Microbes, by latitudes and altitudes, shed new light on life's diversity

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Jessica Green, right, works with Lise Ovreas, a scientist with the University of Bergen (Norway) Center for Geobiology, to obtain microbes at Svalbard, an island in a Norway-controlled archipelago about 300 miles south of the North Pole. Photo by Steve Coulson

Microbial biologists, including the University of Oregon's Jessica L. Green, may not have Jimmy Buffett's music from 1977 in mind, but they are changing attitudes about evolutionary diversity on Earth, from oceanic latitudes to mountainous altitudes.

In two recent National Science Foundation-funded papers in the *Proceedings of the National Academy of Sciences*, Green and colleagues show that temperature, not productivity, primarily drives the richness of bacterial diversity in the oceans, and that life, both plant and microbial, by altitude in the Rocky Mountains may be close, but not exactly, to what biologists have theorized for years.

Swedish naturalist and botanist Carl Linnaeus, the father of taxonomy who died in 1778, proposed that the planet once was covered by oceans, except for Paradise Island on the equator, and that all organisms emerged from the island and migrated as waters receded. More than a century later, microbiologist Lourens G.M. Bass Becking in the 1930s wrote that "everything is everywhere, but the environment selects."

"What's interesting to me," said Green, a professor of biology and member of the UO Center for Ecology and Evolutionary Biology, "is that the founders of these disciplines envisioned the same thing: That you have this broad dispersal of all of the organisms that each happened to be studying, and that they would colonize the surface of the Earth depending on whether the environment was suitable for them."

In the last decade, microbial biology, using molecular techniques, has changed everything, Green said in an interview about the two PNAS papers and an extensive review of microbial biogeography in the May 23 issue of the journal Science. She was lead author on the Science paper.

"Before now, all biologists could do was look at the biodiversity of microbes that could be cultured in a petri dish. We now know that the vast majority of microbial life cannot be kept in captivity. Now we have the ability to grab DNA from the environment and try to characterize different species or taxonomic groups using genetic material, allowing our field to blast off."

Yet, she added: "We are just beginning to scratch the surface of what these patterns look like."

Green was among several co-authors on a project led by biologist Jed A. Fuhrman of the University of Southern California and published in PNAS in May.

Using samples of ocean-dwelling bacteria collected over 15 years from 57 locations around the world and sorting them into species or taxonomic units, researchers found twice as many microbes at the equator than at the poles. In particular, they found that samples from colder waters still contained many bacterial species, suggesting that productivity as generated by light through photosynthesis has little influence on diversity.

Warmth dictated such diversity, the seven co-authors concluded, but they left open the possibility that the kinetics of metabolism related to temperature is still linked with photosynthesis. "What we found," Green said, "was that the diversity gradient more correlated with temperature than primary productivity."

As for the mountains, traditional wisdom, beginning with Linnaeus, has said that diversity of animal and plant life is highest at the bottom and decreases as you climb. While that scenario has been observed, a second one is emerging, that of a hump shape, with diversity at its height just above the foothills.

In a paper published Aug. 12 in a PNAS special publication (the "Sackler Colloquium: In the Light of Evolution--Biodiversity and Extinction") , Green, as principal investigator, and five colleagues documented diversity patterns of a combination of plant and microbial life, focusing on flowering plants and soil-abundant Acidobacteria, in the Rocky Mountains in Colorado. They found significant differences, using a combination of classical taxonomic and phylogenetic approaches.

Plant communities became less phylogenetically clustered than did microbial life as they drew samples from five sites rising over 24 miles, from 8,071 feet to 11,089 feet. As they went higher, plant life saw a decline in species richness, but for microbes, researchers saw a hump shape in species richness as they went up the slopes.

Their conclusion: "From our study, we saw that environmental selection seemed to play a larger role and was more important for microbes than the plants," Green said.

The trick to the research, she said, involved the scale from which the samples were drawn. Plants were gathered from one-meter-square quadrants, while microbes were taken from soil cores. "You have to be careful about the conclusions that you make," Green said. "So on a 2,000-meter elevation gradient, for example, the spatial scale relative to the body size of a plant is much, much larger when you consider what the universe looks like to a microbe."

That spatial consideration, she said, led her team to narrowly focus on the diversity of Acidobacteria rather than a wide range of microbes present in each area. This allowed the researchers to focus on patterns within one microbial phylum.

"Diversity patterns on mountainsides have been studied mostly on plants and animals for hundreds of years," Green said. "Yet microbes are the most diverse set of organisms on Earth, and they are really important for how ecosystems work. Our study establishes the first elevation-gradient pattern for microbes. We found that, yes, microbes do have a diversity pattern that is similar to what has been studied for plants and animals, but the pattern is different than what you see for plants in the Rockies, and there is much to be done to understand why microbes might have a different biodiversity pattern."

It could boil down to finding a good comparative technique, she said. "I don't think that microbes are fundamentally different from a biological standpoint from plants and animals. I think that we haven't figured out how to study them in an analogous way."

Source: University of Oregon