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The Sulphur Bacteria: Concluding Remarks

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The sulphur bacteria: concluding remarks

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The superb collection of papers presented to this symposium has taken us on a remarkably comprehensive tour of the microbiology, biochemistry, biogeochemistry and environmental role of the sulphur bacteria. I think the contributors have brought us up to date with the current status of knowledge and understanding of these bacteria, their importance in the sulphur cycle, and their impact on the human environment.

I do not wish to recapitulate the information presented, other than to single out some key points. Prodigious advances have been made in the microbiological elucidation of sulphate reduction. Organisms are now known (thanks largely to the recent work of Norbert Pfennig and his colleagues and the biochemical studies of Rudolph Thauer's group) that can couple the reduction of sulphate to the oxidation of organic compounds from the level of hexose sugar completely to carbon dioxide. It has alsc be shown that diverse oxidized sulphur compounds (sulphite, thiosulphate, polythionates and elemental sulphur) can all be reduced to sulphide. Thus organisms in anoxic environments can convert carbon and sulphur completely to carbon dioxide and sulphide: acetate and sulphur can no longer be regarded as 'end-products' of metabolism in anaerobic environments. Similarly the oxidative mechanisms of the chemolithotrophs and photolithotrophs seem at last to be close to complete understanding in terms of enzymes catalysing oxidation reactions and the electron transport systems linked to them.

The energetics and carbon relations of all the sulphur bacteria, and the complex interactions of autotrophy, lithotrophy, heterotrophy and mixotrophy, are becoming clear: very pleasing progress especially when one considers that this is the first major meeting devoted to the sulphur bacteria to be held since work on mixotrophy and its importance to competition and survival were seriously begun. Studies on the microbiology, biochemistry and chemistry of oxic-anoxic interface environments clearly have a great way to go. Similarly work on zoocoenoses involving sulphur, such as the sulphur bacteria symbionts of the Pogonophora and other marine animals (Southward *et al.* 1981), has only just begun.

A question peripheral to the study of the organisms arose in informal discussion during the meeting: namely, the *spelling* of sulphur and its compounds. Should spelling with an 'f' become a standard for international scientific usage, just as '*Desulfovibrio desulfuricans*' is 'international English' (Postgate 1979; Postgate & Campbell 1966), and the one-time use by British authors or journals of '*Desulphovibrio desulphuricans*' (Abd-el-Malek & Rizk 1960; Postgate 1953, 1960; Furusaka 1961) has ceased.

Postgate (1979) pointed out that since the Romans did not use 'ph', *sulfur* would have been with us always had Latin and the Roman Empire persisted longer in Britain. Looking at its etymology one finds that in languages derived from the same roots as English, 'ph' does not occur in the spelling of sulphur and its compounds: thus *Schwefel*, *Sulfid* (German); *soufre*, *sulfate* (French); *sulfere* (old French); *zolfo* or *solfo*, *iosolfato* (Italian); *azufre* (Spanish); *sulfer* or *solfer* (Dutch (*O.E.D.* 1933)) and in current Dutch usage, *swavel*, *sulfide*, *sulfaat*; *and sulfur*(*em*)

(Latin). So where did the divergence occur in English? In Old English one finds *swefel* and *swefl* (Klein 1966; Onions 1966); in Anglo-Norman *sulf(e)re*; and in late Middle English *soufre* and *solfre* (Onions 1966). Turning to the *Oxford English Dictionary* (*O.E.D.*) 1933) one finds the element to have been spelled in English as sulphur, sulphre, sulphure, sulfur, soulfre, soulphre, solfre, sulfure, sulfre, sulphyr, sulfer.... However, although the use of 'f' occurred as late as 1549 as 'sulfure' and around 1400 as 'solfre', it seems that 'ph' has been fairly consistently employed since at least 1390 (*O.E.D.* 1933): ...fyre of sulphre...' and in the same work '...sulphur...'; and later, in 1420: '...sulphure...' Thus Postgate's (1979) remark that 'it is a century too late for this error to be corrected' is even optimistic, since we have in fact six centuries of consistent usage of 'ph' and the scientific literature will have to continue its acceptance of the duality of 'sulphur' and 'sulfur', just as it accepts 'haem' and heme', 'aluminium' and 'aluminum', and so on. Indeed we should ask when the use of 'f' became established as American English. In 1828, sulphur was so spelt in the U.S.A. (Webster 1828), with no mention of an 'f' alternative. By 1907, its entry in Webster's Dictionary became 'sulphur (L. better *sulfur*)' (Porter 1907); and by 1961 the official word was 'sulfur', with 'sulphur' being relegated as a variant of 'sulfur' (Gove 1961); and 'sulfur' alone appears in the abridged 1977 edition of Webster's Dictionary. The forces eliminating 'sulphur' from American have thus acted only in recent decades and have reinstated a form dormant since the reign of Richard II. It is axiomatic that language is not obliged to justify itself: usage is its maker. Suffice it to conclude with the thought that the problems to be solved are identical with either spelling!

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