Hey, bacteria are individuals too

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Each person carries 10 times as many bacterial cells as human cells, the former of which have continued to evolve in response to medicine's most potent antibiotics. But microscopic bugs don't just dictate human health—they're also integral to the health of every body of water on the planet. According to Ferdi Hellweger, an associate professor of civil and environmental engineering at Northeastern, microbial pollution represents one of the most significant problems for our lakes, rivers, and estuaries.

Nevertheless, he said, our tools for studying microbes have been, until recently, rather archaic. "The traditional approach has been to take all the cells, grind them up, and then send them through a machine in the chemistry lab," he explained. "It seems absurd now."

Traditionally, microbial ecologists thought all bacterial cells were the same. "Once you know how one behaves, you know how they all behave," said Hellweger, who hosted a workshop on the changing face of microbial modeling in 2011.

This perspective begot a modeling approach for bacterial behavior that relied on strategies from the physical sciences: "We modeled them as if they're molecules, using chemical equations," Hellweger explained.

But recent advances in observational technologies have shown that populations of individual bacteria are as diverse as the human population or any other species. "We're starting to see all this exciting individuality from one cell to its neighbor," said Hellweger. "We're inundated with a flood of novel observations but our traditional analysis tools can't handle them."

In an opinion paper recently published in the journal *Proceedings of the National Academy of Sciences*, Hellweger and his colleagues from the workshop put forth an emerging strategy for dealing with this new microbial data: modeling individual bacteria.

The approach also allows for a better examination of the properties that emerge when those individual agents act as a collective population, Hellweger explained. Biofilms, for example, are colonies of bacterial cells that work together almost as a single organism. But the cells that are buried deep within the biofilm are genetically distinct and behave quite differently from the cells on the surface, which have a much greater supply of available oxygen and nutrients. To understand the biofilm, Hellweger explained, we need to first understand its individual cells.

Despite the fact that our bodies are teeming with bacterial cells, our understanding of the microbiome—that collection of cells that live in and on us—is quite limited. We know it's important, Hellweger said, but we don't know how it works. Likewise, we realize that our water supply is exceedingly reliant on a perfect balance of microorganisms, but we aren't yet sure what that balance looks like in great detail.

To answer questions such as these, Hellweger said, researchers need to develop a keen understanding of the bacterial community. Until science can accommodate the individuality of the cells that make up that community, the effort is unlikely to get very far.

More information: www.pnas.org/content/110/45/18027.full

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