Microbial Showers…

The Rain-Making Bacteria

Jay Hardy, CLS, SM (ASCP)

Jay Hardy is the founder and CEO of Hardy Diagnostics. He began his career in microbiology as a Medical Technologist in Santa Barbara, California.

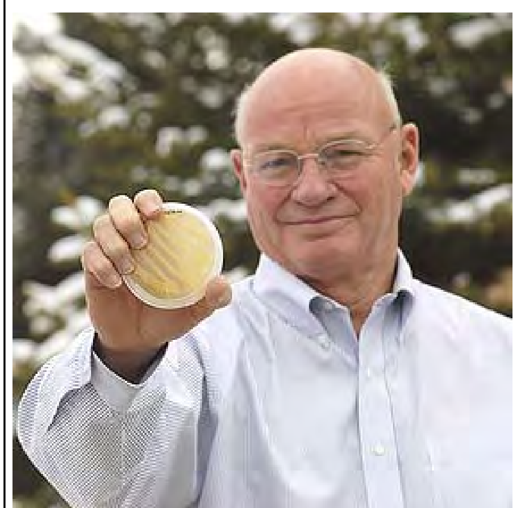
In 1980, he began manufacturing culture media for the local hospitals. Today, Hardy Diagnostics is the third largest media manufacturer in the U.S.

To ensure rapid and reliable turn around time, Hardy Diagnostics maintains six distribution centers, and produces over 2,700 products used in clinical and industrial microbiology laboratories throughout the world.

During a cloudburst we often say that it's raining "cats and dogs". In reality, it's actually raining bacteria; a natural phenomenon that presents no cause for alarm. The sky, once thought of as a sterile void, is actually teeming with bacteria, which are vital for watering the plants below.

Biological precipitation, or the "**bio-precipitation**" cycle as it is called, starts when bacteria form colonies on the surface of plants. Winds will then sweep the bacteria into the atmosphere, and ice crystals form around them. Water molecules clump onto the crystals, making them bigger and bigger. The ice crystals turn into rain or snow and fall to the ground. When precipitation occurs, the bacteria have the opportunity to make it back down to the ground. If even one bacterium lands on a plant, it can multiply and form colonies, thus causing the cycle to repeat itself over and over.

Nuclei are the seeds around which ice is formed. Snow and most rain begin with the formation of ice in clouds. Dust and soot can also serve as ice nuclei. But biological ice nuclei are different from dust and soot nuclei because only these biological nuclei can cause freezing at warmer temperatures.



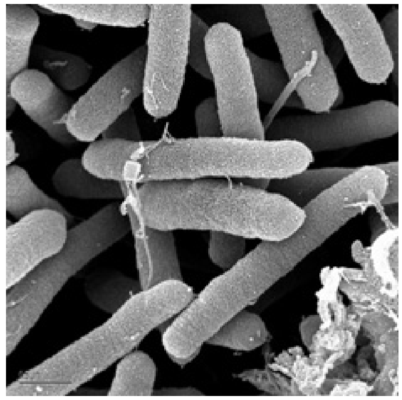
David Sands of Montana State University has been studying bio-precipitation for 25 years.

Recent discoveries show that “rain-making bacteria” are more efficient at forming these nuclei than inert particles, due to their larger size and surface area.

Minerals can only orient a few water molecules but bacterial proteins are big and can orient many simultaneously. Ski resorts exploit this property by using attenuated bacteria for the seeding of artificial snow. The older method of seeding clouds with silver iodide has been in use for over 60 years.

Most research to date involves the ability of *Pseudomonas syringae* to serve as the nuclei in the promotion of ice crystals. “Ice-minus bacteria” is a nickname given to a variant of this microorganism. This strain of *P. syringae* lacks the ability to produce a certain surface protein, usually found on wild-type "ice-plus" *P. syringae*. The "ice-plus" protein (Ina protein, "Ice nucleation-active" protein) found on the outer bacterial cell wall acts as the nucleating centers for ice crystals. This facilitates ice formation, hence the designation "ice-plus." The ice-minus variant of *P. syringae* is a mutant, lacking the gene responsible for ice-nucleating surface protein production.

> *“…microbes can metabolize and grow in clouds, meaning that the atmosphere may represent an environment for life”*



Electron micrograph of *Pseudomonas syringae,* which produces a surface protein that serves as nuclei around which ice crystals form at warmer temperatures than usual.

This lack of surface protein provides a less favorable environment for ice formation. Both strains of *P. syringae* occur naturally, but recombinant DNA technology has allowed for the synthetic removal or alteration of specific genes, enabling the creation of the ice-minus strain.

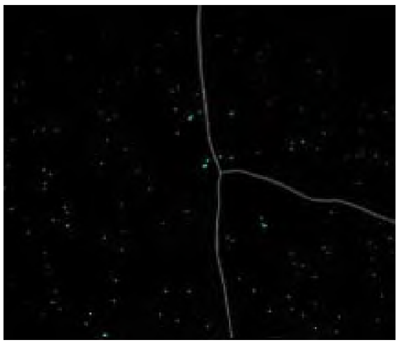
The introduction of an ice-minus strain of *P. syringae* to the surface of plants causes competition between the strains. Should the ice-minus strain win out, the ice nucleate provided by the wild type *P. syringae* would no longer be present, thus lowering the level of frost development on plant surfaces at normal water freezing temperature (0^{o}C)

Everyone knows that water freezes at 0^{o} C; however few know that ultra pure water (without nuclei forming particles) freezes at -40^{o}C. The ice-forming bacteria increase the temperature at which ice crystals form, thus wreaking havoc for farmers when tender leaves are destroyed by a coating of ice.

In the United States alone, it has been estimated that frost accounts for approximately $1 billion in crop damage each year. As *P. syringae* commonly inhabits plant surfaces, its ice nucleating nature incites frost development at warmer

temperatures than 0^o C, freezing the buds of the plant and destroying the crop.

Pseudomonas syringae is not the only ice nucleator, but is the most common, and all varieties share a common cell wall protein structure that serves as a scaffold for free-floating water molecules.



The green dots *are P. syringae* bacteria that are suspended in ice. The bacteria provide a surface for water vapor to join and form ice crystals, which later fall to earth as snow or rain.

The discovery of bio-precipitation has many far reaching implications. For example, a reduced amount of bacteria on crops could affect the climate. Because of the bio-precipitation cycle, overgrazing in a dry year could actually decrease rainfall, which could then make the next year even dryer.

Rain-making bacteria have been found around the globe, even in Antarctica. "Previous work has shown that" said Brent Christner, a researcher from Louisiana State University. "It is possible that cloud-borne microbes could 'turn on' their ice nuclear proteins in the atmosphere and subsequently be returned to the ground in snow or rain. This is a very exciting possibility that further research could unearth."

This discovery reminds us once again of the importance of microbes in our environment, even in the sky above us.

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