THIS WEEK

EDITORIALS

Restore justice in Turkey

Hundreds of academics and scientists are among those caught up in political crackdowns in Turkey. The government should end the state of emergency.

Peace is a dangerous cause to fight for in Turkey right now. In the latest blow to academics, 11 members of the Turkish Medical Association, including its president, Raşit Tükel, were arrested in early-morning raids last week. Their crime? Using the slogan that war is a matter of public health, the association had called for a halt to the Turkish army's cross-border assault on military units of Syrian Kurds, launched on 20 January to international consternation. (The Kurdish units targeted have been fighting alongside US troops against the Islamist terrorist organization ISIS in northwest Syria.) The raids follow the arrest of more than a thousand academics who signed a petition in January 2016 calling for peace in the country's southeast, where government forces were fighting Kurdish separatists. Many face criminal charges, and hundreds lost their jobs.

University professors and scientists were also among the 150,000 public servants who were detained and dismissed when draconian laws and a state of emergency were imposed after a failed coup in July 2016. Now, a report published on 18 January (see go.nature.com/2el9qze) by human-rights organizations in Turkey shows that many of those dismissed stand accused of supporting the FETÖ, or Gülen, organization believed by the government to have been behind the coup attempt. Membership in other terrorist organizations is also alleged and, as a result, many of these academics face serious terrorism-related charges.

The report details, as far as it is possible to do so, the arrests, detentions and trials of those caught up in the post-coup purges, and raises concern that miscarriages of justice might be occurring on a large scale. Universities have been hard hit — the report says that 5,822 professors and researchers lost their jobs, 380 of whom were signatories of the 2016 Academics for Peace petition. More than 21,000 health-care professionals were among those fired from public service, and a further 4,113 were judges and prosecutors; their loss partly explains why trials are moving forward so slowly. The report notes that even having downloaded a particular encrypted smartphone text-messaging system (called ByLock), favoured by Gülenists and that prosecutors claim was available only through personal introduction, was enough to condemn someone.

The plight of Turkey's academics must not be forgotten. They must be allowed fair hearings and trials without further delay. Telling their stories can be powerful, too. Last week, *Nature* published an interview with theoretical physicist Ali Kaya at Boğaziçi University in Istanbul, who has been charged with being a member of a terrorist organization, about how he managed to carry on his research during his 15 months of incarceration. Colleagues in other countries had tweeted about his achievement — a tactic that other scientists might adopt to help their colleagues in Turkey avoid falling out of the public consciousness.

The general situation in Turkey — whose president is becoming increasingly authoritarian and bellicose, and which hovers on outright civil war — endangers the serious efforts the country has recently been making to improve its research base. As one part of the government oversees mass arrests and orchestrates war, other parts are quietly but determinedly working to fix some of the entrenched problems in the research system. Thousands of new PhD places have been created in recent years, along with some brand-new research institutes, and universities have been energized into competing with each other by offering financial rewards for strong performers. It is a start, and has been enough to persuade at least some young scientists doing postdocs abroad to return home to establish independent research labs.

"The situation in Turkey endangers efforts to improve its research base."

This is a source of hope in more ways than one. Science can provide a channel for maintaining contact and discussion between countries and cultures in politically tense times. Inevitably, however, like other professionals, many of the scientists making successful careers in Turkey have half-formed emigration plans in mind. The Turkish government needs to make its scientists feel safe. It should revoke the newly extended state of emergency, which has long since outlived its legitimate purpose. ■

Hardware upgrade

Artificial intelligence is driving the next wave of semiconductor innovations.

Advances in computing tend to focus on software: the flashy apps and programs that can track the health of people and ecosystems, analyse big data and beat human champions at Go. Meanwhile, efforts to introduce sweeping changes to the hardware that underlies all that innovation have gone relatively unnoticed.

Since the start of the year, the Semiconductor Research Corporation (SRC) — a consortium of companies, academia and government agencies that helps to shape the future of semiconductors — has announced six new university centres. Having watched the software giant Google expand into hardware research on artificial intelligence (AI), the main chip manufacturers are moving to reclaim the territory. As they do so, they are eyeing the start of a significant transformation — arguably the first major shift in architectures since the birth of computing.

This would be important to science: research in fields from astronomy and particle physics to neuroscience, genomics and drug discovery would like to use AI to analyse and find trends in huge sets of data. But this places new demands on traditional computer hardware. The conventional von Neumann architecture keeps data-storage units inside computers separate from data-processing units. Shuttling information back and forth between them takes time and power, and creates a bottleneck in performance.

To take advantage of AI technology, hardware engineers are looking to build computers that go beyond the constraints of von Neumann design. This would be a big step forward. For decades, advances in computing have been driven by scaling down the size of the components, guided by Gordon Moore's prediction that the number of transistors on a chip roughly doubles every two years — which generally meant that processing power did the same.

Modern computers bear little resemblance to early machines that used punch cards to store information and mechanical relays to perform calculations. Integrated circuits now contain transistors so small that more than 100 million of them would fit on the head of a pin. Yet the fundamental design of separate memory and processing remains, and that places a limit on what can be achieved.

One solution could be to merge the memory and processing units, but performing computational tasks within a memory unit is a major technical challenge.

Google's AlphaGo research shows a possible, different, way forward. The company has produced new hardware called a tensor processing unit, with an architecture that enables many more operations to be performed simultaneously. This approach to parallel processing significantly increases the speed and energy efficiency of computationally intensive calculations. And designs that relax the strict need to perform exact and error-free computation — a change in strategy known as approximate computing — could increase these benefits further.

As a result, the power consumption of AI programs such as AlphaGo has improved dramatically. But increasing the energy efficiency of such hardware is essential for AI to become widely accessible.

The human brain is the most energy-efficient processor around, so it is natural for hardware developers to try to mimic it. An approach called neuromorphic computing aims to do just that, with technologies that seek to simulate communication and processing in a biological nervous system. Several neuromorphic systems have already demonstrated the ability to emulate collections of neurons on tasks such as pattern recognition.

These are baby steps, and now the SRC has stepped in to try to encourage the hardware to walk. Under its Joint University Microelectronics Program, the SRC has quietly placed its focus on developing hardware architecture. A new centre at Purdue University in West Lafayette, Indiana, for example will research neuromorphic computing, and one at the University of Virginia in Charlottesville will develop ways of harnessing computer memory for extra processing power.

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This technological task is huge. So it is heartening to see the SRC, traditionally US-centric, opening its doors. South Korean firm Samsung joined in late 2017, the fifth foreign company to sign up in the past two years. This is a welcome sign of collaboration. But that commercial rivals would work together in this way also signals how technically difficult the industry thinks it will be to develop new hardware systems.

As this research develops, *Nature* looks forward to covering progress and publishing results. We welcome papers that will enable computing architectures beyond von Neumann, such as components for neuromorphic chips and in-memory processing. Scientists across many fields are waiting for the result: computers powerful enough to sift all of their new-found data. They will have to wait a while yet. But the wait should be worth it. ■

Maths revision

A decadal update of academic mathematics shows the value of taking one's time.

Mathematics has its own way of doing things. Not for mathematicians the breakneck chase after the latest academic fad. "It goes up and down over the centuries," said one expert, when asked whether fluid dynamics — her focus — is now trendy.

Maths moves at its own pace, and the field is currently involved in a global effort to analyse, audit and agree new classifications of how mathematicians study and make use of maths. The MSC2020 system, due to appear in 2020, will formally approve new categories of maths, and split existing definitions into finer classes.

MSC stands for Mathematics Subject Classification, and it provides taxonomical order. In the current MSC2010, for instance, the code 03 represents mathematical logic and foundations. Going deeper, 03E is set theory and 03E72 is fuzzy set theory.

Why bother? The system is jointly managed by the mathematical resource zbMATH, curated by the Leibniz Institute for the Structure of Information in Karlsruhe, Germany, and by the American Mathematical Society's *Mathematical Reviews*. Each is a 'meta-journal' that systematically summarizes and reviews every paper that comes out in the peer-reviewed mathematical literature. *Mathematical Reviews* and zbMATH use the MSC in their internal workflows, and many other journals have adopted the system to assign submissions to editors and reviewers. Mathematicians also use the numerical codes to search for papers in their speciality.

To keep the system up to date, every ten years the two organizations consult reviewers and request suggestions for new entries from the broader community. Nominations opened in July 2016 and close this August. A theme emerging for proposed new categories is for fields that mix traditional disciplines — such as 'algebraic statistics' and 'numerical algebraic geometry'.

Take topological data analysis, a popular candidate for inclusion. The theory has its roots in topology — the study of shapes and their arrangements within one another — which includes knot theory and higher-dimensional spaces. For more than a century, topology was mostly a pure-maths affair. But researchers have found ways to use it to give structure to large data sets, and so topological data analysis has been born.

More generally, the revision takes the pulse of broader cultural shifts. Suggested new categories indicate that more mathematicians have started to collaborate with researchers in other fields.

Recognition of a new subfield can depend on building citations, and that is a slow process in maths. A recent study of some 20 million references for more than 900,000 mathematical articles in zbMATH found that the time it takes for a paper's citations to peak is several years longer than in other fields — and is lengthening. Consequently, it takes a while for even the most dramatic breakthroughs to register in the MSC system. Many mathematicians expect Peter Scholze, a number theorist at the University of Bonn in Germany, to win a Fields Medal this year for his pioneering work on perfectoid spaces. But, as a research category, perfectoid spaces — only around since 2010 or so — is probably too undercooked yet to make the cut for MSC2020.

Can such a rigid hierarchy survive in an age of fluid metadata and keyword tagging? For now, it remains relevant. Studies have found a high correlation between clustering of the mathematical literature into topics — as measured from citation networks — and the MSC, at least at its upper levels. But things might change. For its own journals, for example, the American Physical Society changed in 2016 from a system similar to the MSC to a hybrid one called Physics Subject Headings. This has both a hierarchical tree of subfields and a broader set of 'facets' that cut across them like a Venn diagram, encompassing many terms. Maths might do the same at some point — but, quite correctly, in its own time. Maths has no need to start following fashion now. ■

CORRECTION

The Editorial 'Restore justice in Turkey' (*Nature* **544,** 145; 2018) stated that the text-messaging system ByLock was available only through personal introduction, in fact, it was widely available and could have been downloaded by anyone.