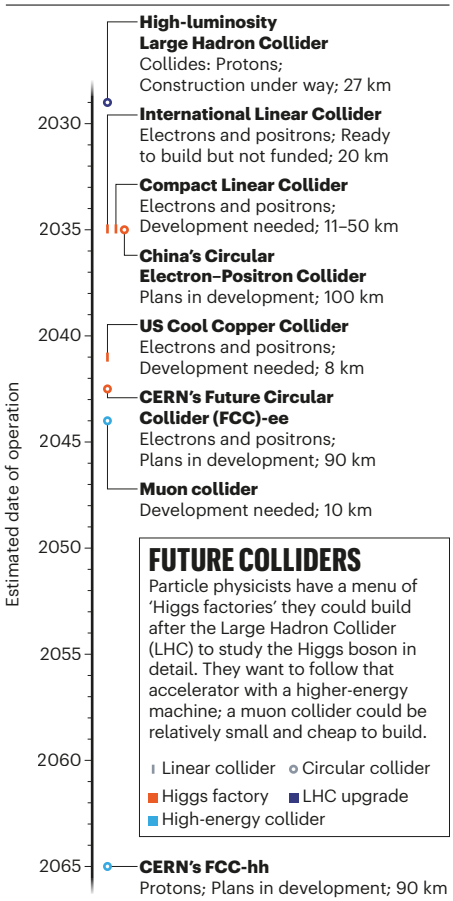
particles called neutrinos. Some argued for the go-ahead on CMB-S4, a next-generation survey of the cosmic microwave background.

A call that cut across disciplines was to ensure that a wide range of facilities exists to hunt for dark matter. The failure to find a theoretically predicted kind of dark matter known as weakly interacting massive particles (WIMPs) in the past ten years, either at the massive detectors designed to search for them or at the LHC, means that dark matter must be even more exotic than had been thought.

Physicists want to look for much lighter candidates for dark matter, and to reframe their search to take into consideration that it could exist as a whole family of particles, rather than just one, says Suchita Kulkarni, a dark-matter physicist at the University of Graz in Austria, who attended the Snowmass meeting. Finding it will take a few large and sensitive projects — such as those already looking for WIMPs — and many more small experimental ones, says Micah Buuck, a physicist at Stanford University.

The two-year Snowmass process, to which physicists from around the world submitted 521 papers, was "exhausting, but thrilling", says Cushman, who is a member of the steering group. Crunch time will come next year, when the US federal Particle Physics Prioritization Panel, known as P5, will use Snowmass's conclusions — and budget considerations — to make investment recommendations to federal funders.



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NUCLEAR WAR BETWEEN TWO NATIONS COULD SPARK GLOBAL FAMINE

A pall of smoke from burning cities would engulf Earth, causing worldwide crop failures, models show.

By Alexandra Witze

Even a small conflict in which two nations unleash nuclear weapons on each other could lead to worldwide famine, research suggests. Soot from burning cities would encircle the planet and cool it by reflecting sunlight back into space. This in turn would cause global crop failures that — in a worst-case scenario — could put five billion people on the brink of death.

"A large per cent of the people will be starving," says Lili Xia, a climate scientist at Rutgers University in New Brunswick, New Jersey, who led the work. "It's really bad."

The research, published on 15 August (L. Xia *et al. Nature Food* **3**, 586–596; 2022), is the latest in a decades-long thought experiment about the global consequences of nuclear war. It seems especially relevant now, given that Russia's war against Ukraine has disrupted global food supplies, underscoring the far-reaching impacts of a regional conflict.

Nuclear war comes with a range of lethal impacts, from killing people directly in atomic blasts to the lingering effects of radiation and other environmental pollution. Xia and her colleagues wanted to look at the consequences farther afield from the scene of war.

They modelled how climate would change in various parts of the world after a nuclear war, and how crops and fisheries would respond to those changes. The scientists analysed six war scenarios, each of which would put different amounts of soot into the atmosphere, and cut surface temperatures by anywhere between 1 °C and 16 °C. The effects could linger for a decade or more.

A nuclear war between India and Pakistan, perhaps triggered over the disputed Kashmir region, could send between 5 million and 47 million tonnes of soot into the atmosphere, depending on how many warheads were deployed and cities destroyed. A full-out nuclear war between the United States and Russia could produce 150 million tonnes of soot.

Using data from the Food and Agriculture Organization of the United Nations, Xia's team calculated how declining crop yields and fishery catches after a nuclear war would affect the number of calories available for people to eat. The scientists studied several options, such as whether people continued to raise livestock or whether they routed some or all crops meant for livestock to humans instead. The study assumed that people would cut back on or eliminate food waste. It also assumed that international trade would stop as countries chose to feed people within their own borders rather than exporting food.

Xia notes that the study relies on many assumptions and simplifications about how the complex global food system would respond to a nuclear war. But the numbers are stark. For even the smallest war scenario, of an India–Pakistan conflict that results in 5 million tonnes of soot, calorie production across the planet could drop by 7% in the first 5 years after the war. In the worst case of a United States–Russia war, calorie production would drop by 90% three to four years after the war.

'Let's move to Australia'

The nations most affected would be those at mid- to high latitudes, which already have a short season for growing crops and would cool more dramatically after a nuclear war than would tropical regions. The United Kingdom, for instance, would see sharper drops in the amount of food available than would a lower-latitude country such as India.

One nation that would be less affected is Australia. Isolated from trade in the wake of a nuclear war, Australia would rely mainly on wheat for food. And wheat would grow relatively well in the cooler climate induced by atmospheric soot. On a map in the study showing large portions of the world in red, indicating starvation, Australia gleams an untouched green, even in the severe-war scenarios. "The first time I showed my son the map, the first reaction he had is, 'Let's move to Australia,'" Xia says.

The study is a useful step towards understanding the global food impacts of a regional nuclear war, says Deepak Ray, a food-security researcher at the University of Minnesota in Saint Paul. But more work is needed to accurately simulate the complex mixture of crop production around the world, he says.

Understanding the potential consequences of nuclear war in detail could help nations to improve their risk assessments. "It is rare to happen — but if it happens, it affects everyone," Ray says. "These are dangerous things."