

Alpine bacteria show unexpected ability to fight viruses

30.9.2026 - | École polytechnique fédérale de Lausanne EPFL

EPFL researchers found that bacterial communities in Alpine lakes, which are resistant to viruses that infect them, can reduce the infectivity of other viruses in the lab. These findings suggest potential biotechnological applications in various fields, including agriculture.

A silent, long-running competition has been taking place in the Swiss alpine lakes for millions of years, killing trillions of organisms every single day while no one can even notice. This competition is held between bacteria and viruses and pushes both microorganisms to engage in a relentless evolutionary battle.

In a recent study published in *Environmental Science and Technology*, Anna Carratalà, scientist at the EPFL Laboratory for Environmental Virology, and her team have observed in the lab that alpine bacteria are able to resist attacks from a variety of viruses belonging to the family of bacteriophages (or phages), which are viruses that infect bacteria and take them as hosts to reproduce before destroying them. More surprisingly, the researchers also observed that some of these alpine bacteria were able to reduce the capacity to infect of very different viruses that are not naturally present in alpine lakes, suggesting broader antiviral properties.

Bacteria adaptation to harsh conditions

Alpine lakes are subject to extreme conditions: low nutrient concentration, low temperatures, ice cover in wintertime, and high UV radiation in summer. In these severe environments where few animals and plants can survive, microbial life is dominated by bacteria and viruses, which form large communities and play key roles in the ecosystems.

The researchers wanted to determine whether the bacterial communities that are least susceptible to phage infections in alpine lakes could also fight viruses that are not naturally found in these environments. To this end, Carratalà and her team took water samples from 24 alpine lakes in Valais. They took these samples to the laboratory and obtained 200 different bacterial strains, that they used to create experimental microbial communities. They then exposed them to three types of viruses: Echovirus 11, Influenza A (responsible for the flu), and Potato virus X. These are viruses that are very distinct from those found in the alpine lakes and serve as models to test the antiviral properties of bacteria.

“Earlier studies revealed that bacteria can “remember” past viral infections through information stored in their DNA, helping them defend themselves against future attacks,” says the researcher. When exposed to an alpine mixture of bacteriophages, bacteria showed diverse degrees of susceptibility to the viral infections. The production of enzymes may also help neutralize the virality of bacteriophages. However, the exact molecular mechanisms that underpin the antiviral properties of the bacteria isolated from the Swiss Alps are still unknown.

Applications in agriculture

Applications in human health might still sit far in the future, but Carratalà and her team already observed promising results to fight plant viruses infecting crops. For instance, these findings open

up the avenue for using alpine bacteria to fight viruses in hydroponic cultures, which are crops that grow without soil using a mineral nutrient solution in water, like the tomatoes industrially produced in greenhouses. In this environment, viruses can easily move between plants, thus spreading the infection.

Tests with plants carried out at Agroscope. 2026 EPFL/Anna Carratalà CC-BY-SA 4.0

In collaboration with Olivier Schumpp, a researcher at Agroscope, they demonstrated that plants infected with a harmful virus lost their vulnerability after being exposed to bacteriophage-resistant bacteria. However, Carratalà remains prudent: "This is a promising application that goes beyond the laboratory, but it is still an intermediate step before a real application in a hydroponic environment."

Protecting microorganism biodiversity

In collaboration with the Summit Foundation and with their support, scientists will continue their research to comprehend the role of microorganism biodiversity in alpine environments. "This understanding is particularly important at a time when humans are driving rapid environmental changes," says Carratalà.

The researchers also aim to identify the precise molecular mechanisms that allow alpine lake bacteria to reduce the ability of viruses to cause infections. "In the longer term, this knowledge could open new avenues for developing innovative, biologically inspired approaches to water treatment and improving water safety," says Tamar Kohn, EPFL professor and leader of the Laboratory of environmental virology.

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