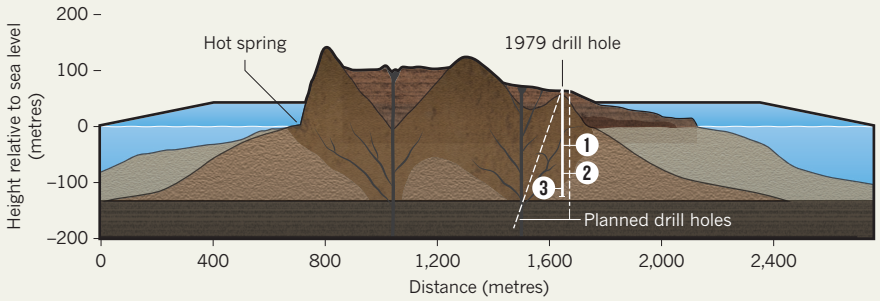
GOING DEEP

A project to drill into the Icelandic island of Surtsey could reveal how microbes there have changed over time. Researchers last drilled at Surtsey in 1979.

Microbes underground
(Sampled from 1979 drill hole in 2009)

1. 95 metres depth: Maximum temperature, 130 °C, forms a thermal barrier to keep surface microbes from contaminating greater depths.
2. 145 metres depth: Archaeal community dominated by *Archaeoglobus*, 80 °C.
3. 172 metres depth: Bacterial and archaeal communities, 54 °C.



SOURCE: REFS 1 & 2

by seabirds. The 1.3-square-kilometre island is a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage site, set aside strictly for science. "This is one of the most pristine environments on Earth," says Marie Jackson, a geologist at the University of Utah in Salt Lake City and principal investigator for the US$1.4-million project, which is partly funded by the International Continental Scientific Drilling Program.

On 28 July, Iceland's coast guard plans to begin moving 60 tonnes of drilling equipment and other supplies to Surtsey by helicopter. "This is the most complicated logistics operation I've taken part in," says Guðmundsson. Strict environmental regulations require all waste to be removed from the island, including the sterilized seawater that functions as drilling fluid. Only 12 people will be allowed on Surtsey at any given time, even as drilling proceeds 24 hours a day. Others will stay on the neighbouring island of Heimæy, where a warehouse will become a core-analysis lab.

Microbiologists have continued to monitor the 1979 hole, where the maximum temperature has slowly cooled from 140 °C to about 130 °C. It is now rife with microorganisms that are probably indigenous to Surtsey[2], says Viggó Marteinsson, a microbiologist at the Matís food- and biotechnology-research institute in Reykjavik. These organisms are thought to have colonized Surtsey from the seawater below, protected from contamination from above by scorching rock. Marteinsson expects to find similar types of microbe, including bacteria, archaea and viruses, in the new hole (see 'Going deep').

After the hole is drilled, engineers will lower five incubation chambers to different depths. These will remain in place for a year before they are retrieved, so that researchers can determine what organisms colonize them. Monitoring which microbes move in, and how quickly, will offer scientists an unprecedented chance to study how the deep biosphere evolves in space and time, Marteinsson says.

Meanwhile, geologists and volcanologists on the team will be investigating the second, angled hole. "That will allow us to reconstruct the way subsurface layers are connected — what we call the structure of the volcano," says Jocelyn McPhie, a geologist at the University of Tasmania in Hobart, Australia.

The drilling should reveal the earliest stages of the Surtsey eruption, before it broke the surface of the ocean in November 1963. In the mix of seawater and heat, hydrothermal minerals formed in the volcanic rock — making it less porous and buttressing it against erosion. The drill core should reveal how these minerals were created over time, Jackson says, and scientists might be able to take hints from this process to build stronger concrete for structures such as nuclear-waste containers.

With such strength, Surtsey's core is likely to remain an island for thousands of years, says Guðmundsson. That's in stark contrast to many volcanic islands, such as one that appeared near Tonga in 2014 but has already eroded by 40% (ref. 3). "Because the vast majority of these islands disappear, we most likely substantially underestimate the number and volume of eruptions occurring at or just below sea level in the ocean, and hence the associated volcanic risk," says Nico Fournier, a volcanologist with the GNS Science research institute in Taupo, New Zealand.

Whatever comes out of the Surtsey drilling, it should dramatically expand the snapshot gleaned from the 1979 project, says James Moore, an emeritus geologist with the US Geological Survey in Menlo Park, California, who was a leader of the earlier effort. "We made a lot of estimates that are going to be tested now," he says. "It feels wonderful." ■

1. Jackson, M. D. *et al. Sci. Drill.* **20,** 51–58 (2015).
2. Marteinsson, V. *et al. Biogeosciences* **12,** 1191–1203 (2015).
3. Cronin, S. J. *et al. Eos* http://dx.doi.org/10.1029/2017EO076589 (2017).

BIOTECHNOLOGY

US agencies tackle gene drives

National-security community studies risks of method to quickly spread DNA modifications.

BY EWEN CALLAWAY

The JASONs, a group of elite scientists that advises the US government on national security, has weighed in on issues ranging from cybersecurity to renewing country's nuclear arsenal. But at a meeting in June, the secretive group took stock of a new threat: gene drives, a genetic-engineering technology that can swiftly spread modifications through entire populations and could help vanquish malaria-spreading mosquitoes.

That meeting forms part of a broader US national security effort this year to grapple with the possible risks and benefits of a technology that could drive species extinct and alter whole ecosystems. On 19 July, the US Defense Advanced Research Projects Agency (DARPA) announced US$65 million in funding to scientists studying gene-editing technologies; most of the money will be for work on gene drives. And a US intelligence counterpart to DARPA is planning to fund research into detecting organisms containing gene drives and other modifications.

"Every powerful technology is a national security issue," says Kevin Esvelt, an evolutionary engineer at the Massachusetts Institute of Technology in Cambridge, who won DARPA funding to limit the spread of gene drives.

VISUALS UNLIMITED/NPL

Gene drives could be targeted at mosquitoes.

Esvelt says he also attended last month's JASON meeting in San Diego, California, where he outlined how would-be bioterrorists might weaponize gene drives. But he is much more concerned about the potential for accidental release of gene-drive organisms by scientists, he says. "Bio-error is what I'm worried about."

So, too, is the US military, says Renee Wegrzyn, the programme officer leading DARPA's 'Safe Genes' initiative, which supports research on restraining gene drives. The technology has been developed in recent years in fruit flies, mosquitoes and other organisms, using CRISPR gene editing. A UK-based team hopes to begin field tests of gene drives in *Anopheles gambiae* mosquitoes, the main carrier of malaria in Africa, as soon as 2024. "I've been very excited to watch the advances, but I've noted with increasing concern that the advances are outpacing biosecurity," Wegrzyn says.

The JASONs' gene-drive discussion involved around 20 scientists, according to Philipp Messer, a population geneticist at Cornell University in Ithaca, New York, who attended the meeting. "I'm not used to that kind of conference," says Messer, who says he told the group about his lab's efforts to study the evolution of resistance to CRISPR gene drives in fruit flies. "We just had open discussions about this technology and what we think the current state of the field was and what we think the problems are." Gerald Joyce, a biochemist at the Salk Institute for Biological Studies in La Jolla, California, and a JASON member who Messer says co-organized the meeting, declined to comment on the meeting, which is likely to lead to a classified report.

"Every powerful technology is a national security issue, but bio-error is what I'm worried about."

Under the DARPA programme, seven teams won four-year contracts. Esvelt plans to develop CRISPR gene drives in nematode worms — a fast-reproducing model organism — that are designed to spread a genetic modification in a local setting and then fizzle out. He and the other teams receiving military funding also plan to develop tools to counter rogue gene drives that spread out of control. Such methods include chemicals that block gene editing or 'anti-gene drives' that can reverse a genetic modification.

Other efforts are afoot to fund studies on the national-security implications of gene drives. This week, the Intelligence Advanced Research Projects Activity (IARPA), which is part of the Office of the US Director of National Intelligence, will hold a meeting about a planned funding programme for detecting genetically modified organisms that are potentially harmful, including ones that contain gene drives.

Todd Kuiken, who studies policy relating to synthetic biology at North Carolina State University in Raleigh, is glad to see gene-drive research receive more funding. But he has qualms about the US military's interest; with Safe Genes, DARPA has become the world's largest government funder of gene-drive research. Kuiken worries that this could sow suspicions about gene drives in parts of the world that view the US military in a less-than-favourable light, including countries that stand to benefit from the elimination of disease carriers such as mosquitoes.

Esvelt shares those concerns but sees military support as the only way, for the time being, to advance gene-drive technology, while making it safer for eventual deployment. Private funders such as the Bill & Melinda Gates Foundation, in Seattle, Washington, and the Tata Trusts, a charity based in Mumbai, India, have spent tens of millions on gene-drive research, but this funding has been directed to specific projects or institutions. "No one else is offering us large amounts of money," Esvelt says.

The DARPA programme explicitly prevents the release of gene-drive organisms and requires contract winners to work under stringent biosafety conditions and to disclose planned experiments to the public — measures that should reduce the risk of accidental release, Esvelt adds. "If what you're worried about is your cowboys running amok and causing trouble, then what you really want to do is employ the cowboys to make sure they stay out of trouble." ■

AGEING

Brain stem cells rejuvenate mice

Transplanted cells slow decline and increase lifespan.

BY SARA REARDON

Stem cells in the brain could be the key to extending life and slowing ageing. These cells — which are located in the hypothalamus, a region that produces hormones and other signalling molecules — can reinvigorate declining brain function and muscle strength in middle-aged mice, according to a study published this week in *Nature* (Y. Zhang *et al. Nature* http://dx.doi.org/10.1038/nature23282).

Previous studies have linked the hypothalamus to ageing. That makes sense, because the region is involved in many bodily functions, including inflammation and appetite, says Dongsheng Cai, a neuroendocrinologist at Albert Einstein College of Medicine in New York City.

Cai and his colleagues showed that stem cells in the hypothalamus disappear as mice grow older. When the researchers injected their mice with viruses that destroy these cells, the animals experienced declines in memory, muscle strength, endurance and coordination. They also died sooner than untreated mice of the same age.

Next, the team injected stem cells from the hypothalami of newborn mice into the brains of middle-aged mice. After four months, these animals had better cognitive and muscular function than untreated mice of the same age. They also lived about 10% longer, on average.

The researchers found that these stem cells release molecules called microRNAs, which help to regulate gene expression, into the cerebrospinal fluid. When the team injected these microRNAs into the brains of middle-aged mice, they found that the molecules slowed cognitive decline and muscle degeneration.

The findings represent a breakthrough in ageing research, says Shin-ichiro Imai, who studies ageing at Washington University in St. Louis, Missouri. The next steps would be to link these stem cells with other physiological mechanisms of ageing, he says. Imai would also like to know whether the microRNAs from the cells can pass into the bloodstream, which would carry them throughout the body.

Cai says his team is trying to identify which of the thousands of types of microRNA produced are involved in ageing. The researchers also hope to investigate whether similar mechanisms exist in non-human primates. ■