be studied closely by a NASA mission called Europa Clipper, which is due to launch in late 2024.

In 2035, JUICE will fire up its main engine again to enter orbit around Ganymede, at an altitude of 500 kilometres, where it will remain for at least 9 months. This will be a delicate manoeuvre, says Scott Bolton, a planetary scientist at the Southwest Research Institute in San Antonio, Texas. "You have to really go slow around Ganymede and match its orbital speed, in order to get trapped," says Bolton, who is the principal investigator for Juno, an ongoing NASA mission that has been orbiting Jupiter since 2016. "If you're moving just a little bit too fast, Jupiter's gravity pulls you away."

Bigger than the planet Mercury, Ganymede is the largest moon in the Solar System, and the only one known to have its own magnetic field.

Although Juno was designed to study Jupiter, it has also conducted fly-bys of two of the planet's icy moons, sending back spectacular images. "When we set out and designed Juno, I hadn't imagined that some day we'd fly by really close to Europa and Ganymede," says Bolton. The mission is also planning two fly-bys of Io – the rocky fourth moon discovered by Galileo that neither JUICE nor Europa Clipper is scheduled to visit – in December 2023 and February 2024.

Hidden oceans

Some of Jupiter's icy moons are thought to harbour liquid water underneath their predominantly water-ice surfaces – potentially providing an environment for some form of life to have evolved. In the mid-1990s, NASA's Galileo probe provided hints of such a water ocean on Ganymede and, more convincingly, Europa. Further evidence came in 2015 from Hubble Space Telescope observations of Ganymede's aurorae (J. Saur *et al. J. Geophys. Res. Space Phys.* **120**, 1715–1737; 2015), which are created by its magnetic field similarly to how Earth's geomagnetism produces the aurorae borealis and australis.

One of the most conclusive tests of the ocean theory will come from topographical maps made by JUICE's laser altimeter. Because Ganymede moves slightly closer to and farther from Jupiter during its weekly orbit, and because it experiences the gravitational pull of the other moons, it stretches and compresses under tidal forces. On a water world with an ice crust, such deformations might make the surface swing up and down by as much as 10 metres, says JUICE project scientist Olivier Witasse, who is based at the ESA in Noordwijk. "If it's only a solid tide, it would be less than a metre," he adds.

Heavy load

Loaded with 3.5 tonnes of propellant, JUICE weighs nearly 6 tonnes. On its journey, it will deploy 85 square metres of solar panels – the bare minimum for operating around Jupiter, where solar energy is only 4% as powerful as on Earth. JUICE will also deploy a plethora of booms and antennas for its ten onboard instruments, which were built by teams in France, Germany, Italy, the Netherlands, Sweden and the United States. In addition to mapping the icy moons' surfaces, these instruments will study the chemistry of the satellites' thin atmospheres, Jupiter's strong magnetic field and radiation belts, and more.

By the time JUICE and Europa Clipper arrive, Juno will have long exhausted its propellant and ended its mission. But researchers are excited at the prospect of having two probes in the system at the same time, which could enable simultaneous measurements to be made of Jupiter's magnetic field at two locations, says Cynthia Phillips, a planetary geologist at NASA's Jet Propulsion Laboratory in Pasadena, California, who is on the Europa Clipper team. "These and other synergistic observations are being studied by a joint JUICE–Clipper steering committee," says Phillips. Both missions are scheduled to end with a controlled crash landing on Ganymede's surface. The one that lasts the longest might observe the other's impact up close.

ESA–CNES–ARIANESPACE/OPTIQUE VIDEO DU CSG/S. MARTIN

The JUICE spacecraft ahead of its launch at the spaceport in French Guiana.

DEATH THREATS AND SEXIST ATTACKS: CLIMATE SCIENTISTS DETAIL ABUSE

Survey highlights experiences of dozens of researchers who have endured harassment online.

By Myriam Vidal Valero

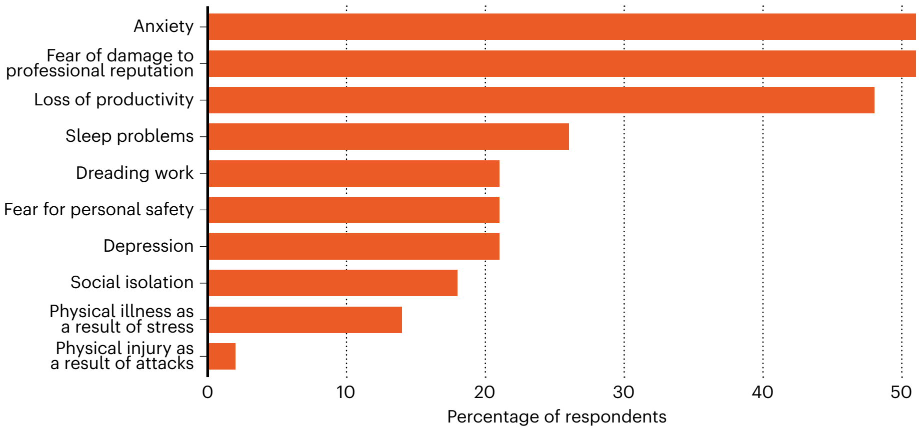
In 2013, Richard Betts called the police because someone online had threatened to string him up with piano wire. The threat happened after Betts, a climate scientist at the University of Exeter, UK, tweeted about the rising temperatures the world would experience the following year. This wasn't the first time someone had responded negatively to his comments about climate change; nor would it be the last. And Betts isn't alone.

A survey by the international non-governmental organization Global Witness hints at the extent of online abuse faced by scientists working on climate topics worldwide, some of which takes a toll on their work or well-being (see go.nature.com/3zwftii).

The organization contacted thousands of researchers doing climate-related work. Among the 468 respondents, 39% said they had experienced online harassment or abuse related to their climate research. Many respondents reported anxiety, sleeping

IMPACTS OF ABUSE

Climate scientists who experienced online harassment related to their research reported a range of consequences for their work and health.



SOURCE: GLOBAL WITNESS

problems or a loss of productivity (see 'Impacts of abuse').

The survey suggests that women receive more sexist attacks than do men — 34% of the female climate scientists who experienced abuse said they had faced attacks specifically relating to their gender, and 13% faced threats of sexual violence.

"[People tell me] I should let the men take care of this kind of research," said Helene Muri, an ecologist at the Norwegian University of Science and Technology in Trondheim, in her survey response. Media outlets often want to interview her, and she has received negative e-mails and violent comments on social media. "The more extreme cases are comments in the direction that I should kill myself."

The results are concerning, says Henry Peck, who works for Global Witness in London, because such online attacks could discourage researchers from pursuing this line of work or sharing their findings. "People are feeling less willing, less likely to post on social media as a result of abuse," he says.

Peck thinks social-media platforms should take responsibility for tackling abuse. But scientists' institutions can also enact protective policies, says Fiona Fox, chief executive of the Science Media Centre (SMC) in London.

In 2019, the SMC published advice to help scientists stay safe online (see go.nature.com/3iyyqij). The guidance emphasizes the importance of not answering or engaging with the negative comments, and of researchers' institutions being supportive. "Just straightforwardly saying, 'we've got your back, we've got your back, you are not alone,'" is a good start, Fox says. It is important to emphasize that the benefits of speaking out outweigh the costs, she adds. "It's integral to science to be open."

STEM-CELL-DERIVED 'EMBRYOS' IMPLANTED IN MONKEYS

An embryo-like ball of cells offers a way to study pregnancy without the usual ethical dilemmas.

By Gemma Conroy

Scientists have created balls of cells that resemble embryos and trigger changes seen in early pregnancy in macaques. The stem-cell-derived blastoids could help researchers understand human embryo development without the ethical dilemmas of using real embryonic cells, according to a study published in *Cell Stem Cell* (J. Li *et al. Cell Stem Cell* https://doi.org/gr3t76; 2023).

"The work highlights the amazing potential of stem-cell-based embryo models as a means to explore embryonic stages that are typically difficult to access *in vivo*," says Naomi Moris, a developmental biologist at the Francis Crick Institute in London.

The mechanisms of human embryo development are still largely unstudied, owing to the ethical difficulties of sourcing and experimenting with human embryos.

In the laboratory, researchers have previously generated blastoids — balls of cells that resemble blastocysts, the clusters of dividing cells that form about five to six days after fertilization. In March 2021, for instance, a team led by Leqian Yu, a developmental biologist at the University of Texas Southwestern Medical Center in Dallas, reported successfully producing blastoids from human stem cells and developing them for ten days in a culture dish (L. Yu *et al. Nature* **591**, 620–626; 2021).

Monkey models

Zhen Liu, a developmental biologist at the Chinese Academy of Sciences' Institute of Neuroscience in Shanghai, and his colleagues turned to cynomolgus monkeys (*Macaca fascicularis*), otherwise known as crab-eating macaques, which are commonly used as lab animals because they have some biological similarities to humans. In cell culture, the researchers exposed monkey embryonic stem cells to various growth factors so that they would differentiate into cell types found in natural blastocysts.

After about a week, the stem cells had formed the signature spherical structure of a blastocyst and had differentiated into the three cell lineages that lay the foundation for tissues and organs to form. "This has not even been achieved in the study of *in vitro* prolonged culture of natural monkey blastocysts," the authors say.

When the researchers profiled roughly 6,000 individual cells using single-cell RNA sequencing, they found genetic characteristics similar to those seen in natural blastocysts. Some cells expressed genes associated with the endoderm — the innermost cell layer that eventually forms the linings of the respiratory and gastrointestinal tracts — and others were enriched with genes involved in placental development. But the blastoids weren't a perfect reflection of natural blastocysts: some cells could not be classified, and some didn't express as much protein as expected.

By day 15, the researchers could see what looked like an outline of the yolk sac, which provides nutrition before the placenta forms, and the amnion, the outer membrane that surrounds the developing embryo. Of the 41 blastoids, 5 also developed features that resembled the primitive streak, a structure that marks the beginning of the cells rearranging themselves to form the layout of the body, including its left–right, top–bottom configuration.

Liu and his team then transferred the blastoids into the uteri of eight cynomolgus monkeys. For seven to ten days after the transplant, three of the monkeys had gestational sacs — fluid-filled cavities that are the first features seen by ultrasound during pregnancy. The