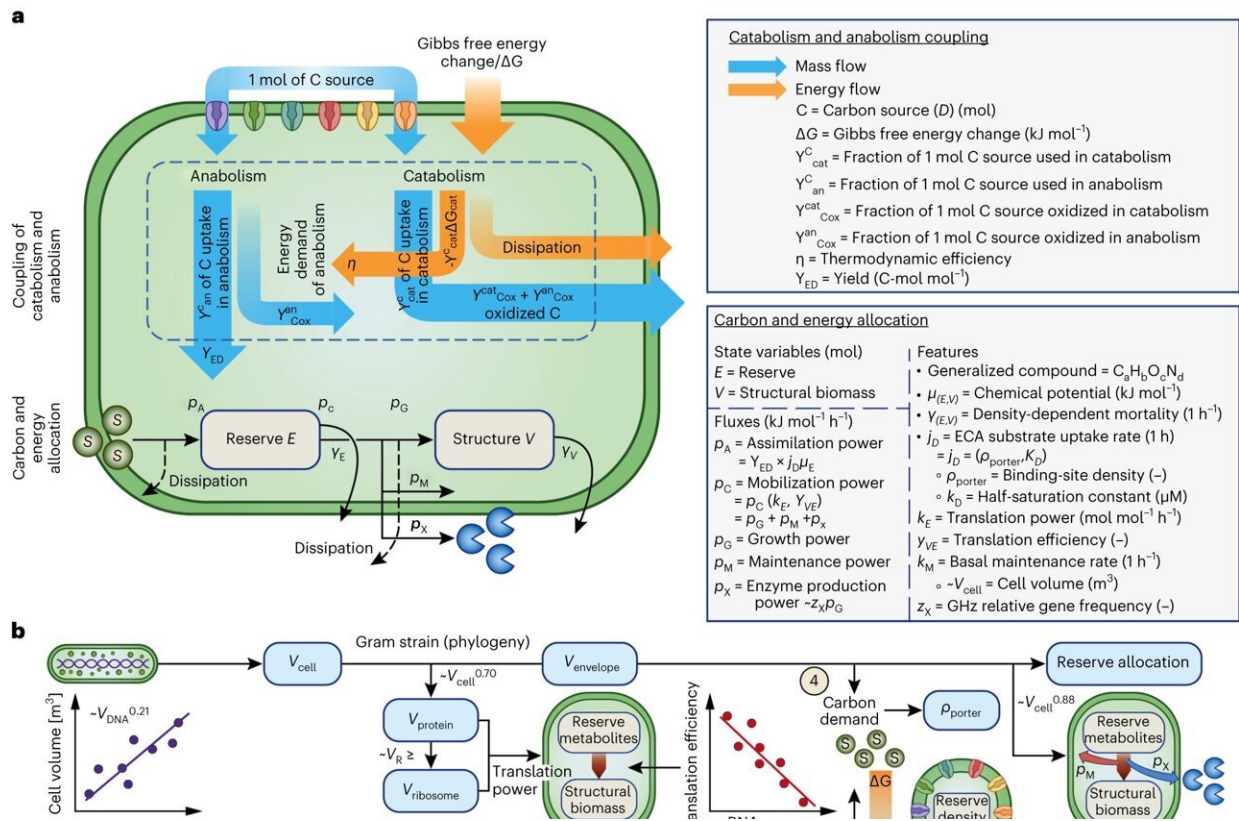


Improving climate predictions by unlocking the secrets of soil microbes

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Overview of DEBmicroTrait. Credit: *Nature Microbiology* (2024). DOI: 10.1038/s41564-023-01582-w

Climate models are essential to predicting and addressing climate change, but can fail to adequately represent soil microbes, a critical

player in ecosystem soil carbon sequestration that affects the global carbon cycle.

A team of scientists led by the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) has developed a new model that incorporates genetic information from microbes. This new model enables the scientists to better understand how certain soil microbes efficiently store carbon supplied by [plant roots](#), and could inform agricultural strategies to preserve carbon in the soil in support of plant growth and [climate change mitigation](#).

"Our research demonstrates the advantage of assembling the genetic information of microorganisms directly from soil. Previously, we only had information about a small number of microbes studied in the lab," said Berkeley Lab Postdoctoral Researcher Gianna Marschmann, the paper's lead author.

"Having genome information allows us to create better models capable of predicting how various plant types, crops, or even specific cultivars can collaborate with soil microbes to better capture carbon. Simultaneously, this collaboration can enhance soil health."

This research is described in a new paper that was recently published in the journal [Nature Microbiology](#). The corresponding authors are Eoin Brodie of Berkeley Lab, and Jennifer Pett-Ridge of Lawrence Livermore National Lab, who leads the "Microbes Persist" Soil Microbiome Scientific Focus Area project.

Seeing the unseen: Microbial impact on soil health and carbon

Soil microbes help plants access soil nutrients and resist drought, disease,

and pests. Their impacts on the carbon cycle are particularly important to represent in climate models because they affect the amount of carbon stored in soil or released into the atmosphere as carbon dioxide during the process of decomposition.

By building their own bodies from that carbon, microbes can stabilize (or store) it in the soil, and influence how much, and for how long carbon remains stored belowground. The relevance of these functions to agriculture and climate are being observed like never before.

However, with just one gram of soil containing up to [10 billion microorganisms and thousands of different species](#), the vast majority of microbes have never been studied in the lab. Until recently, the [data scientists](#) had to inform these models came from only a tiny minority of lab-studied microbes, with many unrelated to those needing representation in climate models.

"This is like building an ecosystem model for a desert based on information from plants that only grow in a tropical forest," explained Brodie.

The world beneath our feet

To address this challenge, the team of scientists used genome information directly to build a model capable of being tailored to any ecosystem in need of study, from California's grasslands to thawing permafrost in the Arctic. With the model using genomes to provide insights into how [soil microbes](#) function, the team applied this approach to study plant-microbiome interactions in a California rangeland. Rangelands are economically and ecologically important in California, making up more than 40% of the land area.

Research focused on the microbes living around plant roots (called the

rhizosphere). This is an important environment to study because, despite being only 1-2% of Earth's soil volume, this [root zone](#) is estimated to hold up to 30-40% of Earth's carbon stored in soils, with much of that carbon being released by roots as they grow.

To build the model, scientists simulated microbes growing in the root environment, using data from the University of California Hopland Research and Extension Center. Nevertheless, the approach is not limited to a particular ecosystem. Since certain genetic information corresponds to specific traits, just as in humans, the relationship between the genomes (what the model is based on) and the microbial traits is transferable to microbes and ecosystems all over the world.

The team developed a new way to predict important traits of microbes affecting how quickly they use carbon and nutrients supplied by plant roots. Using the model, the researchers demonstrated that as plants grow and release carbon, distinct microbial growth strategies emerge because of the interaction between root chemistry and microbial traits.

In particular, they found that microbes with a slower growth rate were favored by types of carbon released during later stages of plant development and were surprisingly efficient in using carbon—allowing them to store more of this key element in the soil.

The root of the matter

This new observation provides a basis for improving how root-microbe interactions are represented in models, and enhances the ability to predict how microbes impact changes to the [global carbon cycle](#) in [climate models](#).

"This newfound knowledge has important implications for agriculture and soil health. With the models we are building, it is increasingly

possible to leverage new understanding of how carbon cycles through soil. This in turn opens up possibilities to recommend strategies for preserving valuable carbon in the soil to support biodiversity and plant growth at scales feasible to measure the impact," Marschmann said.

The research highlights the power of using modeling approaches based on [genetic information](#) to predict microbial traits that can help shed light on the soil microbiome and its impact on the environment.

More information: Gianna L. Marschmann et al, Predictions of rhizosphere microbiome dynamics with a genome-informed and trait-based energy budget model, *Nature Microbiology* (2024). [DOI: 10.1038/s41564-023-01582-w](#)

Provided by Lawrence Berkeley National Laboratory

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