

Quantifying microbial energy supplies with the Water-Organic-Rock-Microbe (WORM) Portal

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Microbes need energy to grow, reproduce, repair damage, maintain their metabolisms, and interact with their environment. Phototrophic microbes can harness the power of sunlight while chemotrophs derive energy from chemical compounds. Thermodynamic calculations can tell us whether a chemotrophic metabolic reaction will yield energy in an aqueous environment depending on fluid composition, temperature, and pressure. If the calculation reveals that energy is *not* available for a reaction, the reaction can be ruled out as a viable metabolic strategy in that system. Similarly, energy supplies can be quantified for energy-yielding reactions to generate hypotheses about how chemotrophic microbes harness energy in a system. Because of its usefulness for interpreting chemotroph metabolic strategies, several recent studies have quantified microbial energy supplies in natural systems and growth experiments using free and open-source software tools developed for the Water-Organic-Rock-Microbe (WORM) Portal online computing environment [1, 2, 3, 4].

The WORM Portal is an NSF-funded geochemical modeling platform for researchers, students, and the public that can be accessed for free through an internet browser. The WORM Portal comes pre-packaged with computational Jupyter notebook tools and educational demos covering a variety of topics in geobiology and geochemistry. In this presentation, we will demonstrate how the WORM Portal can be used to quantify microbial energy supplies, chemical affinities, and power (energy over time) in water samples and growth media under ambient conditions and elevated temperatures and pressures, and how you can apply the WORM Portal to quantify energy supplies in your own systems of interest.

[1] Alain et al. (2022). Sulfur disproportionation is exergonic in the vicinity of marine hydrothermal vents. *Environmental Microbiology*, 24(5), 2210-2219.

[2] Howells et al. (2025). Energetic and genomic potential for hydrogenotrophic, formatotrophic, and acetoclastic methanogenesis in surface-expressed serpentinized fluids of the Samail Ophiolite. *Frontiers in Microbiology*, 15, 1523912.

[3] Parsons et al. "Hydrothermal Seepage of Altered Crustal Formation Water Seaward of the Middle America Trench, Offshore Costa Rica." *Geochemistry, Geophysics, Geosystems* 25.1 (2024): e2023GC011246.

[4] Rhim et al. (2024). Mode of carbon and energy metabolism shifts lipid composition in the thermoacidophile Acidianus. *Applied and Environmental Microbiology*, 90(2), e01369-23.

