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Multi-author Reviews

Biology of halophilic bacteria, Part I

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Introduction. Biology of halophilic bacteria: Research priorities and biotechnological potential for the 1990s

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The eight papers accompanying this introductory review are part of the proceedings of an American Society for Microbiology Conference held in Williamsburg, VA from November 15–22, 1992. Conference attendees participated in discussions centered around the title of this introduction. One goal of the meeting was to identify the most important research priorities for the coming decade. A second goal was to discuss the biotechnological potential of microbes that live in hypersaline environments. These eight papers are the first of the invited talks to be published in this journal. Another group will appear in a future issue.

Many microbiologists, biochemists, and geneticists are familiar with the numerous physiological and molecular advances that have come from studies of extremely halophilic and halotolerant bacteria. Since these organisms were first described in 1880[5,6] and 1919[14] they have provided large amounts of unique discoveries and fascinating information. Extreme halophiles in particular have been proven to be a rich source of biological information. Among the more important discoveries arising from studies of extreme halophiles are bacteriorhodopsin[3,15], halorhodopsin[19], ether-linked lipids[12,20], and the presence of highly acidic proteins that are characteristic of many microbes from hypersaline environments[13]. This list is by no means complete but I do think it illustrates the value of research on extremely halophilic bacteria.

As might be expected, the halotolerant and moderately halophilic eubacteria have proven to be more similar to non-halophilic bacteria. Nevertheless, these organisms have contributed significantly to our knowledge of the phase behavior of lipids[22,23], physiological changes during adaptation to different NaCl concentrations[26–28] and the function of compatible solutes in protecting cells from high salts[7].

While halophilic bacteria have been the subject of much basic scientific interest, their biotechnological potential has been largely ignored. This is indeed strange, given the fact that these microorganisms are intimately involved in some of man's oldest industrial processes. In fact, the need for the red pigmentation of evaporation ponds was recognized as early as 2500 B.C.[1] In addition, halophilic bacteria have been shown to be important in numerous other industrial processes. Moderate halophiles and halotolerant bacteria are needed in the production of a wide range of salty foods such as Thai fish sauce and soy sauces[24], they have also been isolated from pickling brines[14], salt-cured bacon[21] and oilfield production brines[2]. Extreme halophiles are also present in leather curing vats and their enzymes may even help to soften and de-hair the leather (D. Bailey – personal communication). Despite this intense involvement their actual value in processes and their potential utility in other areas seems to be underappreciated. To my knowledge there is relatively little work being sponsored in such areas as new strain or new product development. Yet, many of the properties that make halophiles so well adapted to a hypersaline lifestyle are properties that could be valuable in biotechnology.

Recently, halophilic bacteria have been shown to produce a variety of hydroxyalkanoates that can be made into useful thermally processed plastics[18]. These materials are produced in quantities that rival the productivity of non-halophiles but they are easier to harvest (halophiles lyse in fresh water) and the organisms grow on a cheaper carbon source[18]. Some eubacterial halophiles also produce significant amounts of extracellular polymers which have highly desirable rheological properties[17]. Other eubacterial halophiles also produce large amounts of compatible solutes such as Ectoine[29] which can impart salt tolerance to some non-halophilic organisms[7].

In the future, the salt resistant properties of halophiles in general may offer unique possibilities for treatment of

hypersaline waste streams, such as slaughterhouse wastes, chemical brines, oilfield produce waters, refinery wastes, and even some agricultural wastes. They may also prove useful for the removal of toxic selenium and other heavy metals from some saline waters (L. Hochstein – personal communication).

For the present, it would seem that interest in the microbiology of extreme environments in general and halophiles in particular appears to be increasing. Since 1986, there have been at least four books published on the microbiology of extreme environments[4,8–10]. Another five books devoted exclusively to halophiles have also appeared[11,16[2vols.],17,25].

The meeting held in Williamsburg was the fourth international conference held since 1986 and more are being planned.

The papers that will comprise this Multi-author Review include some that are purely ecological and taxonomic, others that discuss physiology, molecular biology, biophysics, and yes, biotechnology. I sincerely hope that the readers of this series enjoy the articles and learn some new things about some old microbial friends.

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