change — and that it doesn't hang around long enough to raise the risk of undesired changes.

This was particularly important for the Beethoven mice, because the animals carry one mutated copy and one normal copy of the *Tmc1* gene. The two versions differ by only a single DNA letter, and Liu's team wanted Cas9 to disable the mutated copy — not the normal one. Rather than use a virus, Liu's team injected the lipid-encased Cas9 protein bound to its guide RNA into one ear of each mouse and then tested the hearing in each ear up to eight weeks later.

In all the tests, mice with treated ears performed better than control mice that had not been injected with the gene-editing components. For example, eight weeks after the injection, untreated control mice did not react to an abrupt 120-decibel noise — roughly the volume of a rock concert or a chainsaw. Mice that received the treatment, however, were significantly startled by the noise.

"This is a nice extension of previous work," says Daniel Anderson, a biomedical engineer at the Massachusetts Institute of Technology in Cambridge. The ability to selectively knock out the mutant form of the gene, despite a difference of just one DNA letter between it and the normal form, highlights the potential of CRISPR–Cas9 gene editing, he notes.

It will take further tests in animals and people before it will be clear whether the same approach could work for humans who have *TMC1* mutations. (Liu is co-founder of the company Editas Medicine, also in Cambridge, which aims to develop therapies that harness CRISPR–Cas9 to treat genetic disorders.) Liu's lab is also hoping to test the technique in the eye, to tackle genetic causes of blindness.

The Cas9 protein and its guide RNA are unlikely to travel far from the site of injection, making the approach ill-suited to treating conditions such as muscular dystrophy, which affect large swathes of tissue.

"The delivery method very much needs to be catered to the exact disease and what cells you're delivering to," says Gersbach, who advises Editas. "This work is a step in that direction." ■

TECHNOLOGY

Blockchain moves to science

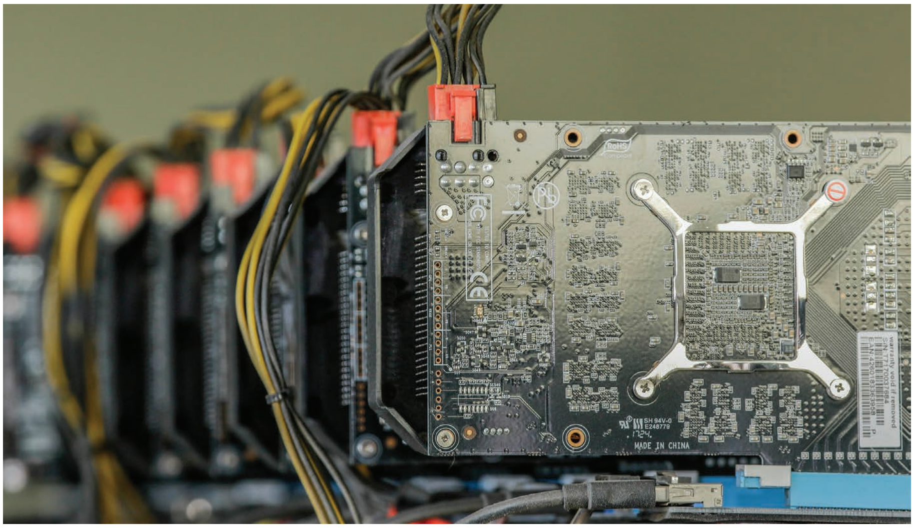
Proponents say the system behind Bitcoin could lend security measures to the scientific process.

BY ANDY EXTANCE

The much-hyped technology behind Bitcoin, known as blockchain, has intoxicated investors around the world and is now making tentative inroads into science, spurred by broad promises that it can transform key elements of the research enterprise. Supporters say that it could enhance reproducibility and the peer-review process by creating incorruptible data trails and securely recording publication decisions. But some also argue that the buzz surrounding blockchain often exceeds reality, and that incorporating the approach into science could prove expensive and introduce ethical problems.

A few collaborations, such as Scienceroot and Pluto, are already developing pilot projects to use blockchain for science. Scienceroot aims to raise US$20 million, which will help to pay both peer reviewers and authors within its electronic journal and collaboration platform. To draw in this money, it plans to exchange some of the 'science tokens' it uses for payment for another digital currency, known as ether, starting in early 2018. And the algebra program Wolfram Mathematica — widely used by researchers — is currently working towards offering support for an open-source blockchain platform called MultiChain. Scientists could use this, for example, to upload data to a shared, open workspace that isn't controlled by any specific party, according to MultiChain.

Blockchain, a technology that creates an immutable public record of transactions, has a "Wild West, boom or bust culture", says Martin Hamilton, a London-based resident futurist at Jisc, which supports digital services in UK education. He warns that academics and entrepreneurs might be tempted to add the technology solely to make their projects seem "magical and sparkly". As one sign of this trend, consulting firm Deloitte has identified more than 24,000 aborted, largely financial blockchain projects on the GitHub software-development platform in 2016 alone. Yet Hamilton still says blockchain has incredible potential. "There will be things that we try which simply blow up in our faces," he says. "But the rewards can be huge, if you're willing to take a calibrated risk."



SEUNG-IL RYU/NURPHOTO/GETTY

Mining for bitcoins creates a large computational demand.

Blockchain underlies cryptocurrencies such as Bitcoin, which is traded as units called bitcoins with a lowercase 'b'. It is created by a community of 'miners', who run Bitcoin software on their hardware and compete to discover a hard-to-find number by trial and error. The victor of this contest adds an encrypted block of transactions to the chain and earns a financial reward. They communicate the extended blockchain to all other miners, and the process starts again.

FOOLPROOF TRACKING

Mining takes a lot of computation, which makes it unlikely that any individual will win twice in a row. This is crucial, because if miners could add more than one block at a time, they could gain power over the record and even discard earlier blocks they had added. That would effectively refund their transactions and enable them to spend the same bitcoins again. In 2016, a consortium of miners highlighted ▶

that vulnerability by working together to add multiple blocks, although the group voluntarily disbanded once it came close to achieving its goal.

One way in which blockchain technology could help scientists is by reliably collecting and preserving data concerning research activities. This would make it easier to reproduce results in cases where published accounts insufficiently explain methodologies, according to Joris van Rossum, director of special projects at Digital Science, a research-technology firm in London. Blockchains could also be used to track each transaction in the peer-review process, says van Rossum, which could build trust in the process by recognizing reviewers' efforts and potentially rewarding them with digital currency. And open blockchains would generate information such as how frequently researchers collect measurements, enabling people to look beyond metrics such as publications and citations, he says (J. van Rossum *Blockchain for Research;* Digital Science, 2017).

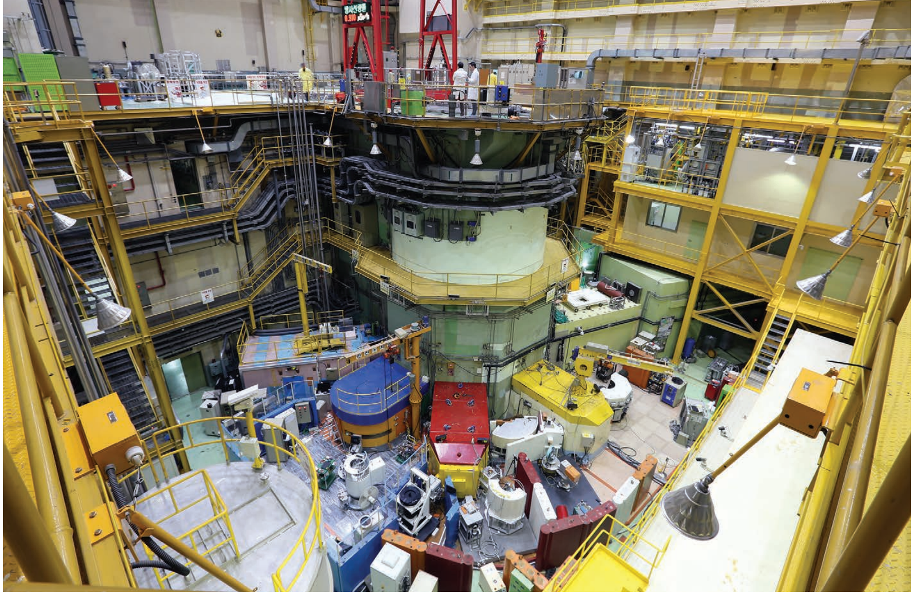
CURRENCY-FREE SCIENCE

Scienceroot and Pluto are part of the same 'universe' of open-blockchain technology as cryptocurrencies, says Gideon Greenspan, founder of London-based Coin Sciences, which developed MultiChain. Greenspan says that such currency-style blockchains are unsuitable as scientific archives, because recording each transaction incurs a financial cost, and these can easily add up.

Private "permissioned" blockchains without the currency element — which MultiChain lets people set up — are a better choice, Greenspan says. This approach sacrifices the security offered by Bitcoin's mining process in favour of a simpler system that gives members permission to add blocks to the chain in turn.

Claudia Pagliari, who researches digital health-tracking technologies at the University of Edinburgh, UK, says that she recognizes the potential of blockchain, but that researchers have yet to properly explore its ethical issues. What happens if a patient withdraws consent for a trial that is immutably recorded on a blockchain? And unscrupulous researchers could still add fake data to a blockchain, even if the process is so open that everyone can see who has added them, says Pagliari. Once added, no one can change that information, although it's possible that they could label it as retracted.

In Pagliari's experience, researchers exploring blockchain are becoming wise to its problems. She notes that fellow speakers at a 'hackathon' held in November in London were careful to warn about hype. That suggests "a realism that no solution is perfect and the value of blockchain in this context remains unproven", Pagliari says. ■


COURTESY OF KAERI

Engineers inspect the HANARO research reactor in Daejeon.

PHYSICS

South Korean reactor to restart experiments

Facility shutdown had slowed neutron research in the region.

BY DAVID CYRANOSKI

After a three-and-a-half-year hiatus, South Korea's nuclear research reactor has restarted operations, and experiments there will resume this month. Scientists and students are eager to make up for lost time after the facility was closed for repairs in 2014.

"Students have been thirsty for neutrons," says Sung-Min Choi, a materials scientist and neutron-scattering expert at the Korea Advanced Institute of Science and Technology in Daejeon.

After the High-Flux Advanced Neutron Application Reactor (HANARO) in Daejeon was shut down in July 2014, the South Korean nuclear regulator ordered the facility to address whether it could resist seismic activity before it could restart. Following the earthquake in March 2011 off the coast of Japan, which triggered a tsunami that swamped the Fukushima Daiichi nuclear power station, many governments, including that of South Korea, insisted that reactors be able to withstand major earthquakes or other disasters.

HANARO completed alterations, including reinforcing its walls, in April 2017. But the agreement that had been reached with local government required that a citizens' watchdog group be permitted to verify the safety of the site, which took until September.

The burden of HANARO's closure has been particularly heavy on early-career scientists. "We lost a generation of neutron scatterers," says Sungil Park, a physicist at the Korea Atomic Energy Research Institute in Daejeon.

Japanese researchers have also struggled with the closure of nuclear reactors in that country. The Japan Atomic Energy Agency announced in June 2016 that it would restart its JRR-3 facility by March 2018, but the process is behind schedule and there is no longer an estimate of when it will be able to restart, according to a spokesperson for the agency.

Japanese scientists are making do. Mitsuhiro Shibayama, a condensed-matter physicist at the University of Tokyo, shifted his research projects to X-ray and light scattering so that his students could progress. "Many graduate students left without any experience on neutron-beam experiments and many professors have had to change their research topics," he says.

In South Korea, researchers are starting to rebuild their community as HANARO undergoes final tweaks before experiments can start. "It will be a hectic but happy week for all of us working at HANARO," says Park. ■

CORRECTIONS

The Editorial 'Nurture negatives' (*Nature* **551,** 414; 2017) erroneously stated that *Psychological Science* had released a replication report. In fact, the report was in *Perspectives on Psychological Science*.

A quote in 'The axolotl paradox' (*Nature* **551,** 286–289; 2017) implies that animals obtained from a breeding facility in Kentucky have a high rate of malformations. This is not the case. The animals referred to may trace their lineage to the facility, but have been bred and potentially inbred elsewhere.