more attractive — and more efficient. Some projects will even pay people to use their information. The ultimate goal of many teams is to train AI algorithms on the data they solicit using the blockchain systems.

These efforts come as the public grows increasingly concerned about how tech giants mine and profit from personal data, including some medical information. In 2016, DeepMind, an AI company in London owned by Google's parent, Alphabet, became mired in controversy after press reports revealed that a branch of the UK National Health Service had given the company access to 1.6 million patient records without adequate consent. The information included names and sensitive information, such as whether a person had a sexually transmitted disease.

"Right now, Google and Facebook have siloed repositories of data about you that you have no control over," says Andrew Lippman, a computer scientist at the Massachusetts Institute of Technology in Cambridge. "But in the world of medicine, there is no Facebook." Using blockchain to secure and share decentralized medical information "could be a model of data-identity control" generally, he adds.

Blockchain is a distributed electronic system that records transactions in an expanding chain of 'blocks' that are extremely difficult to alter. To break into one block, a hacker would have to tamper independently with all the blocks that link to it — a daunting task.

In Hadley's study, blockchain will function as a series of switches that guide how data flow between participants, clinicians and researchers. Women taking part will be able to give or revoke access to their data using an online portal, breastwecan.org, that relies on blockchain to secure data stored in the cloud.

The researchers plan to train their AI algorithm on millions of mammograms from healthy women and those with breast cancer. The goal is to classify tumours more precisely than doctors do; physicians miss up to one-quarter of cancers present in mammograms. The accuracy of an algorithm generally grows as it is trained on more, and more varied, data, just as a radiologist's ability to distinguish tumours improves with experience.

"We need to engage people so that they show us their data."

Hadley hopes that women will share their mammograms to improve breast-cancer screening generally — and to gain access to, and control over, information that has customarily been held by clinics. Women who participate in the study will be able to view their scans on breastwecan.org, along with standard clinical interpretations of their risk of breast cancer, based on tissue density, age and other known factors.

Other groups are developing blockchain-based marketplaces to broker data exchanges between individuals and companies or academic researchers — and arrange payment. One such effort is Nebula Genomics, a start-up co-founded by geneticist George Church of Harvard University in Cambridge, Massachusetts. Nebula aims to connect people who want their genomes sequenced with companies willing to pay for that service in return for access to the resulting data. People who pay for their own sequencing will be able to sell access to their genetic information using Nebula; payment will come in the form of digital tokens that can be exchanged for US dollars.

Church says that Nebula will ensure that its partner companies keep any promises they make — on issues such as how long a company will retain a person's data. By contrast, when customers of genomic-sequencing firms such as 23andMe in Mountain View, California, consent to share their data for research, they largely relinquish control over how it is used. Many sequencing firms sell anonymized genetic data in bulk to biotechnology and pharmaceutical firms.

Giving people more control over their medical records could also yield more-immediate health benefits, Lippman says. He and his graduate students have developed a blockchain-based system for sharing health records, called MedRec, that will be tested at Beth Israel Deaconess Medical Center in Boston this year. The system allows users to insert information into their health records, including data from wearable electronic devices such as Fitbits. Clinicians and researchers could use these extra data, with permission, to tailor treatments.

Ultimately, Hadley says, the immense amount of routine medical data that physicians collect can yield medical advances only if the information is shared and studied. "We need to engage people so that they show us their data," he says. "So we need to think in medicine about the technologies that let us have good data governance, and blockchain happens to be one of them right now." ■ SEE EDITORIAL P.285

ENERGY

MIT renews push for fusion energy

Collaboration with company aims to feed grid in 15 years.

BY JEFF TOLLEFSON

The Massachusetts Institute of Technology (MIT) in Cambridge will work with a private firm to develop technology for producing energy from nuclear fusion within the next 15 years. If successful, the multimillion-dollar effort could help to unlock a virtually limitless source of pollution-free energy.

The approach — which has so far attracted US$50 million — is based on high-temperature superconductors that have become commercially available in the past few years, the team announced on 8 March. The new generation of superconductors will allow researchers from MIT and Commonwealth Fusion Systems (CFS) in Cambridge to strengthen the magnetic field that contains the hot-plasma fuel used in conventional tokamak reactors. That could pave the way for reactors that are smaller, cheaper and easier to build than those based on previous designs — including the international ITER project under development in southern France, which is over budget and behind schedule.

"It's about scale, and it's about speed," says Robert Mumgaard, chief executive of CFS. The company — an MIT spin-off — has attracted $50 million from Italian energy giant ENI, and plans to invest $30 million of that sum in research and development at MIT over the next three years. Mumgaard says that the collaboration between academics and industrialists should help to drive fusion technology out of the lab and into the marketplace.

Fusing hydrogen atoms to form helium releases massive amounts of energy, which can be harnessed to produce carbon-free electricity. But sustaining the extreme temperatures that are required for this process in a confined space remains a daunting challenge that has defied most hopes and expectations to date.

CFS is the latest in a series of companies pursuing fusion energy as a clean-power source. Tokamak Energy, a company based near Oxford, UK, is also developing a tokamak reactor using high-temperature superconductors. But observers say that the MIT initiative is the most significant of its kind.

"There are no guarantees," says Stephen Dean, who heads Fusion Power Associates, an advocacy group in Gaithersburg, Maryland. But "if MIT can do what they are saying — and I have no reason to think that they can't — this is a major step forward", he says.

The first challenge will be to transform a commercially available superconductor into a large, high-performance electromagnet, which could take around three years, says Martin Greenwald, deputy director of MIT's Plasma Science and Fusion Center. Within the next decade, the team hopes to develop a prototype reactor that can generate more energy than it consumes. Then, they hope to develop a 200-megwatt pilot power plant that can export electricity to the grid.

Stewart Prager, former director of the Princeton Plasma Physics Laboratory in New Jersey, says it's good news that the MIT proposal is attracting private capital. But he warns that private investment won't be enough to make up for stagnant budgets in the US fusion programme. "This funding for MIT is terrific, but there's just no way you are going to get the private sector to take on the full brunt of the fusion programme," Prager says.

For their part, MIT researchers hope that their work will generate more government interest in fusion research. "If we can change that narrative, we can potentially reinvigorate the rest of the programme," Greenwald says. ■

SEISMOLOGY

Drillers probe risk of big quakes in New Zealand

A major expedition is investigating the enigmatic sea-floor fault zone.

BY ALEXANDRA WITZE

An international team of geoscientists has launched a fully fledged onslaught to understand New Zealand's biggest earthquake and tsunami hazard.

On 11 March, the *JOIDES Resolution* drill ship began a two-month expedition to bore deep into the Hikurangi subduction zone off the east coast of New Zealand's North Island. There, the Pacific plate of Earth's crust dives, or subducts, beneath the Australian plate. The grinding of these geological titans has the potential to unleash a magnitude-9 earthquake and accompanying tsunami.

The drilling effort is part of a broader project to better understand the danger of the Hikurangi. "It's a major earthquake and tsunami hazard to the largest population centres, and it's not very well understood," says Laura Wallace, a geophysicist at the GNS Science research institute in Lower Hutt, New Zealand, and co-chief scientist on the upcoming cruise. The expedition will also give researchers the chance to probe the fault's role in a type of enigmatic slow-motion earthquake.

Whatever the scientists find will help to inform their understanding of seismic processes in other parts of the world with similar geologic settings, says Susan Schwartz, a geophysicist at the University of California, Santa Cruz.

Work kicked off in October, when researchers sprinkled nearly 300 seismometers in a dense array near the town of Gisborne on the North Island. Around the same time, two research vessels — the US *Marcus Langseth* and New Zealand's *Tangaroa* — deployed seismometers on the sea floor and blasted sound waves into the ocean crust to study its structure. Then, in December, the *JOIDES Resolution* did some initial drilling at three sites off the coast near Gisborne, to prepare for the bigger expedition that kicked off this week.

ANTHONY PHELPS/REUTERS

The Kaikoura earthquake in 2016 caused extensive damage on New Zealand's South Island.

ANATOMY OF A DANGER ZONE

Together, the studies aim to build a detailed picture of the guts of the subduction zone. It is perhaps the largest geophysical-research effort in New Zealand's history, says Stuart Henrys, a geophysicist at GNS Science who led the deployment of the land seismometers. The governments of New Zealand, the United States, the United Kingdom and Japan are helping to fund research on the fault over five years.

One thrust of the work is to determine whether, and how often, the Hikurangi might rupture in quakes as large as magnitude 8 or 9. A section of the fault offshore near Wellington is geologically locked and does not move, whereas a more northern part, near Gisborne, moves slowly. The seismic studies should help to illuminate the behaviour of rocks on either side of the fault and how that influences earthquake risk in both regions, Henrys says.

Another big question is the role of 'slow-slip' events akin to slow-motion earthquakes, in which the action unfolds over weeks or months, rather than seconds or minutes. Geologists aren't sure how slow-slip events influence the risk of larger quakes along a fault, but the Hikurangi is a natural laboratory for exploring that, Wallace says. Researchers ▶