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Branched tetraether membrane lipids: A versatile group of molecular fossils as testimony of past climate change (Outstanding Young Scientist Lecture)

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Studying fossils of any kind provides a small window into past times and could learn us why the world around us is as it is today (and might become in the near future). Like paleontologists studying bone remains and palaeobotanists studying fossil plant remains, many organic geochemists study fossil molecules to learn about geochemical cycles, evolution, ecology and climate.

Branched Glycerol Dialkyl Glycerol Tetraether (GDGT) membrane lipids are an example of such molecular fossils and have been the core subject of my research. These molecules were initially detected a decade ago in near coastal marine sediments and structurally resemble isoprenoid GDGTs, a group of membrane lipids synthesised by Archaea, a Domain of life separate from Bacteria and Eukarya. With nuclear magnetic resonance techniques we showed, however, that branched GDGTs are of bacterial rather than archaeal origin and analysis of soils, peat bogs and marine surface sediments pointed to a terrestrial origin. As isoprenoid GDGTs are mainly produced by marine archaea the ratio between the two groups, the Branched vs. Isoprenoid Tetraether (BIT) index, could be used to trace the input of soil organic matter into marine sediments. In this lecture I will provide examples of applications of this BIT index in the Channel River during the last Glacial Maximum and the Congo deep sea fan over the last deglaciation.

Meanwhile, it appeared that in soils the distribution of individual branched GDGTs, which differ in their content of methyl branches and cyclopentane rings, was different from place to place. Analysis of over 100 soils at different locations revealed that the distribution of the branched GDGTs is most strongly related to both soil pH and annual mean air temperature. This is explained by the fact that bacteria have to adapt the composition of their cell membrane to ambient conditions in order to keep it properly functioning. This empirical relation opened opportunities to reconstruct past annual mean air temperatures (and soil pH) from the branched GDGT distribution in sedimentary archives. I will present examples of such reconstructions from central tropical Africa during the last deglaciation, the southern North Sea basin during the Miocene cooling period (Ĩ7-5Ma), and the Arctic Ocean during the Palaeocene-Eocene thermal maximum (5̃5.5 Ma).

So far, the applications of these proxies have shown to be rather successful. However, as with every new proxy, several questions and uncertainties remain. In part this is due to the fact that the bacteria that synthesise these lipids are as yet still unknown. My future research will therefore be dedicated to searching for the biological precursor organism and to further validation of these molecular proxies. In addition, the potential of this new continental temperature proxy for application in lake sediments will be investigated, initially focusing on the last deglaciation. Alongside the improvement of analytical techniques, this hopefully results in some more secrets of this fascinating and versatile group of molecular fossils to be revealed.