the utility of a citation index, which caught the research community’s attention some half a century later.

While emerging algorithms can potentially anticipate incremental advances in science, such as the observation of gravitational waves, it is beyond their capacity to predict the accidental isolation of penicillin, or the serendipitous discovery of x-rays, as it is beyond the scope of most humans.

“Any kind of model that makes strong bets on the trends of the past is likely to perpetuate the kinds of problems that we have now, without leaving us open to the weird and unexpected innovations that no-one sees coming,” says Larremore.

Models of scientists’ careers don’t need to be good predictors to be useful, says Vincent Traag, a computational social scientist at the Centre for Science and Technology Studies, Leiden University. By allowing researchers to uncover the mechanisms underlying the phenomena they observe — “we can start thinking of how to address questions such as the replicability crisis, publication biases, and inappropriate incentives,” says Traag.

Gaps in the publication records of individuals expose the many lost opportunities — from those who have abandoned academia out of a sense of failure, or to raise children, or for unexplained reasons.

“The big piece of the puzzle that is missing is a quantitative understanding of failure,” says Wang, who is analysing grant application data from the US National Institutes of Health to capture signals not just of acceptance, but also rejection. “It happens all the time, yet we know so little about it.”

When it comes to tracking talent, some traits have little to do with merit. Studies of the $h$-index, for example, have found that women are cited less than men.

“If we put this into an approach that predicts impact, then it would favour men, rather than women,” says Sinatra, who is working on developing data-driven measures and models to identify the source and contribution of forms of bias so they can be corrected, and not perpetuated in predictive modelling.

“So much of the past ‘success’ has been correlated with looking and sounding, well, like me — white, male, native English speaking, past affiliation with Harvard,” says Larremore. “There is a danger of reading too much into the patterns of the past.”
# RISING STARS TABLES

The top 50 rising institutions, ranked by change in adjusted fractional count (adjusted FC*) from 2015 to 2017. Also listed are each institution’s FC and total number of articles (AC) in 2017, percentage change in adjusted FC from 2015 to 2017, and global rank in the 2018 annual tables.

For more tables of rising institutions in the Nature Index go to [www.natureindex.com](http://www.natureindex.com)

## TOP 50 INSTITUTIONS

<table>
<thead>
<tr>
<th>RANK</th>
<th>INSTITUTION</th>
<th>COUNTRY/REGION</th>
<th>FC 2017</th>
<th>AC 2017</th>
<th>CHANGE IN ADJUSTED FC 2015–2017 (%)</th>
<th>CHANGE IN ADJUSTED FC 2015–2017 (%)</th>
<th>2018 ANNUAL RANK</th>
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<tr>
<td>1</td>
<td>University of Chinese Academy of Sciences</td>
<td>China</td>
<td>255.65</td>
<td>1,399</td>
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<td>Tsinghua University</td>
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<td>Shanghai Jiao Tong University</td>
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<td>61.29</td>
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<td>Southern University of Science and Technology</td>
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<td>University of California, Irvine</td>
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<td>162.50</td>
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<td>23.7%</td>
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<td>30.7%</td>
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<td>United States</td>
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<td>449</td>
<td>28.55</td>
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<td>China</td>
<td>148.28</td>
<td>376</td>
<td>28.40</td>
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<td>Max Planck Society</td>
<td>Germany</td>
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<td>China</td>
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<td>32.8%</td>
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<td>China</td>
<td>92.45</td>
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<td>40.6%</td>
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<td>China</td>
<td>52.05</td>
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<td>104.9%</td>
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</tr>
<tr>
<td>23</td>
<td>Nanjing Tech University</td>
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<td>24</td>
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</tr>
<tr>
<td>25</td>
<td>National University of Singapore</td>
<td>Singapore</td>
<td>229.18</td>
<td>574</td>
<td>24.49</td>
<td>12.0%</td>
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</tr>
<tr>
<td>26</td>
<td>Soochow University</td>
<td>China</td>
<td>158.44</td>
<td>299</td>
<td>23.80</td>
<td>17.7%</td>
<td>67</td>
</tr>
<tr>
<td>27</td>
<td>California Institute of Technology</td>
<td>United States</td>
<td>299.63</td>
<td>891</td>
<td>22.95</td>
<td>8.3%</td>
<td>22</td>
</tr>
<tr>
<td>28</td>
<td>Shenzhen University</td>
<td>China</td>
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<td>131</td>
<td>22.77</td>
<td>233.6%</td>
<td>422</td>
</tr>
<tr>
<td>29</td>
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<td>China</td>
<td>51.58</td>
<td>110</td>
<td>22.43</td>
<td>76.9%</td>
<td>289</td>
</tr>
<tr>
<td>30</td>
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<td>China</td>
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<td>158</td>
<td>22.41</td>
<td>38.3%</td>
<td>175</td>
</tr>
<tr>
<td>31</td>
<td>University of Oslo</td>
<td>Norway</td>
<td>65.58</td>
<td>335</td>
<td>22.13</td>
<td>50.9%</td>
<td>238</td>
</tr>
<tr>
<td>32</td>
<td>Memorial Sloan Kettering Cancer Center</td>
<td>United States</td>
<td>110.11</td>
<td>280</td>
<td>21.60</td>
<td>24.4%</td>
<td>115</td>
</tr>
<tr>
<td>33</td>
<td>King Abdullah University of Science and Technology</td>
<td>Saudi Arabia</td>
<td>109.98</td>
<td>237</td>
<td>21.56</td>
<td>24.4%</td>
<td>116</td>
</tr>
<tr>
<td>34</td>
<td>University of North Carolina at Chapel Hill</td>
<td>United States</td>
<td>195.39</td>
<td>468</td>
<td>21.32</td>
<td>12.2%</td>
<td>49</td>
</tr>
<tr>
<td>35</td>
<td>University of Bristol</td>
<td>United Kingdom</td>
<td>152.12</td>
<td>467</td>
<td>20.82</td>
<td>15.9%</td>
<td>72</td>
</tr>
<tr>
<td>36</td>
<td>China University of Geosciences</td>
<td>China</td>
<td>47.32</td>
<td>113</td>
<td>20.80</td>
<td>78.4%</td>
<td>307</td>
</tr>
<tr>
<td>37</td>
<td>China Pharmaceutical University</td>
<td>China</td>
<td>34.38</td>
<td>66</td>
<td>20.75</td>
<td>152.3%</td>
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</tr>
<tr>
<td>38</td>
<td>University of Basel</td>
<td>Switzerland</td>
<td>109.67</td>
<td>310</td>
<td>20.45</td>
<td>22.9%</td>
<td>118</td>
</tr>
<tr>
<td>39</td>
<td>Homi Bhabha National Institute</td>
<td>India</td>
<td>50.20</td>
<td>188</td>
<td>20.36</td>
<td>68.2%</td>
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<tr>
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<td>Czech Academy of Sciences</td>
<td>Czech Republic</td>
<td>86.84</td>
<td>369</td>
<td>19.35</td>
<td>28.7%</td>
<td>160</td>
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<tr>
<td>41</td>
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<td>19.20</td>
<td>24.3%</td>
<td>133</td>
</tr>
<tr>
<td>42</td>
<td>Colorado State University</td>
<td>United States</td>
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<td>208</td>
<td>18.89</td>
<td>33.7%</td>
<td>198</td>
</tr>
<tr>
<td>43</td>
<td>ShanghaiTech University</td>
<td>China</td>
<td>23.67</td>
<td>129</td>
<td>18.56</td>
<td>363.7%</td>
<td>&gt;500</td>
</tr>
<tr>
<td>44</td>
<td>TU Dortmund University</td>
<td>Germany</td>
<td>41.82</td>
<td>209</td>
<td>18.42</td>
<td>78.7%</td>
<td>344</td>
</tr>
<tr>
<td>45</td>
<td>University of Pittsburgh</td>
<td>United States</td>
<td>148.04</td>
<td>448</td>
<td>16.84</td>
<td>12.8%</td>
<td>77</td>
</tr>
<tr>
<td>46</td>
<td>Argonne National Laboratory</td>
<td>United States</td>
<td>118.10</td>
<td>616</td>
<td>16.83</td>
<td>16.6%</td>
<td>101</td>
</tr>
<tr>
<td>47</td>
<td>University of Amsterdam</td>
<td>Netherlands</td>
<td>76.42</td>
<td>518</td>
<td>16.77</td>
<td>28.1%</td>
<td>194</td>
</tr>
<tr>
<td>48</td>
<td>The University of Chicago</td>
<td>United States</td>
<td>221.23</td>
<td>680</td>
<td>16.72</td>
<td>8.2%</td>
<td>39</td>
</tr>
<tr>
<td>49</td>
<td>Central South University</td>
<td>China</td>
<td>43.75</td>
<td>114</td>
<td>16.61</td>
<td>61.2%</td>
<td>332</td>
</tr>
<tr>
<td>50</td>
<td>Jinan University</td>
<td>China</td>
<td>29.37</td>
<td>101</td>
<td>16.48</td>
<td>127.9%</td>
<td>458</td>
</tr>
</tbody>
</table>

*R FC figures are adjusted to 2017 levels.
The Nature Index is a database of author affiliations and institutional relationships. The index tracks contributions to research articles published in 82 high-quality natural science journals, chosen by an independent group of researchers. The Nature Index provides absolute and fractional counts of publication productivity at the institutional and national level and, as such, is an indicator of global high-quality research output and collaboration. Data in the Nature Index are updated regularly, with the most recent 12 months made available under a Creative Commons licence at natureindex.com. The database is compiled by Springer Nature.

**NATURE INDEX METRICS**

The Nature Index provides several metrics to track research output and collaboration. These include article count, fractional count, and adjusted fractional count.

The simplest is the article count (AC). A country or institution is given an AC of 1 for each article that has at least one author from that country or institution. This is the case regardless of the number of authors an article has, and it means that the same article can contribute to the AC of multiple countries or institutions.

To get a sense of a country’s or institution’s contribution to an article, and to ensure they are not counted more than once, the Nature Index uses fractional count (FC), which takes into account the share of authorship on each article. The total FC available per article is 1, which is shared among all authors under the assumption that each contributed equally. For instance, an article with 10 authors means that each author receives an FC of 0.1. For authors who are affiliated with more than one institution, the individual author’s FC is then split equally between those institutions.

The total FC for an institution is calculated by summing the FC for individual affiliated authors. The process is similar for countries, although complicated by the fact that some institutions have overseas labs that will be counted towards host country totals.

When comparing data over time, FC values are adjusted to 2017 levels to account for the small annual variation in the total number of articles in Nature Index journals. The adjustment of FC values in each year is done by calculating the percentage difference in the total number of articles in the index in a given year relative to the number of articles in 2017 and applying this adjustment to FC values.

**THE SUPPLEMENT**

Nature Index 2018 Rising Stars is based on data from natureindex.com, covering articles published during six years from 1 January 2012 to 31 December 2017 at the country level, and articles from 1 January 2015 to 31 December 2017 at the institution level.

Most analyses within the supplement use adjusted FC as the primary metric. The tables rank institutions by their absolute change in adjusted FC from 2015 to 2017. The tables also provide the percentage change in FC 2015–2017 and an institution’s global rank in the 2018 annual tables. Separate tables rank the top academic institutions, top young universities under 30 years old, as well as the top institutions in each subject area.