Biosequestration of carbon by heterotrophic microorganisms

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In their correspondence (Microbial production of recalcitrant organic matter in global soils: implications for productivity and climate policy. *Nature Rev. Microbiol.* 29 Nov 2010 (doi:10.1038/nrmicro2386-c1))[1], Liang and Balser point out similarities between the microbial production of recalcitrant non-living organic matter (RNOM) in soils and in sea water, as presented by Jiao *et al.* (Microbial production of recalcitrant dissolved organic matter: long-term carbon storage in the global ocean. *Nature Rev. Microbiol.* **8**, 593–599 (2010))[2] in the conceptual framework of the microbial carbon pump. There is growing evidence indicating that RNOM derived from microorganisms is a large, and possibly dominant, global component of the non-living reduced carbon in water, sediments and soils. This realization has profound implications for our view of the role of microorganisms in biogeochemical cycles and the origins and cycling of RNOM in the environment.

Heterotrophic microorganisms in aquatic and terrestrial systems have an important role in organic matter decomposition. In this role, heterotrophic microorganisms remineralize carbon and are thereby a major source of carbon dioxide to the atmosphere. Bacteria and fungi are noted for their diverse enzymatic capabilities and their ability to degrade complex biopolymers, such as structural polysaccharides and lignins. These microorganisms are nature's ultimate recyclers, growing and multiplying while decomposing life's organic debris. Recent observations indicate a previously unrecognized functional role for heterotrophic microorganisms that transcends the classical role of carbon remineralization and nutrient regeneration. Microorganisms can grow rapidly during organic matter decomposition, and remnants of microbial biomass are released into the environment through a variety of processes, including cell division, lysis by viruses and phages, and protozoan grazing. These microbial remnants include complex biomolecules with unique structural components (such as lipopolysaccharides and hopanoids) that are recalcitrant and can remain in the environment for extended periods of time. The organic remnants left behind often contain molecular fingerprints documenting their specific microbial origins. Altered structural forms of hopanoids can persist as molecular fossils in sediments for as long as 2,500 million years[3]. In this way, heterotrophic microorganisms assume a previously unrecognized functional role in the biosequestration of carbon as RNOM. The microbial source term for carbon dioxide production is clearly of much greater magnitude than the sink term, but the stabilization of non-living reduced carbon as RNOM in water[4], sediments[5] and soils[6] contributes to the regulation of greenhouse gases, influences trace metal and nutrient availability and improves soil moisture retention and fertility.

The cycling of RNOM is an enigma that has baffled biogeochemists for decades. The vast reservoirs of carbon in RNOM on land and in the sea exceed the atmospheric reservoir of carbon dioxide[7], so unravelling the RNOM enigma is a research priority. In a somewhat ironic twist, the microorganisms that are primarily responsible for the decomposition and remineralization of organic matter play an important part in the biosequestration of carbon and the production of RNOM. Future studies are needed to further explore the microbial carbon pump and to identify the microorganisms that form RNOM in the environment.

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Competing interests statement
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