Scientists call for ambitious program to unlock the power of Earth's microbial communities

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U.S. scientists — including microbiologists, physicists, chemists and physicians — announce the creation of the Unified Microbiome Initiative (UMI), an interdisciplinary group that will coordinate areas of microbial research and make funding recommendations to federal agencies, private foundations, and corporate partners.

A consortium of 48 scientists from 50 institutions in the United States has called for an ambitious research effort to understand and harness microbiomes - the communities of microorganisms that inhabit ecosystems as varied as the human gut and the ocean, to improve human health, agriculture, bioenergy, and the environment.

Their proposal, published in the October 30 issue of the journal *Science*, calls for a major research project to develop new research tools and

collaborations that will unlock the secrets of Earth's microbial communities.

"Microbiomes sustain life on our planet and they are laboratories of novelty, green chemistry, and life-changing pharmaceuticals," said Jeff F. Miller, director of the California NanoSystems Institute and the corresponding author of the *Science* paper.

"Understanding how they work might hold the key to advances as diverse as fighting antibiotic resistance and autoimmune diseases, reclaiming ravaged farmland, reducing fertilizer and pesticide use, and converting sunlight into useful chemicals."

Called the Unified Microbiome Initiative Consortium (UMIC), the group of 48 researchers want nothing less than a qualitative shift in how microbiome research is done. Scientists have made substantial progress in cataloging the organisms that live in microbiomes. Now, they need to uncover the function of individual microbes in each community and how those species communicate with each other, their hosts, and their environment. The UMIC is calling for investments in new research tools and cross-disciplinary collaborations that will one day allow us to predict and manage the behavior of microbiomes.

The UMIC consists of leading microbiologists, ecologists, physical scientists, and engineers. The consortium coalesced during a series of coordinated but separately convened meetings held by The White House Office of Science and Technology Policy and The Kavli Foundation. The proposal was born while identifying crosscutting challenges and opportunities in the field, as well as exchanging ideas and developing a strategy for accelerating discovery.

"The key to this effort will be integrating diverse fields to create new experimental tools and new research partnerships. We believe creative

sparks fly when we bring together people that operate at disciplinary boundaries," said Miyoung Chun, executive vice president of science programs at The Kavli Foundation.

Microbiomes are ecosystems of one-celled organisms, such as bacteria, archaea, fungi, protozoa, algae, and plankton, as well as viruses. Over billions of years, they created our oxygen-rich atmosphere and fashioned the rich loam of our soils, and they continue to make life on Earth possible today. The 100 trillion microbes in the human gut - which vastly outnumber the "human" cells in our bodies - are critical to our health and development.

Microbiomes are extraordinarily complex. A few grams of soil or sediment may contain tens or even hundreds of thousands of microbial species, each interacting with one another. This makes it very difficult for scientists to study, much less control, them.

Yet thanks to advances in such fields as genomics, microbiomes have begun to yield their secrets. Only a few decades ago, for example, scientists recognized less than 10 bacterial phyla, large groupings of related life forms. Today, they believe the number of bacterial phyla is closer to 1,000. To put this in perspective, all the multicellular animals in the world comprise only a few dozen phyla.

"To move beyond cataloging microbes, we will need new tools to rapidly determine microbial gene function and monitor the chemicals microbes use to communicate and interact with their environment, and new ways to visualize and model those interactions," said Eoin Brodie, a staff scientist at Lawrence Berkeley National Laboratory's Earth Sciences Division and an author of the proposal.

"We also need better ways to test how different microbes function within the microbiome. Just like we test hypotheses about the functions

of genes in genetic networks by knocking them out and replacing them, we need methods to selectively remove or inhibit specific microbes or metabolisms in microbial networks to determine their roles," Brodie added.

The consortium believes many of these goals could be achieved within 10 years.

The Unified Microbiome Initiative calls for major advances in five areas: (1) understanding the link between genes found in the microbiome and what they do; (2) determining which genes are associated with which organisms; (3) creating tools to detail the behavior of microbes in their native environments; (4) developing better ways to manage data and use it to predict microbiome behavior; and (5) inventing ways to run controlled experiments on microbiomes to test and refine hypotheses.

The initiative would be centered in the United States, but the paper's authors call for international collaborations to set research goals, develop protocols and data standards, and share leading-edge facilities.

In a related paper published simultaneously in the journal *Nature*, three prominent researchers call for an International Microbiome Initiative that would complement the work of the U.S. program.

"Over the past 20 years, new technologies have reshaped our understanding of the essential roles microbes play on our planet. A Unified Microbiome Initiative would develop the transformative tools and research teams we need to harness the power of these communities to improve human health, agricultural productivity, bioenergy production, and environmental stability," Chun said.

More information: "A unified initiative to harness Earth's microbiomes," *Science*, www.sciencemag.org/lookup/doi/ …

1126/science.aac8480

"Comment: Global microbiome effort needed," *Nature*, nature.com/articles/doi:10.1038/526631a

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