BOOKS *et al.*

PHILOSOPHY OF SCIENCE

The meaning of microbes

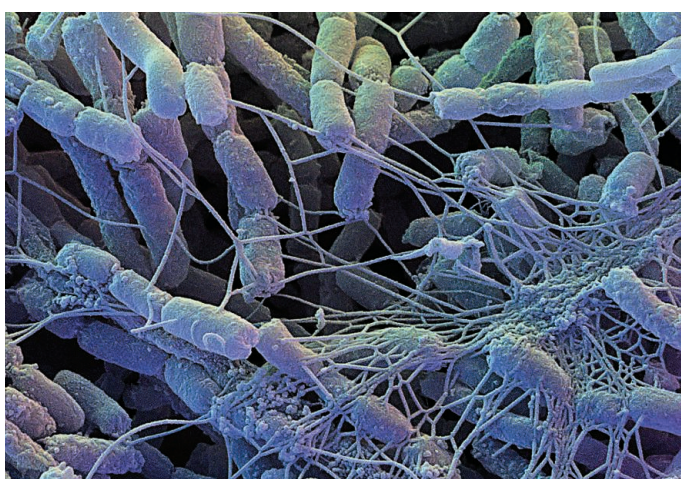
Microorganisms may offer unique insights into the nature and evolution of life

By **Adrian Woolfson**

The American philosopher of popular culture known to the music world as "Madonna" once concluded that "we are living in a material world." In *Philosophy of Microbiology*, Maureen A. O'Malley, a philosopher of biology, authoritatively sets the issue straight, arguing that we are in fact living in a microbial world and that a realization of this will change the way we perceive biological phenomena and the manner in which they are investigated.

To date, the study of microbes has not specifically been identified as having the potential to make unique contributions to the philosophy of biology, but significant advances in this field in recent years may make this a timely moment to consider it as a discrete instrument for empiric philosophical explorations. Laying the ground for her analysis, O'Malley makes a case for the special significance of microbes by describing four of their unique features: their biomass and diversity, ability to impact planetary processes, influence on the major evolutionary transitions, and tendency to coexist in mutually beneficial relationships with other organisms. But while of undeniable importance, will this expanded knowledge of microbes affect the central issues of the philosophy of biology?

From the perspective of prevalence, O'Malley informs us that human life on Earth is an irrelevant detail, thereby debunking another myth of popular culture: that size matters. A mere teaspoon of soil, we learn, contains more microbes than there are humans inhabiting the entire subcontinent of Africa. Microbes account for more than 90% of the biomass of oceans, and upwards of 80 million of them migrate between participants during an intimate kiss. These tenacious critters may be found floating in the stratosphere 50 kilometers above Earth's surface and as uninvited passengers in the capsules we discharge into space. They linger in the depths of oceans, thrive in hot springs, flourish in brine, and vacation at the frozen poles. They live inside us, forming a microbiome, and their mitochondrial endosymbiont remnants power our cells. If there is life on other planets, O'Malley argues, it is likely to be microbial. They unhinge human civilizations through sickness and plagues and generate spores that may lie dormant for millions of years. They facilitated some of the major evolutionary events by oxidizing Earth's atmosphere 2.4 billion years ago and helped form the cellular soup that gave rise to the metazoan body plan. Their protean metabolisms ferment wine, assist with breadmaking, and fix the nitrogen needed to synthesize RNA, DNA, and proteins. Their ubiquitous nature and numerical dominance argue for the importance of their contribution in any overarching philosophical analysis of biological systems.



Known for giving soil its "earthy" odor, *Streptomyces* (shown here) also produce clinically useful antibiotics.

O'Malley begins by outlining some of the core microbiological topics that may inform philosophical debates. These include the role of microbes in photosynthesis, their effects on the major transitions of evolution, and the existence of magnetotactic bacteria that align with Earth's geomagnetic field. The latter have provided philosophy-of-mind debates with a rudimentary example of organismal representation and intentionality.

Microbial classification systems have influenced those of multicellular organisms, and the extensive cooperation between microbes has provided a unique perspective on the "units of selection" debate. Other features, including their generalized capacity for hypermutability and the phenomenon of endosymbiosis, provide some support for O'Malley's assertion that microbes may not always be readily accommodated by the modern evolutionary synthesis.

In her strongest and most ambitious moments, O'Malley imaginatively argues that the lateral exchange of genetic material between bacteria implies a communal mode of genetic ownership, suggesting that the historical focus on single organisms has overlooked an ecological, coevolutionary perspective.

The use of microbes to study evolution experimentally has allowed some of the key philosophical conundrums resulting from the incomplete fossil record to be played out on compressed time scales. These artificial replays of the tape of life are the most concrete example of how the study of microbes may affect philosophical issues, as they have shown that rather than being open-ended, the products of evolution are in some instances highly constrained.

It was the informational simplicity of microbes that accelerated the science of genomics, facilitated the sequencing of the first genome, and opened the door for the synthesis of the first artificial one. It is this aspect of microbes that is perhaps the most philosophically compelling, but one to which the book gives scant attention.

In the end, however, O'Malley succeeds in convincing us that the microbial world is a tractable treasure trove of unexplored philosophical potential that may serve as a heuristic for the macroworld we inhabit. Microbes are not the poor cousins of the dazzling multicellular world but key facilitators of biological complexity. It may indeed be time to take these little critters more seriously and to define the steps necessary to safeguard the invisible microbial universe underpinning our tenuous existence.

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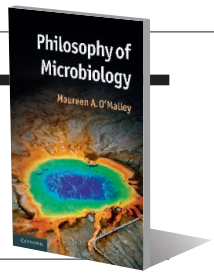

Philosophy of Microbiology
Maureen A. O'Malley
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IMAGE: DAVID SCHARF/SCIENCE SOURCE