ANTARCTICA NEW ZEALAND INFORMATION SHEET

LIFE IN EXTREME ENVIRONMENTS

The presence of liquid water is essential for life and away from the coast this is scarce. Few life forms exist in the high altitude polar ice cap where liquid water is absent and mean annual temperatures are less than -30°C. However, at the margins of the continent and over the surrounding seas mean annual temperatures fall in the range -10 to +5°C. Within this temperature range dramatic changes occur to the properties of water as it shifts back and forth from the solid to the liquid state, often in association with marked changes in salinity. The shift in the properties of water from the solid to the liquid state occurs over a very small temperature range and yet has enormous implications for natural ecosystems.

In the sea, with its constant low temperatures of -1.8°C, biological communities are geared to the annual cycle of sea-ice formation and melt with its attendant fluctuations in light penetration, brine formation and the physical barrier it imposes on wind mixing of the underlying water. In contrast the structure of terrestrial and shallow water inland communities is geared to survival in conditions of extreme cold and of marked fluctuation in the state of hydration and of salinity. Limited bio-diversity induced by extreme environmental conditions inland provides an opportunity to study whole ecosystem processes in a way not possible in complex ecosystems at lower latitudes.

Behavioural, anatomical, physiological and genetic adaptations to Antarctic conditions, both marine and terrestrial, characterise an extreme in the spectrum of earth's life forms. It is organisms in extreme environments that are likely to respond the most to large-scale phenomena such as regional or global changes. Responses of Antarctic species and ecosystems therefore provide indicators of change (see Theme 1A and Theme 4C). Understanding of Antarctic biological processes such as freezing resistance will also provide a vital stimulus to diverse biotechnology industries.

While low temperatures are clearly the dominant environmental influence in Antarctica we still know little of the physiological mechanisms of cold tolerance. Research is lacking on basic functions such as the biochemical pathways, which allow cellular freezing and prevention of membrane rupture in sub-zero temperatures. The combined effects of cold, desiccation and high salinity pose very harsh conditions for life in many Antarctic ecosystems. These interactions require further study. Long periods of darkness and continuous light, particularly under the influence of enhanced UV radiation during the period of ozone depletion provide a further set of extremes. The non-linear nature of ecosystem functioning means that small changes in temperature can markedly affect the length of time that water is in a liquid or solid phase in Antarctica with obvious important consequences for natural ecosystems.

Research into cold-tolerant bacteria, cryo-preservation and production of novel chemicals by diverse Antarctic organisms is of potential value to fishing, agriculture, aquaculture, medical, and pharmaceutical industries. Our ability to detect life elsewhere in space will be enhanced by increased knowledge of organisms in extreme environments.

Living in Antarctica represents a physiological challenge to the human organism. While there has been a considerable amount of research into short-term adaptation to extremely cold climatic conditions and (somewhat longer-term) adjustment to unusual photoperiodicity, very little investigation of these factors has taken place during long-term and naturally occurring field deployments. Research into this area addresses some fundamental questions regarding the nature of human biorhythms and the ability to survive, and thrive, in extreme and unusual conditions.