



French virologist Jean-Michel Claverie, top center, has spent over a decade studying viruses, including ones nearly 50,000 years old found deep within layers of Siberian permafrost. Photo illustration: 731. Photographer: Jeremy Suyker & Jean-Michel Claverie

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Zombie Viruses Are Waking Up After 50,000 Years as Planet Warms

A French virologist's discoveries are raising fears that thawing Siberian permafrost could bring ancient outbreaks back to life.

By [Liza Tetley](#) and [Bhuma Shrivastava](#) (9 octobre 2023 at 10:00 UTC+2)

A FORTNIGHT CAMPING ON THE MOSQUITO-RIDDEN, MUDDY BANKS OF THE Kolyma River in Russia may not sound like the most glamorous of work trips. But it's a sacrifice virologist Jean-Michel Claverie was willing to make to uncover the truth about zombie viruses — yet another risk that climate change poses to public health.

His discoveries shine a light on a grim reality of global warming as it thaws ground that had been frozen for millennia. Claverie, 73, has spent over a decade studying “giant” viruses, including ones nearly 50,000 years old found deep within layers of Siberian permafrost.

With the planet already 1.2C warmer than pre-industrial times, scientists are predicting the Arctic could be [ice-free in summers](#) by 2030s. Concerns that the hotter climate will release trapped greenhouse gases like methane into the atmosphere as the region's permafrost melts have been well-documented, but dormant pathogens are a lesser explored danger. Last year, Claverie's team published research showing they'd extracted multiple [ancient viruses](#) from the Siberian permafrost, all of which remained infectious.

“With climate change, we are used to thinking of dangers coming from the south,” Claverie said in an interview at his laboratory in the Luminy campus of Aix-Marseille University, France, referring to the spread of vector borne diseases from warmer tropical regions. “Now, we realize there might be some danger coming from the north as the permafrost thaws and frees microbes, bacteria and viruses.”



Virologists Jean-Michel Claverie and his wife Chantal Abergel at the Genomic and Structural Information laboratory at Aix-Marseille University in France, on Sept. 25. Photographer: Jeremy Suyker/Bloomberg

WAYS IN WHICH THIS COULD PRESENT A THREAT ARE STILL EMERGING. A heat wave in Siberia in the summer of 2016 activated anthrax spores, [leading](#) to dozens of infections, killing a child and thousands of reindeer. In July this year, a separate team of scientists [published](#) findings showing that even multicellular organisms could survive permafrost conditions in an inactive metabolic state, called cryptobiosis. They successfully [reanimated](#) a 46,000-year-old roundworm from the Siberian permafrost, just by re-hydrating it.

“It’s fundamental from the point of view that we can stop life and then restart it,” says Teymuraz Kurzchalia, a professor emeritus at the Max Planck Institute of Molecular Cell Biology and Genetics, who was involved in the study. “It means it’s innate to some living organisms to somehow diminish or suspend metabolic processes.”

For years, global health agencies and governments have been monitoring for unknown infectious diseases against which humans would neither have immunity nor drug therapies. The World Health Organization in 2017 added a generic “[Disease X](#)” to a shortlist of pathogens deemed a top priority for research and for which it aims to develop a roadmap to prevent or contain an epidemic. Since the Covid-19 pandemic shuttered the world for months, efforts have only intensified.



The “Admiral vessel” on the Kolyma River during a sampling trip to Siberia in 2019. Source: Jean-Michel Claverie

“WHO works with 300+ scientists to look at the evidence on all viral families and bacteria that can cause epidemics and pandemics, including those that may be released with the thawing of permafrost,” said WHO spokesperson Dr Margaret Harris.



North-East Science Station in Chersky (Siberia) in 2019. Source: Jean-Michel Claverie

Though largely unconnected, Claverie's own research occupies a similar frontier. Tucked away at the base of a rocky crag in the outskirts of Marseille, France, the shelves in his laboratory complex at first glance have the feel of a curiosity shop or the home of an eccentric collector.

Plastic bottles of soil samples and glass vials of nondescript brown liquids jostle for space, while Claverie's office sports a woolly rhino vertebra and the remnants of a mammoth tusk his team found on a 2019 expedition to Siberia. Expensive machinery and a biosafety room within the complex, meanwhile, indicate this is far from a frivolous pastime.



For years, global health agencies and governments have been monitoring for unknown infectious diseases against which humans would neither have immunity nor drug therapies. Photographer: Jeremy Suyker/Bloomberg

Like his workspace, Claverie's friendly disposition and ready smile are underlaid with an intimidating level and range of expertise. Coming from a background of theoretical particle physics, applied computer science, and biochemistry, he had no formal training in virology — something Claverie says conversely proved an advantage in his career, coming to the field free of preconceptions.

CLAVERIE WAS BORN AND RAISED IN PARIS BUT HIS CAREER HAS TAKEN HIM all over the world. His first foray into theoretical biology came in 1979 when he turned down a place in the laboratory of famed Massachusetts Institute of Technology biophysicist Alexander Rich, and instead chose to travel to San Diego to track down Francis Crick — the Nobel-prize winning biologist who discovered the molecular structure of DNA. Wandering the corridors of the Salk Institute of Biological Studies, he bumped into the biologist, who, struck by Claverie's enthusiasm and drive, gave him a job referral.

“We had lunch every Wednesday after that,” Claverie says.

It was perhaps this propensity to think outside the box that triggered his fascination with permafrost — [layers of earth](#) that have remained below freezing for at least two consecutive years. Some Siberian samples of permafrost [date](#) back as far as 650,000 years.

“He initiated the work on permafrost after reading that a flowering plant was revived from a piece of fruit that was frozen for 30,000 years,” says Chantal Abergel, Claverie’s wife and an experimental biologist who heads the laboratory’s operations. “He thought if something as complex as a flowering plant could be revived, then we could expect to revive viruses too from permafrost.”



A grid of different mutant viruses waiting for their properties to be determined. Photographer: Jeremy Suyker/Bloomberg

Claverie first [showed](#) “live” viruses could be extracted from the Siberian permafrost and successfully revived in 2014. For safety reasons his research focused only on viruses capable of infecting amoebas, which are far enough removed from the human species to avoid any risk of inadvertent contamination. But he felt the scale of the public health threat the findings indicated had been under-appreciated or mistakenly considered a rarity.



Claverie and Abergel work on an X-ray diffraction device used to determine the 3D structure of viral proteins. Photographer: Jeremy Suyker/Bloomberg

So, in 2019, his team proceeded to isolate 13 new viruses, including one frozen under a lake more than 48,500 years ago, from seven different ancient Siberian permafrost samples — evidence to their ubiquity. Publishing the findings in a 2022 [study](#), he emphasized that a viral infection from an unknown, ancient pathogen in humans, animals or plants could have potentially “disastrous” effects.

“50,000 years back in time takes us to when Neanderthal disappeared from the region,” he says. “If Neanderthals died of an unknown viral disease and this virus resurfaces, it could be a danger to us.”



*A piece of mammoth tusk collected from the Duvanny Yar sampling site in 2019..
Photographer: Jeremy
Suyker/Bloomberg*

Permafrost, soil that was once teeming with animal life, provides the perfect conditions for preserving organic matter: it’s natural, dark, devoid of oxygen and allows for very little chemical activity. In Siberia, it can reach up to a kilometer deep — the only place in the world where permafrost goes down that far — and covers around two thirds of Russian territory. Just one gram was found to harbor thousands of dormant microbe species, according to a [paper](#) published in Nature journal in 2021.

For 400,000 years, underlying permafrost layers have been largely [stable](#). So much so, Russian towns have sprouted-up across Siberia, drilling their foundations deep into the concrete-like frozen soil. But now, with the Arctic warming faster than any other area on earth, vast methane craters have opened up across the region and entire towns are subsiding.

MORE RECENTLY, GEOPOLITICS HAVE CREATED NEW BLIND SPOTS. Organizing trips to Siberia and collaborating with Russian labs was not easy even before Russia invaded Ukraine in February 2022. But communications with former colleagues and collaborators in the country have now practically ground to a halt. Claverie’s laboratory, along with many others across the Western world, are government funded. “We’ve been told not to talk with Russians anymore,” he says.



Various culture media used to grow the amoeba cells in which viruses replicate and multiply. Photographer: Jeremy Suyker/Bloomberg

The effects of global warming on Siberia pose both risks and rewards for the Russian economy. Thawing permafrost is [estimated](#) to be putting around \$250 billion worth of infrastructure at risk and is already thought to have contributed to environmental disasters like the [Norilsk oil spill in 2020](#), as the ground becomes unstable.

Yet the region also boasts a wealth of natural resources — coal, natural gas, gold, diamond and iron ore. Unlike in other permafrost-covered regions like Alaska and Greenland, Claverie says Russia has been more active in mining these soils: “They are digging holes everywhere.”

Some scientists also fear that technology — such as Russia’s floating nuclear power plant, the Akademik Lomonosov — could transform previously unreachable areas along Siberia’s coastline into mining hubs as ice-free routes through the Arctic circle increase accessibility. Mining these deeper depths, beyond the active layer that thaws every summer, would increase the possibility for human interaction with a potentially harmful ancient pathogen, Claverie says.

THAT UNDERSCORES THE DILEMMA INTRINSIC TO RESEARCH TOO — that hunting down the next big threat to humanity could inadvertently propagate the danger. Potential for cross contamination during sampling expeditions is high. As such, some are beginning to advocate less proactive, resource-hungry, approaches instead.

“It would be good to establish a specialized way of following the Inuit population, for example, to see what kind of diseases they get,” Claverie says. “And if there is something coming from the permafrost, we’ll be able to catch it much more rapidly.”



Shelves with the typical equipment used for molecular biology techniques. Claverie's findings in a 2022 study emphasized that a viral infection from an unknown, ancient pathogen in humans, animals or plants could have potentially "disastrous" effects. Photographer: Jeremy Suyker/Bloomberg

Larger organizations are also waking-up to this risk. Earlier this month, the United States Agency for International Development [dropped](#) its \$125 million project to hunt down viruses in Southeast Asia, Africa and Latin America that could potentially infect humans, amid concerns the research itself could spark a pandemic.

Meanwhile, Claverie won't be returning to Siberia, irrespective of the outcome of the war. He says he has made his point that the danger exists, and expeditions to uncover more secrets buried in those frozen depths would be folly.

"The older you get, the better you become at philosophy," he says. "Perhaps it's better to just leave those things alone. "