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Organic proxies for reconstruction of microbial evolution, past climatic and palaeoenvironmental conditions

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In the 75 years of its existence, starting with the pioneering studies of Alfred Treibs, organic geochemistry (or biogeochemistry) has developed in a truly multidisciplinary science. The study of the molecular composition of sedimentary organic matter and its application in our understanding of the evolution of life and the changing conditions on Earth require contributions from many fields. This offers organic geochemists the possibility to interact with scientist from many different disciplines: from microbiologists to hard rock geologists, from soil scientist to physical oceanographers, from petroleum engineers to inorganic geochemist, and from climate modelers to higher plant physiologists. In the last decades, organic geochemistry has also matured and has become a “grown-up science” with important applications in other fields such as, for example, palaeoclimatology and microbiology.

In my Vernadsky Medal lecture I will introduce the concept of organic proxies and explain how important biological validation of organic proxies is for the application of organic proxies in the geosciences. I will illustrate this with examples from the work performed in our research group and will show how the application of organic proxies have resulted in new insights. I will discuss the development and application of marine/lacustrine and continental palaeothermometers based on archaeal and bacterial membrane lipids, respectively, and show how they can aid in our assessment of the warm climates of the mid Cretaceous and at the Palaeocene/Eocene thermal maximum. Application of biomarkers derived from specific carotenoids produced by

photosynthetic green sulfur bacteria has provided evidence for euxinic conditions at the base of the photic zone during sapropel deposition in the Mediterranean and during black shale deposition during oceanic anoxic events. Ladderane lipids derived from bacteria anaerobically oxidizing ammonium will be shown to provide new insights into the loss of nutrient N from the ocean. The application of biomarkers in the reconstruction of microbial evolution will be shown by a combined biomarker and molecular phylogeny study of marine diatoms in combination with the distributions of diatom biomarkers in the geological record.