people are lazy, and encourage governments to make climate change — which will have its worst effects on future generations — their top priority.

"The idea of a climate strike is innovative. It's provocative, and I think it's the right form of non-violent civil disobedience," says Gail Whiteman, a social scientist at Lancaster University, UK, and one of many academics who have voiced their support for the strikes.

GLOBAL SUPPORT

More than 12,000 scientists have signed a statement started by researchers from Germany, Austria and Switzerland in support of the strikes. The letter says that the countries are not doing enough to keep global warming well below 2 °C — the aim of the 2015 Paris climate accord. Young people's concerns are "justified and supported by the best available science", it says.

In New Zealand, more than 1,500 academics released a similar statement. And last month, a letter from 224 UK academics published in *The Guardian* newspaper stated that the young strikers "have every right to be angry about the future that we shall bequeath to them, if proportionate and urgent action is not taken".

"As adults, we have abjectly failed," says Kevin Anderson, a climate scientist at the University of Manchester, UK, and Uppsala University in Sweden, and a signatory of the *Guardian* letter. Before most of the children who went on strike were born, scientists knew about climate change and how to respond to it, he says. But a quarter of a century later, people have collectively failed to act — and humanity is running out of time if it is going to restrict warming to 2 °C, he adds.

Most protestors have been inspired by Swedish teenager Greta Thunberg, who kick-started the movement when she began regularly walking out of classes in August 2018 to sit outside the Swedish parliament in Stockholm with a sign reading "school strike for climate".

Following Thunberg's example, thousands of young people from Belgium to Australia have taken part in strikes over the past few months. Friday's event was the largest so far — a global effort spearheaded by young activists in each country.

"The idea of a climate strike is innovative. It's provocative, and I think it's the right form of non-violent civil disobedience."

Thunberg has become a high-profile figurehead for the youth protests. "You say you love your children above all else, and yet you are stealing their future in front of their very eyes," she said in a speech at the 2018 United Nations climate conference in Katowice, Poland.

Vanessa Nakate, a 22-year-old who lives in the Ugandan capital of Kampala and protested on 15 March, told *Nature* that she found out about Thunberg after she talked to her uncle about how the climate was changing in Uganda, and researched the topic online. She has been spending Friday mornings on strike since January — sometimes alone and sometimes with her friends or siblings, coming in late to her job selling car batteries.

SCHOOL SCEPTICS

Not everyone is so enthusiastic about the strikes. Some politicians — including UK Prime Minister Theresa May — and school leaders have expressed concern that the protests are interfering with children's education. "While we support the right of young people to express themselves, first and foremost, pupils should be in school during term time," said Sarah Hannafin, senior policy adviser for the United Kingdom's National Association of Head Teachers, in a statement. School leaders can't condone children missing out on education, she says, and schools provide a safe platform for teaching children about positive social action.

Whiteman is surprised by the "stuffy" responses of some of those objecting to the strikes. "Education happens in many places," she says. Teachers could use the moment to discuss relevant aspects of literature or history with their students — who are making history themselves, she says.

Hoque, who also attended a strike in February, says that her teachers have backed the students, and have even asked them to tell the class about their experiences when they return to school. "Young people can be the motivators, but at the end of the day, we don't have the ultimate power. It's the policymakers," she says. ■

GENE EDITING

Bulls engineered to produce sperm from another father

'Surrogate sires' could help to spread desirable traits rapidly in some livestock.

BY HEIDI LEDFORD

Reproductive biologists are developing an unusual way to produce farm animals with desirable traits: injecting surrogate fathers — whose own sperm production has been wiped out by gene editing — with sperm-producing stem cells from another male that pass along 'elite' genes to offspring. From then on, the surrogate sire's offspring will genetically be not its own, but the donor's.

The goal is to spread genes for desirable traits, such as disease resistance or heat tolerance, through a population of animals in fewer generations than is possible with conventional breeding. If scientists can surmount lingering technical hurdles, the technique could prove invaluable for pigs, chickens and other livestock that are tricky to breed using artificial insemination. "There's a lost opportunity to improve genetics," says Jon Oatley, a reproductive biologist at Washington State University in Pullman.

The technique could also aid efforts to conserve species for which semen storage is difficult, including many birds.

In the US dairy industry, the practice of artificially inseminating cows with sperm collected from elite bulls, along with careful genetic selection, has yielded cows that produce four times more milk than animals did in the 1940s, before the practice was introduced. But artificial insemination is not often used in beef cattle, because the animals are allowed to roam freely over pasture, making it hard to track down cows at the right stage of their reproductive cycle. And the technique doesn't work well for pigs because their sperm often die in storage.

WHO'S YOUR DADDY?

Oatley and his colleagues are now developing surrogate pig sires. In 2017, the researchers reported that they had used the gene-editing tool CRISPR–Cas9 to disable a gene called *NANOS2* in pigs. Pigs that carry two copies of the knocked-out gene can't produce sperm, but are otherwise unaffected, making them

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LEONHARD FOEGER/REUTERS

Sperm from elite bulls, such as this one, are used to artificially inseminate cows to improve the genetics of dairy cattle.

ideal surrogate sires (K.-E. Park *et al. Sci. Rep.* **7**, 40176; 2017).

Researchers also want to create surrogate mothers that could produce eggs from another female. Another team, led by Michael McGrew of the University of Edinburgh's Roslin Institute, UK, said in 2017 that it had created sterile female chickens using a different gene-editing system to disable a gene called *DDX4* in the chickens' fathers (L. Taylor *et al. Development* **144**, 928-934; 2017). Females that inherit the knocked-out gene are sterile, and could be transformed into surrogate mothers.

McGrew and his team have gone on to transplant stem cells into developing female embryos that carry the disabled *DDX4* gene. The once-sterile recipients went on to lay eggs, McGrew says, and his team is now verifying that the offspring from those eggs came from the transplanted cells.

McGrew hopes to apply the technique in the next year to chicken species whose small populations are highly adapted to local conditions in African countries such as Ethiopia and Ghana. He also hopes to use it to conserve rare breeds of chicken in India and the United Kingdom.

Chicken embryos are an easier target than mammal embryos for transplanting cells, McGrew notes, because they are comparatively easy to access. All a geneticist needs to do is make a small hole in a chicken egg's shell, he says, and inject the cells into the vasculature of the developing embryo. From there, the cells migrate to the right location and multiply.

Pigs pose a greater technical challenge. At the Plant and Animal Genome meeting in San Diego, California, in January, Oatley presented the results of his efforts to transplant sperm-producing stem cells into his would-be surrogate pig sires. The cells survived and generated sperm that seemed normal — but there were far fewer than would be expected from a typical sire.

"The recipient is genetically modified and the sperm are not, but explain that to the regulatory agencies."

"It's obviously not enough sperm to do the job," says Alison van Eenennaam, an animal geneticist at the University of California, Davis, who attended the talk. "But it showed that you could generate sperm and that really is the proof of concept."

Next month, at the Transgenic Technology Meeting in Kobe, Japan, Oatley plans to present further data showing that he can achieve normal fertility in surrogate mouse sires, even when he transplants the sperm-producing stem cells from a genetically dissimilar strain of mice. The trick now, he says, will be to make the system work in livestock.

That could present a formidable challenge, says Ina Dobrinski, a reproductive biologist at the University of Calgary in Canada. Researchers have ways to expand the number of mouse and rat stem cells that give rise to sperm when grown in cultures. But the techniques have not worked well for larger animals, including people, Dobrinski says — despite fervent research aimed at finding ways to restore fertility for boys who have been treated for cancer.

Oatley acknowledges these challenges, but says that a small number of sperm-producing stem cells might be sufficient if they multiply enough after the transplantation. And Bhanu Telugu, a reproductive biologist at the University of Maryland in College Park, says that tweaking the procedure to create a surrogate pig sire — for example, by transplanting the cells when the surrogate is younger — could boost the number of sperm produced.

Oatley estimates that his technique is about five years from the farmyard. But it is unclear whether the approach will be embraced by the public and regulators. Oatley has twice travelled to present his work to the US Food and Drug Administration, and McGrew's team has discussed the matter with regulators in India. It is the offspring of a surrogate sire that would be sold as meat, and the offspring would not be gene edited, but some governments might still regulate them as though they were, McGrew cautions. That could mean a lengthy and expensive approval process.

"You and I know the recipient is genetically edited and the sperm are not, but explain that to the regulatory agencies or the consumers," says Dobrinski. "I'm not sure how a knockout animal would fly." ■

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