PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Introductory Remarks

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Introductory remarks

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The persistence of life on this planet depends on the cycling of the major biological elements – C, H, O, N and S – and it is a truism that microbes play an important, often overriding, part in determining the turnover rate of the biological cycles and hence in determining the biological productivity of various parts of the biosphere. The biological sulphur cycle is no exception to this generalization: microbes play a major quantitative role in the cycling of S in the biosphere and, despite the fact that biologically available sources of sulphur can be locally very abundant, a number of areas of this planet exist in which availability of sulphur limits biological productivity.

The bacteria of the sulphur cycle are of absorbing scientific interest for a number of reasons. The first is that their metabolism is based on the large-scale turnover of an atom, sulphur, which most biologists are inclined to regard as a minor (if important) component of biological systems. Some oxidize sulphides or elemental sulphur to sulphate; others reduce sulphate, sulphur-containing oxy-anions or elemental sulphur to sulphide. Frequently the products of such metabolic processes are toxic; for example, the sulphide formed by *Desulfovibrio* is a general cell poison for most organisms, and the sulphuric acid formed when thiobacilli oxidize sulphur is deleterious to all but a few living things. These metabolic features impose some fascinating and unusual processes on the communal biochemistry that living things appear to share, processes that concern not only the pathways of transformation of such biochemically exotic substrates and the generation of biological energy therefrom, but also the activation of seemingly insoluble substrates (e.g. native sulphur or iron pyrites) and the survival of living cells, and of their systems for taking up trace metals such as Fe, Mo or Co, in the presence of substantial concentrations of neutral sulphide. Such matters present fascinating and sometimes vexing questions to biochemists and physiologists; they also present serious problems for the ecosystem in which they are manifest, because many organisms of more ordinary physiology can be killed, or excluded, by the biochemical activities of the sulphur bacteria when these are manifested on a large scale. Ecosystems in which the sulphur cycle is the dominant process have been given the name 'sulfureta' – a name that will doubtless crop up often in these discussions – and they have a very distinctive macroflora and microflora, as anyone knows who has thinkingly observed a sulphur spring, or a polluted, sulphide-rich pool in autumn.

The scientific questions posed by the sulphur bacteria, and their environmental effects, have been known, at least to specialists, for much of the twentieth century. What is now particularly interesting is that the last decade has seen some substantial advances in our understanding of these bacteria. These advances have taken place at all levels of investigation. The biochemistry of dissimilatory sulphate reduction in *Desulfovibrio* has revealed enzymes and electron carriers of special character and structure whose functions and intracellular distribution are just beginning to be revealed, throwing light on the curious features of energy generation in these bacteria. Yet even as we begin to understand *Desulfovibrio*, entirely new and different genera of sulphate-reducing bacteria are being discovered, some with metabolic properties that have eluded microbiologists for several decades. Unexpected nutritional types on the borderline of autotrophy are being characterized among both sulphate-reducing and oxidative sulphur bacteria, and the pathways of sulphur oxidation in members of the latter group are emerging more clearly. Yet, to my knowledge, the mode of attack on the seemingly insoluble substrates mentioned earlier remains enigmatic. In ecological research, new understanding has been obtained of the involvement of various sulphur bacteria in the mineralization of organic matter in sediments, and of their relation to methanogenic bacteria. An exciting development of the last two or three years has been the demonstration, around marine hydrothermal vents (e.g. in the Galapagos Rift of the Pacific Ocean), of complex ecosystems, including metazoa and probably a zoocoenotic symbiosis, which are ultimately dependent on primary CO_2 fixation by autotrophic sulphur or sulphide-oxidizing bacteria.

The study of these bacteria is now in a buoyant phase and it is an appropriate time to bring together experts on the various groups, with diverse specializations, to present and discuss recent developments in their areas. Not only may we thus move towards a wider and more synthetic understanding of the basic science of these organisms, but we may also hope to understand more precisely, and therefore be able to influence more effectively, the many and diverse effects that these bacteria have on our economy and environment.

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