

Unveiling the hidden world of microorganisms and their impact on the Earth's ecosystems

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Microorganisms are the unseen drivers of the Earth, impacting everything from the air we breathe to the soil beneath our feet. The roles they play in maintaining ecosystem functioning, particularly in the biogeochemical cycling of carbon, nitrogen, phosphorus, sulfur, and metals, are profound. Microbial communities are critical in mediating organic carbon mineralization, methane cycling, denitrification, and sulfate reduction, all of which regulate carbon storage and greenhouse gas emissions.

Microbial ecology has made significant advancements since the 1970s, transitioning from a culture-based microbial ecology in the 1980s to a genome-based microbial ecology after the 2000s. This shift became possible thanks to pioneering work from Dr. James M. Tiedje and other leading microbial ecologists¹. To date, the use of cutting-edge experimental and computational technologies has started to illuminate the hidden world of these microorganisms, providing an avenue to explore microbiome functions in diverse environments such as the ocean, soil, and wetlands. This has significantly broadened our understanding, enabling us to investigate the functional potential of microbiomes and understand their influence on the environment.

To celebrate James M. Tiedje's 80th birthday and honor his outstanding contributions to microbial ecology, the Institute for Environmental Genomics at the University of Oklahoma hosted a special symposium in association with iFAST (International Forum on Advanced Environmental Sciences and Technology), which is an interactive online forum for eminent scientists to share their most recent advances in environmental sciences and technology with and foster interdisciplinary networking among environmental researchers, engineers, students, and the general audience. The iFAST seminars have covered a diverse array of frontier research topics in environmental sciences and technology, particularly those related to climate change, environmental protection, theoretical ecology, community ecology, evolutionary biology, microbial ecology, and environmental genomics (<https://www.ou.edu/ieg/seminars>). The symposium, known as iFAST-Microbial Ecology, was successfully held online in April 2022, and the majority of the members of James M.

Tiedje's Academic Family were invited as speakers (<https://www.ou.edu/ieg/seminars/special/ifast2204>).

After the iFAST-Microbial Ecology event, some members of Jim Tiedje's Academic Family were invited to contribute articles on diverse ecological topics in various formats to *mLife* and a virtual special issue on microbial ecology is assembled.

It is becoming increasingly clear that microbial diversity is extremely high in various habitats, and one of the fundamental goals in microbial ecology is to determine how such extreme microbial biodiversity is generated and maintained across space and time. The exploration of microbial processes and the scale at which they occur continues to highlight the importance of quantitative models and trait-based models for an improved understanding of environmental biodiversity² and biogeochemical processes³.

In the face of growing environmental challenges, Liu et al. have explored the impacts of emerging pollutants such as microplastics and nanoplastics on methanogenic digestion of waste-activated sludge⁴. Their findings reveal the potential for resilience and functional redundancy within the digestion microbiome, despite initial suppression of methanogenesis by plastic exposure.

Climate change continues to be a pressing concern, and our understanding of its effects on microbial communities and carbon dynamics is advancing^{5,6}. Qiu et al. show that warming and rainfall reduction can differentially affect the abundance and composition of bacteria and fungi in semi-arid grasslands, with implications for soil carbon efflux⁷.

One area of research that has garnered increased attention is the study of gut microbiota-derived trimethylamine (TMA). TMA is associated with cardiometabolic disorders and represents an intriguing example of microbial involvement in the etiology of non-communicable diseases. Comprehensive genomic screening has revealed the bacteria responsible for TMA synthesis and has led to crucial insights into their ecophysiology⁸. These findings can potentially contribute to the development of strategies to restrict TMA formation, offering a promising avenue for therapeutic intervention.

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Examining the role of the mitogen-activated protein kinase (MAPK) HOG pathway in filamentous fungi, Li et al. offer important insights into the responses of *Trichoderma guizhouense* to blue light stimuli⁹. Their genome-wide transcriptome analysis has revealed the significant roles of the transcription factor ATF1 in regulating blue light responses, conidial germination, vegetative growth, and oxidative stress resistance. Their findings underscore the intricate interplay between light stimuli and stress signaling in fungi.

In addition to these areas of research, our fellow researchers have investigated various other aspects of microbiology, including the complex issue of species identification in prokaryotes and other microorganisms¹⁰, the influence of environmental selection and evolutionary processes on ecosystem functions¹¹, competitive interactions within eukaryotic phytoplankton¹², the role of microbial communities in B12 biosynthesis¹³, the effects of antibiotic resistance in the environment¹⁴, and the correlations between intestinal microbiota and antimicrobial resistance¹⁵.

We are grateful for the support and contributions of our editorial board members, authors, and reviewers, who have contributed to the success of this virtual special issue. As we look to the future, we are proud to be part of this vibrant community. This is an exciting era where we are beginning to uncover the enormous potential of unseen microorganisms. There is a pressing need to continue pushing the boundaries of our understanding and exploring the intricate relationships between these microorganisms and their environments. The study of microbial ecology is a dynamic and ever-evolving field that continues to provide new insights about the world around us. By continuing to explore and understand microorganisms on our planet, we are not only expanding our scientific knowledge but also generating applications that will help improve the well-being of humanity and the Earth.

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