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A boost from biohackers

Do-it-yourself scientists in Germany can bring techniques out of the lab and help the country learn to love — and trust — biology.

In most parts of the world, including Berlin, you could — if you wished — do some simple molecular-biology tricks in your kitchen. You might, for instance, insert the gene for the green fluorescent protein into harmless *Escherichia coli*, and cause the bacteria to glow green. But do so in the German state of Bavaria, and you could go to prison.

Germany's attitudes towards biology can seem inconsistent, but they stem from a deep fear of repeating history. Many of the country's politicians see biology as a terrifying business. They sense the nervousness of their electorate towards anything that smacks of interfering with nature — the atrocious experiments done on people by the Nazis continue to resonate. Politicians are also exquisitely attuned to the more fundamental, evolutionary fear of unleashing uncontrollable disease.

These concerns present a dilemma because those politicians would also like biology — now a major, highly competitive international business — to contribute to the German economy, and overzealous regulations make the country a less attractive place for scientists to develop it. Strict monitoring and control over experimental biology is non-negotiable: mistakes could lead to catastrophic consequences for health or the environment, should pathogens or, say, invasive plant species accidentally escape from labs. But overextension of these regulations into areas of biology known to be safe is counterproductive.

Although European Union member states are obliged to comply with EU legislation on genetically modified (GM) organisms, they have some flexibility over how those rules are written into their national laws. In Germany, regulations for GM organisms are strict: it is the only country in which infringement can lead to imprisonment of up to three years. And Germany's federal system leads to another complication, because each of the country's 16 states hold responsibility for how the rules are implemented.

It's time the country took a rational look at the inconsistencies that have arisen, and began to do something about it. Help in getting the public to accept this process could come from an unlikely source: do-it-yourself (DIY) biologists, sometimes known as biohackers. Despite an unfair reputation in some quarters for being unpredictable and threatening, many DIY biologists merely want to follow their curiosity independent of the formal culture of institutions. Some are artists who want to express themselves in green fluorescent protein rather than paint, or otherwise engage intellectually with what they see as the most important scientific and societal revolution of our time. Indeed, in doing so, biohackers could help to inject a sense of proportionality into the German public consciousness, with their diverse public displays of safe — and marvellous — biology. And that would help biologists, including those who work on GM organisms, who need public support for their work.

An incident earlier this year exemplifies the role that biohackers can have, and the respect they deserve from authorities and mainstream scientists. Bavarian authorities discovered pathogenic bacteria, some antibiotic-resistant, in a CRISPR kit sent from a supplier in California. These kits allow DIY biologists to make small, targeted edits to the genomes of supplied microorganisms. The US company involved, Odin, is a main source for DIY biologists because it markets and sells biological reagents to individuals. The Bavarian authorities sent its analysis of the kit to the European Centre for Disease Prevention and Control (ECDC), which assessed the risk of infection for healthy users of the supplies and deemed it very low. The three pathogens involved are commonly found in the environment, including the human gut — and the ECDC declared the risk of increasing the burden of multi-drug resistance genes in the environment to be insignificant. Germany has now banned all imports from Odin, except to certified high-safety-level labs. Where the contamination came from is unclear. (Odin did not reply to *Nature*'s request for comment.)

"It's time the country took a rational look at the inconsistencies that have arisen."

DIY biologists were appalled to learn of it, not only because experiments could fail if kits don't contain what they are supposed to, but also because they want to remain working within the law. But they were also frustrated by the refusal of Bavarian authorities to let them see the data — a concern also shared by the European Molecular Biology Laboratory in Heidelberg, which agreed to analyse three other samples of microorganisms supplied by Odin and collected by the DIYers from different sources. Scientists at the laboratory cultured one of the bacterial colonies and fully sequenced its genome (the other samples failed to grow). The results, now online, confirm contamination (go.nature.com/2bkupnw). The effort also highlights the commitment of biohackers to open science and responsible procedures.

Such test cases could help Germany to develop a more rational approach to evaluating the promise and perils of biology — and so encourage a German public perception that biology does not always need to be locked up in a lab. ■

Weird weather

Scientists take the bold step of explicitly blaming humans for extreme events.

The weird weather just keeps on coming. An oppressive heatwave dubbed Lucifer stifled Europe in August, then a series of powerful Atlantic hurricanes hammered the Americas. Now, unseasonably hot and dry conditions are driving wildfires in California. During and after such events, the same question always arises: is global warming to blame?

Basic theory suggests that climate change will lead to more extreme weather, but making the link to individual events is difficult. There

was a time when the typical answer was something along the lines of, 'Perhaps, but it's hard to say.' The science has advanced over the past several years, and scientists have identified global warming's relative contribution to many extreme weather events. Now, for the first time, climate researchers are reporting that some weather events would have been outright impossible without the warming influence of humanity's greenhouse-gas emissions.

This kind of confident assertion rarely makes its way into the scientific literature. Yet it appeared in three studies included in a special annual edition of the *Bulletin of the American Meteorological Society* (*BAMS*) dedicated to attributing the causes of extreme weather events (see go.nature.com/2bgtz6n). If these results hold up, the implications would be profound and unsettling: humanity has already pushed the global climate into a new regime. To be clear, natural variability will always have a major role, but the blame for some of the most extreme weather phenomena — as well as some of the resulting impacts — would rest squarely on our own shoulders.

Released on 13 December, the research in question focused on 2016, the hottest year on record. One modelling study, led by scientists at the US National Oceanic and Atmospheric Administration, compared the temperature record to a simulated baseline climate without human greenhouse-gas emissions (T. R. Knutson *et al. Bull. Am. Meteorol. Soc.* **99,** S11–S15; 2018). In baseline simulations of some 24,000 years of weather from seven climate models, nothing like the record warmth of 2016 ever occurred. Greenhouse-gas emissions, chiefly those from fossil-fuel use, are a prerequisite for this kind of heat. What's more, the paper indicates that greenhouse gases began to push the climate outside the realm of natural variability around 1980.

These conclusions necessarily assume that today's climate models are sufficiently robust to capture the full range of natural variability. Others will certainly weigh in on the question, but the results suggest that we may need to reframe how we think about extreme events. The epic El Niño warming event in the eastern tropical Pacific Ocean in 2015–16, for example, might have pushed global temperatures to record levels, but only because it was amplified by more than a century of greenhouse-gas emissions. From this perspective, global warming might also be to blame for many of the impacts that we normally attribute to El Niño itself, which roils weather patterns across the globe.

Indeed, a second study in the special issue identified global warming as the culprit behind heatwaves that gripped much of southeast Asia in 2016 (Y. Imada *et al. Bull. Am. Meteorol. Soc.* **99,** S97–S101; 2018). In India, the heat killed at least 580 people from March to May. Thailand recorded its highest temperature ever — 44.6 °C — on 28 April, and energy consumption across the region hit record levels as people turned on air conditioners for relief. El Niño might have exacerbated the situation, says the study, but the temperatures "would never have happened without the anthropogenic warming".

"Climate change is a clear and present danger, not a distant threat."

Researchers came to the same conclusion in a third study, focused on marine warming in the Gulf of Alaska and the Bering Sea that began in 2014 and climaxed last year (J. E. Walsh *et al. Bull. Am. Meteorol. Soc.* **99,** S39–S43; 2018). El Niño might have been involved, but global warming set the stage, with far-reaching consequences. Ice on Alaskan rivers broke up earlier than ever; a lack of sea ice affected fishing; and toxic plankton blooms reduced shellfish harvests. Tens of thousands of seabirds were found dead, probably starved.

Extreme weather would be expected from time to time, regardless of global warming. In fact, of the 131 papers investigating extreme events that *BAMS* has published over the past 6 years, 35% found that global warming played no appreciable part. Nevertheless, the latest results suggest that the climate is entering uncharted territory, and that would mean that weather will increasingly fall outside the historical norm. From this perspective, humanity hasn't just loaded the dice. We have replaced them with a whole new type that behave in ways we don't fully understand.

The solution has been clear for more than two decades: governments need to take aggressive action to curb greenhouse-gas emissions. By attributing real-world impacts to global warming, scientists are providing citizens and political leaders with further evidence that climate change is a clear and present danger, not a distant threat to future generations. Perhaps in 2018, policymakers will finally realize which way the wind is blowing. ■

Follow the star

Mysterious traveller from afar highlights a seasonal message.

In October, a group of wise women and men spotted a mysterious light in the sky. There has been much excited chatter since about what it might mean. A space rock has come travelling. And as December draws to a close, the unusual visitor is heading away again, its brief message to Earth seemingly delivered. Our interstellar guest is from another star system entirely, one it was bundled out of perhaps even billions of years ago. Long-predicted, this is the first confirmed visit of an object from so far away. We are probably its first company in some time. And already it has seen enough.

A bright light shone around it. Long-term exposure to cosmic rays has created an insulating organic-rich layer on its surface (A. Fitzsimmons *et al. Nature Astron.* http://doi.org/chks; 2017). This coating — more pink than silver — could have protected an ice-rich interior from being vaporized during its passage close to the Sun. And it could help to explain some of the initial confusion over the visitor's true nature. Sky-watchers scanning for interstellar objects tend to be on the look-out for a comet. These are expected to produce a distinctive haze as their outer layers of ice sublimate, making them much easier to spot as they pass close to the Sun.

The absence of a tail saw the object reassigned instead as a rocky asteroid, which it could be. But its organic shield protects the unlikely possibility that it could be a comet after all — models suggest ice might be hidden underneath, undisturbed by the body's flirtation with the Sun.

It could come from a planet a long way from here. If it is not a comet, a paper posted to the arXiv server this month speculates, it might be a fragment of a distant planet ripped apart by a process of gravitational vandalism known as tidal disruption (M. Ćuk preprint at https://arxiv.org/abs/1712.01823; 2017).

Despite the best listening efforts of telescopes on Earth, the object has remained silent. And to the disappointment of alien-hunters across the planet, there is no sign of technology. (It was always a long shot, but the unusual cigar-shape boosted hopes that it was built and not formed.) Nonetheless, astronomers have called it 'Oumuamua, a Hawaiian term for scout. In *Nature* this week, its discoverers (who spotted it using the Pan-STARRS telescope on Hawaii's Maui island) say the object seems to be a "messenger sent from the distant past to reach out to us" (see page 378).

'Oumuamua might not be talking but it could still be listening. At this time of year, it's traditional for many radio stations across the United States to play the 1949 Hawaiian tune '*Mele Kalikimaka*', which offers a greeting of love, peace, joy and compassion. As 'Oumuamua speeds away there are worse impressions for it to take from Earth — even if, like most souvenirs, the significance is lost on many of the planet's locals. ■