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Introduction

Extremophilic Archaea and Bacteria

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Archaea represent a distinct evolutionary domain like the bacterial and the eukaryotic kingdoms. It has been more than a decade since a minireview series focused on the unique properties of archaeal membranes and of their essential bioenergetic systems appeared compiled in a special volume of the *Journal of Bioenergetics and Biomembranes* (1992). In the meantime, not only have a vast number of novel species and genera been detected, but about 20 genomes from archaea have been fully sequenced as well. Accordingly, the amount of information about specific archaeal metabolic and bioenergetic functions has increased significantly, thus necessitating a new minireview series that provides a fundamental reevaluation of the field. At the same time, it is important to note that archaea which usually inhabit very harsh environments share a number of properties with extremophilic bacterial organisms with respect to ability to grow only under extreme conditions of temperature, acidity, or salinity. In addition, a large number of enzymes from extremophiles have gained biotechnological interest as laboratory tools in molecular genetics as well as in large scale processes like the food industry, waste removal, ore leaching, and carbohydrate polymer degradation (Leuschner and Antranikian, 1995).

On the basis of the above, it seems reasonable to discuss the extensive recent progress made in research on both extremophilic archaea and bacteria in a combined series of minireviews. Therefore, this minireview series focuses on such extremophiles and discusses recent progress made in the following three areas of research: 1) Transport across plasma membranes, 2) Primary energy transducers in membranes, and 3) Secondary energy transducers in membranes and cytosol.

The first section that focuses on membrane transport addresses the importance of ABC transporters in archaea. These transporters are involved in a broad number of solute uptake and extrusion processes. As such, the transport of compatible solutes is of special interest as it concerns extremophiles thriving in high salinity environments as highlighted in one of the minireviews. DNA transport covered in a separate minireview is another important topic intimately related to the process of bacterial transformation and DNA exchange. An understanding of these processes in archaea and hyperthermophiles may prove of special importance for the development of novel techniques to be used in the future in their genetic manipulation. To date, all attempts to generate a reliable technique for stable transformation of extreme acidophilic archaea have failed.

The second section of this minireview series combines reviews on components and principles of electron transport and coupled energy conservation in extremophiles. Here, the role of electron transport involving the novel coenzyme methanophenazine in methanogenesis is highlighted as well as the evolutionary relationship between modules of NiFe-hydrogenases and the respiratory complex I. Respiratory chains from thermophilic prokaryotes involving novel components are also reviewed in this issue, while in parallel a review focusing specifically on respiratory complexes of aerobic archaea is in press elsewhere (Schäfer, 2004). New insights into the metabolism of elemenal sulfur is presented by a study on *Acidianus ambivalens*, and for the first time an electron pathway from sulfur oxidation into the respiratory chain is directly demonstrated which surprisingly involves a protein subunit shared between the terminal oxidase and a thiosulfate dehydrogenase.

The third and final section of this minireview series focuses on phosphoryl transfer in motor proteins emphasizing the latest view on the diverse subunit stoichiometries of the rotor in F-, A-, and V-type ATP-synthases/ATP hydrolases. The importance of P-type ATPases in extremophiles is reviewed as well, complemented by an orginal report on a new archaeal P-type ATPase that includes preliminary efforts toward a 3D structure. In addition, the current state of research on proton-translocating pyrophosphatases and their phylogenetic relationship in extremophiles is discussed. Finally, the membrane bound exo-pyrophosphatase of *Sulfolobus* has been genetically characterized and a

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novel functional role in antibiotic resistance is discussed together with a proposed dolycholpyrophosphatase activity.

Although the presented selection of topics cannot cover the whole range of research activities being conducted on extremophilic archaea and bacteria, it may encourage the reader interested in bioenergetics to delve more deeply into the field of prokaryotic bioenergetics and biochemistry at a time when there is increased interest in human and other eukaryotic genomes. Significantly, projects leading to these genome benefited greatly with the aid of thermostable enzymes from extremophilic prokaryotes.

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