Lipidomics for geochemistry: The intersection of metagenomics, microbial genetics, and environmental lipid profiling

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Microbes simultaneously occupy Earth's lowest and highest trophic levels. Along with unicellular algae, they provide much of our primary production; and along with fungi, most of our heterotrophic consumption. The record of microbial life preserved in sedimentary lipid biomarkers potentially reflects the entirety of these complex processes, and with the staggering diversity of microbial species and biochemical pathways [1,2], it is a wonder that organic geochemists obtain any useful information at all – yet we do. In various combinations, microbial biomarkers can carry unique stable isotope signatures of metabolic processes, can reflect taxonomically or physiologically distinct biological sources, can be linked systematically to biosynthetic pathways using molecular genetics, and/or can retain information about depositional and diagenetic conditions. Together these properties yield rich records for paleoecology and paleoclimate applications, over both short and long timescales.

Due to their high capacity for preservation, lipids are a traditional target for studying the microbial signatures preserved in sediments. More recently, the desire to relate particular lipid structures to microbial species distributions has brought the field into the "omics" era, now using DNA sequencing in parallel with more traditional structural and isotopic characterizations. Known as "lipidomics", this approach is a concept that unites investigations of the great diversity of lipids with a better understanding of the distribution of the genes that encode the enzymes of their biosynthetic pathways. Here I review several recent examples of lipidomics in practice. These examples show the potential of such approaches – either alone or in tandem with compound-specific isotopic analyses – to achieve a better understanding of the origins of biomarker signatures preserved in the geologic record.

[1] Sogin, M.L., *et al* (2006) *Proceedings of the National Academy of Sciences USA* **103**: 12115-12120. [2] Pearson, A. (2013) Lipidomics for geochemistry. Treatise on Geochemistry (2nd Edition) **12**: 291-336.