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Diseases Hidden in Ice: Ancient Bacteria in Permafrost Could Spread Ancient Diseases

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Ancient Bacteria in Permafrost Could Spread Ancient Diseases

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As global warming advances, permafrost soils that are well over hundreds of thousands of years old are melting. As the soils thaw, ancient dormant bacteria and viruses are being revived. Permafrost is frozen ground; specifically, it has been frozen for at least two consecutive years. It combines rock, soil, sediment, ice, and organic material, commonly found in regions with high altitudes and latitudes.

As Earth's climate warms, so does the permafrost, thawing the ice inside. This melting releases carbon dioxide and methane, which causes temperatures to increase even faster and melt more permafrost. This thawing can lead to dramatic impacts on the planet and living organisms. Numerous villages in polar and high-altitude areas face structural damage to their houses and roads because they are on top of thawing permafrost. Another negative impact occurs when microbes start decomposing organic material in the permafrost, which releases greenhouse gasses into the atmosphere. Furthermore, as the ice thaws, ancient bacteria and viruses begin to surface and spring back to life after being preserved cryogenically for thousands of years. Increased drilling and mining in permafrost regions may bring humans into contact with these ancient microorganisms.

A study that collected ice cores from the Guliya ice cap on the Tibetan Plateau in 1992 and 2015 discovered that the exteriors of these ice cores were contaminated while the insides were still in pristine condition. Once scientists sterilized the surface of the ice cores, they reached a layer uncontaminated by modern microbes. The deep layer revealed 33 distinct groups of virus genera, 28 of which were never previously studied.

In 2014, French researchers Chantal Abergel and Jean-Michel Claverie of Aix-Marseille University discovered two giant viruses, Pithovirus sibericum, and Mollivirus sibericum, along with two others in 30,000-year-old Siberian ice cores. These viruses are classified as giant because they can be viewed under a light microscope, whereas most require an electron microscope. A giant virus also contains significantly more genes than an average virus. Abergel and Claverie's viruses were almost 50 percent bigger than anything identified before. Upon testing the viruses, Abergel and Claverie found them capable of causing infection. Claverie believes that, despite being frozen for over 30,000 years, "a few viral particles that are still infectious may be enough, in the presence of a vulnerable host, to revive potentially pathogenic viruses."

Viruses have various potential life cycles and interactions with their physical environment that determine their influence on bacteria. The life cycle of a virus can be broadly summarized in five steps: attachment, penetration, replication and gene expression, maturation, and lysis. The first step is attachment; during this stage, the virus, or "phage," will attach itself to the receptor on the host cell membrane. Receptors help the virus to recognize the host cell. In the second step, penetration, the phage or its genetic material will enter the cell either by injecting its genetic material, merging with its membrane, or through endocytosis. The next step is genome replication and gene expression; the viral genome is transcribed and translated into viral protein, with materials and processes supplied by the host cell. The viral proteins help manipulate the host's genome and encourage phage genome replication. Next, the newly made proteins will synthesize during maturation to create new viral particles. The last step is lysis. In this stage, the newly constructed viruses may exit the host cell. This cycle still functions after the virus is frozen, allowing it to infect a host after it thaws. In the hope of reviving Mollivirus sibericum from dormancy, Claverie searched for a host organism that M. sibericum could infect and grow inside and found success with a single-cell amoeba. Viruses are not alone under the surface; ice can also trap bacteria, algae, archaea, and fungi in ice.

> Anthrax spores from the carcass would have spread across the area through the nearby reindeer.

"Not long ago, frozen environments which cover a significant portion of the earth were considered devoid of life deserts," said Vanya Miteva, a Penn State professor. However, recent studies prove otherwise, revealing numerous microorganisms in the ice. Dust particles, snow, and animal activities froze the microorganisms in the ice. As snow falls, it traps air, water, and microbes. The layers of snow get compacted and form solid ice that traps those materials in place. The survival of microorganisms in ice is mainly due to their ability to persist in a dormant or slow-motion metabolic state. However, dormancy for long periods usually leads to the risk of significant DNA damage to the point that it will not have any functional DNA to replicate again. A study by Markus Dieser, John Battista, and Brent Christner provides direct evidence of enzymes that repair DNA lesions, extending the range of complex biochemical reactions that occur in bacteria at frozen temperatures. Provided that sufficient energy and nutrient sources are available, a functional DNA repair mechanism would allow cells to maintain genome integrity and augment microbial survival in icy terrestrial or extraterrestrial environments. These energy sources could be tiny cracks in the ice containing water or an animal carcass providing nutrients.

As the ice melts, bacteria and viruses can escape in various ways. The ice can be considered a natural bank of various dormant propagules such as seeds, eggs, cysts, and spores from plants and invertebrates. Another viable way that frozen bacteria or viruses spread is when the bodies of infected animals or humans are preserved in the ice and do not decompose. When the ice thaws, the bacteria or viruses can replicate and infect other hosts, including humans.

In December 2016, a remote community in Salekhard, Siberia, experienced an unusual outbreak that resulted in the hospitalization of 90 people and the death of a young boy. Russian officials discovered that the highly infectious agent, anthrax, had killed him. After scientists began looking underground, they believed the outbreak originated from the carcass of an infected reindeer who had died over 70 years ago. Anthrax spores from the carcass would have spread across the area through the nearby reindeer.

Scientists worry that as the permafrost melts, various pathogens could revive diseases once considered eradicated. • • •