Tropospheric Microbes Are Suprisingly Diverse Yet Stable

Noah Fierer audio interview

Airborne microbial diversity is much greater than expected, albeit spare compared to that in the ocean and in the soil, according graduate student Robert M. Bowers, his advisor Noah Fierer, and their collaborators at the University of Colorado, Boulder, and elsewhere, who collected their data at Storm Peak lab in northwestern Colorado at an elevation of 3,200 meters. Moreover, the species of bacteria that they observe in the troposphere remain relatively stable over time, despite changing conditions. Further, ice nucleation-a precursor to precipitation-does not correlate with the local abundance of known ice-nucleating microbes. Details appear in the August *Applied and Environmental Microbiology* (**75:**5121- 5130).

Roughly 100 species of bacteria and equivalent numbers of fungal species were found in each of nine air samples from Storm Peak-far fewer than in urban or rural air samples, and fewer than in one sample of snow from there, which contained 800 species, Bowers says. Airborne microbial population density values range from 9.6×10^5 to 6.6×10^6 cells per m^3, with roughly equivalent numbers of bacteria and fungi. "These airborne microbes are likely to play some role in cloud formation, and can therefore be said to play a role in the global radiation budget," he says.

"Gram-negative proteobacteria were the most commonly detected bacteria," says Eoin Brodie of the Lawrence Berkeley Laboratory, who was not involved in the research. This dominance contrasts with previous findings, he points out. For example, in urban aerosols, spore-forming grampositive bacteria such as the bacilli and actinomycetes tend to be dominant. He notes that because so few species in the air samples could be grown in culture, they were identified by rapid "pyrosequencing" of ribosomal genes.

"On average, about 40% of the organic carbon in the atmosphere is probably intact cells," Fierer says. The stability of microbial populations within the troposphere, despite both changes in climate conditions and the source of the air, suggests that the atmosphere "is a tough place to live." It takes a tough but stolid set of microbes to contend with high-intensity UV radiation, lack of food, and low moisture in that setting. Further, he asks, "What are these things doing up there? Do they have any influence on atmospheric conditions? There is recent data, and anecdotal evidence from Bob [Bowers] and others showing that some of the best nucleators are bacteria and fungal cells, so what percentage of nucleation is driven by cells?"

"Data such as these will help to constrain the biological contribution to atmospheric ice-nuclei populations so that numerical models can estimate the role of organisms in cloud processes," says Paul DeMott of Colorado State University, Fort Collins. "It is intriguing because these particles represent a highly dynamic source. Climate may impact their abundance, and their abundance may impact climate by impacting cloud and precipitation processes." He speculates that they might seed clouds via green plants.

"Proteobacteria have previously been implicated in ice nucleation," Brodie says.

However, the study findings do not support the idea of a relationship between abundance of icenucleating bacteria and numbers of ice nuclei. This discrepancy with earlier findings suggests to him that "either other, as yet unknown, bacteria are involved or that fungal spores or abiotic mechanisms of ice nucleation dominate the process at this site."

David Holzman