

Could microorganisms in permafrost hold the secret of immortality? What does this mean?

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ABSTRACT. For more than a century there have been reports of living organisms in permafrost, some of which are claimed to be millions of years old. Interest in organisms surviving in extreme environments (extremophiles) has been stimulated recently by reliable evidence of bacterial growth in many quite different and unexpected situations. Such bacteria can have an abnormal longevity. This paper examines frozen ground as an environment for microorganisms and a comparison is made with the characteristics of those living in other extreme environments. It seems certain that some species of bacteria survive in permafrost for long periods of time - far in excess of their 'normal' life span. The characteristics of 'permafrost' bacteria are such that they present opportunities for biotechnical engineering of species so as to increase their effectivity in bioremediation of contaminated ground in cold regions.

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Introduction

Extremophiles are organisms which live in apparently quite unsuitable environments (Horikoshi and Grant, 1998). Ashcroft (1999) in her wide-ranging discussion of physiological adaptation to extreme circumstances, considers, in addition to human beings, organisms that live at great depths in Antarctic glaciers and others that live deep in the high temperatures and pressures of the Earth's crust. Parkes (2000) reviews convincing cases of bacteria in diverse environments which have remained viable over inordinate lengths of time.

Living (or at least viable) bacteria apparently occur deep in solid-frozen ground (permafrost) in the cold regions (see the review by Gilichinsky and Wagener, 1995) and these appear to be living 'fossils'. Some 'come to life' and reproduce in the laboratory. Apparently isolated from the world as we know it, for perhaps millions of years, they might be regarded as a threat, perhaps of past diseases or plagues which they might carry. But the many people who have unwittingly handled

permafrost samples through the years do not seem to have suffered. On the other hand such bacteria may give clues to the very origin of life in holding the secret, if not of eternal life, at least of delaying mortality.

Fredrickson and Onstott (1996) review the many questions raised by evidence of living microorganisms deep in the earth's crust, notably where temperatures are high and water scarce. Kushner (1978) reviewed bacterial activity at temperatures near and below freezing point. In this paper, we consider the conditions that occur tens or hundreds of metres down in the frozen layers of the earth - the permafrost. Rather than reexamining the individual cases reported (a few of which are from a century ago) cited by Gilichinsky and Wagener, we consider present-day knowledge of frozen ground as an environment and its implications for the physiology of psychrophile (cold-loving) bacteria and other organisms. For example, are living bacteria as old as the permafrost itself or can contamination with more recent bacteria have occurred? Do the bacteria reproduce in the permafrost? Where in the microstructure of frozen ground are the bacteria actually located? And to what extent are 'normal' metabolic processes taking place? - or are they inactive and cryopreserved?

Answers to such questions are important. The survival of DNA in organisms over hundreds of thousands of years has great significance in studies of evolution (Tiedje, 2001). Perhaps the possibility of survival of pestilential organisms in old burial sites should not be too lightly dismissed. Conditions on Mars are such that the recent evidence of moist, frozen soils there (Kargel and Strom, 1992), suggests these are the most likely, perhaps only, situation where life could exist on that planet in a