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Gas Replacements for GFP to Track Microbial Dynamics in Soils and Sediments

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Metagenomic analyses offer unprecedented views of soil microbial communities, and additionally provide a host of testable hypotheses about the biological mechanisms driving global biogeochemical fluxes. Outside the biogeosciences, hypotheses generated by metagenomics are often tested using biosensors, microbes programmed to respond in a detectable way to either changes in their metabolism or changes in the environment. A very large number of microbial behaviors can be monitored using biosensors, but these sensors typically report in ways that are undetectable in soils, e.g. by releasing green fluorescent protein (GFP). We are building a new class of biosensors that report by releasing easily-detected gases.

We will provide an overview of the potential uses of gas-reporting biosensors in geobiology, and will report the current development these sensors. One goal in the development of these sensors is to make tractable the testing of gene expression hypotheses derived from metagenomics data. Examples of processes that could be tracked non-invasively with gas sensors include coordination of biofilm formation, nitrification, rhizobial infection of plant roots, and at least some forms of methanogenesis, all of which are managed by the easily-engineered acyl homoserine lactone cell-cell communication system. Another relatively simple process to track with gas sensors is horizontal gene transfer. We will report on the progress of these proof-of-concept examples.