Antarctica's smallest inhabitants.

Life on Earth always needs water, even in Antarctica where the most abundant life is found beneath the thick ice covers of its numerous ponds and lakes. These inland watery habitats are home to permanent populations of micro-organisms These dominate the continent even more than the large, summer visitors (e.g. seals, penguins) found at the coast.

Consequently it is micro-organisms which should be the true icons of Antarctica, with favourable streams, lakes and patches of soil, rock, ice and snow able to provide a suitable habitat.

Also Antarctica is so large that even though the percentage area of exposed rock and soil is small, in summer it equals the area of New Zealand's Canterbury province.

Small forms of Antarctic life.

Besides microscopic bacteria, fungi and viruses Antarctica is home to three other groups of tiny organisms:

1.Algae

Algae are free - living and widespread in Antarctica and although individual algae are microscopic some aggregate into large green or brown mats on the bottom of lakes and ponds. That such large mats form in such cold water, seems unusual, but in Antarctica this is possible as there are so few animals feeding on the algae.

The most common type of algae in Antarctica are those that first evolved three billion years ago. Called 'blue - green algae' they are really bacteria that can photosynthesise like plants.

An adaptation shown by such micro-organisms is to dehydrate themselves, which prevents damaging ice crystals forming within their cells. Remarkably, with the first drop of water in the spring, these dried specimens can be photosynthesising again within thirty minutes.

2. Lichens

Many Antarctic lichens are drab, dull and inconspicuous, but a few are brightly coloured, especially where birds fertilise the rocks. Each lichen is made up of several organisms, a fungus and one or two species of algae. The algae photosynthesise and produce food for the fungus, whereas the fungus protects the algae from intense light, while retaining water and minerals. About 420 species of lichen have been identified in Antarctica, with about 75% occurring near the coast.

3. Mosses

Mosses are low growing plants that can absorb water and nutrients over their entire surface. Such a system also means water is easily lost, yet many moss species survive long periods of dehydration. For photosynthesis mosses require a good supply of water, and temperatures above freezing, which means Antarctica provides only five to fifteen weeks of growth each year. During this 'growing season' only half a millimetre of growth may be achieved, but in some wet sub - antarctic sites mosses can, over centuries, develop layers of peat up to 2.5 metres deep.

Lake Fryxell in the McMurdo Dry Valleys abounds with life in the water below the ice.

Antarctic lakes - sanctuaries for life.

The unique and varied lakes of Antarctica provide unusual habitats, in which micro-organisms can flourish.

1. The 'Dry Valley' lakes.

The lakes of the McMurdo Dry Valleys were first discovered by Robert Falcon Scott and his companions in 1903 when they walked down into the head of the Taylor Valley from the Antarctic ice sheet. During their short visit they were struck by the presence of large, deep lakes that:

- were permanently capped by a thick layer of ice
- had a moat of open water in summer
- had water inflows, but no outflows.

We now know that with up to a seven metre thick ice blanket protecting the water from wind and waves, the upper waters of these lakes mix slowly and the deeper water is so salty and dense it does not mix with the water above. Although little sunlight penetrates the icy surface, over long periods there has been sufficient energy to have warmed the deep saline layers making them warmer than the surface waters. This layering or '*stratification*' of the lake waters, due to temperature and salinity, results in different micro-organisms being found at different depths.

Lake Vanda in the Wright Valley provides a striking example of this stratification, throughout its 70 metre depth. The upper fresh water hovers around 0°C and has high concentrations of dissolved oxygen, whereas the dimly lit bottom water is three times saltier than the sea, lacks oxygen and is a surprisingly warm 24°C.

Snow landing on Lake Vanda's clear ice is quickly blown away by strong winds, hence much of the light striking the lake ice is transmitted to the water below. The striking deep blue - green colour of Vanda's water is due to red and orange wavelengths being absorbed nearer the surface, while the other wavelengths penetrate deeper.

Surprisingly more photosynthetic micro-organisms are found in the dimmer depths, as the surface water is so pure it lacks sufficient nutrients. However the deepest water lacks oxygen, so is populated mainly with anaerobic, decomposer bacteria which produce hydrogen sulfide.

This hydrogen sulfide supports the growth of other types of bacteria, some of which combine it with oxygen to produce sulfates and water. These chemical reactions release energy, which is then used to make larger organic molecules from carbon dioxide. In this way some bacteria living at the bottom of Lake Vanda are able to manufacture their own food, without the need for sunlight.

2. Life within the surface ice.

The ability of Antarctic micro-organisms to survive extreme habitats is shown by their presence in the ice covering its lakes. Micro-organisms enter this icy habitat as dark fragments from colonies that either blow onto the lake and melt their way downwards, or as bubble covered fragments that float up through the water and move up through the ice as new ice forms beneath.

The proliferation of micro-organisms in lake ice can be seen within the 19m thick ice of Lake Vida, another McMurdo Dry Valley lake, where there can be up to 2 million micro-organisms in each millilitre of ice. Remarkably these populations of micro-organisms represent generations extending back over 2800 years.

3.Lakes beneath the ice.

Most of the liquid fresh water in Antarctica lies beneath its massive ice sheets and glaciers. This water lies in more than 380 hidden 'sub - glacial' lakes which hold almost eight percent of Earth's total lake waters.

Lake Vostok is one such lake being approximately 250km by 50km, with water 670m deep. Despite the cold this water stays unfrozen, due to geothermal heat from below and the immense weight of nearly 4km of ice above - creating pressures 400 times that of the surface.

The upper layer of the Lake Vostok is composed of a 200m thick zone where lake water has refrozen onto the moving ice - cap above. An ice drilling programme based at Vostok Station has removed a 3623m ice core, stopping 120m above the lake surface to avoid contaminating Lake Vostok itself, with surface micro-organisms. However even at this depth the refrozen lake water contains up to seven times more bacteria than the glacial ice above, suggesting Lake Vostok is home to numerous micro-organisms.

Examination of DNA from these micro-organisms in the ice cores has revealed a wide range of bacteria, including those which use energy from chemical reactions, rather than sunlight, to fuel cell processes. As similar bacteria are found in surface hot springs it suggests any food chains present are driven by the energy from geothermal hot spots below.

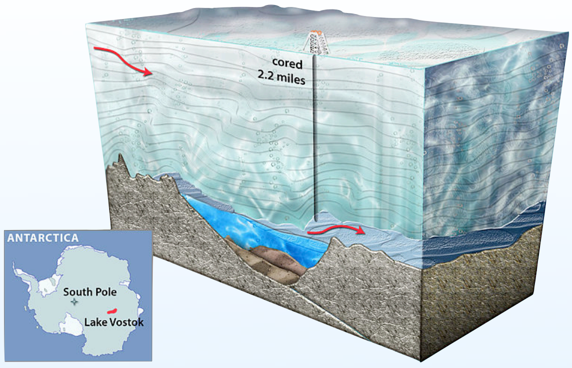
If such food chains do exist they are likely to have evolved independently for over a million years. Consequently, through international agreement, deeper drilling is currently banned to avoid accidentally contaminating Lake Vostok's unique waters with chemicals or new micro-organisms. Another large sub glacial lake, Lake Ellsworth, will probably be sampled in the summer of 2012 - 13.

Cryoconites

Within the ice of glaciers, lakes and ponds are vertical, water filled holes that vary from a few centimetres to a metre wide or deep. At their base is a a thin layer of sediment, hence their name *Cryoconites,* meaning "cold rock dust". They can form quickly over a few days, when dust or rock is blown onto the ice and its darker colour means it warms more easily, causing it to melt its way downwards. Water at the pond surface can freeze to form a lid of ice, resulting in the ponds becoming entombed beneath the glacier surface,and repeatedly freezing and melting for years.

Although a cryconite may seem an extreme habitat in which to live, conditions inside are often more favourable than those on the surface, consequently they often contain communities of micro-organisms and small invertebrate animals.

Such communities must still tolerate freezing over winter and the freeze - thaw cycles of summer. Another challenge within these watery columns is that the only nutrients available are those in the little sediment at their base and what can be obtained from the air, by organisms such as nitrogen fixing bacteria (e.g. the blue - green algae *Nostoc*, which is common within cryconite ponds).

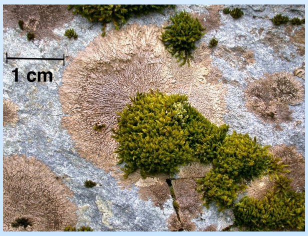


Sampling the 'sub - glacial' waters of Lake Vostok involves removing a 3.6 kilometre (2.2 mile) core of ice from a moving ice sheet.

Practical Challenges

1.Mosses and lichens

In Antarctica mosses live in damper places than lichens. Carry out a physical search to see if this is also true in New Zealand. Be sure to present some data that backs up your answer.

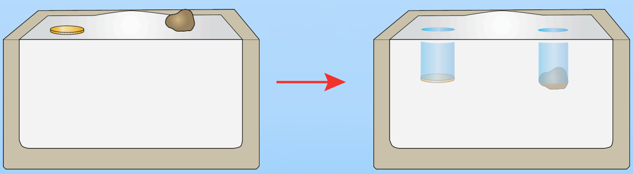


Green mosses and pinkish lichens growing on a rocky surface

2. Freeze - thaw cycles.

The warming of dark material that is sitting on ice, is an important step in the formation of Cryoconites. Carrying out the following simulates this process:

1. Freeze an ice cream container full of water.
2. Wrap an insulating material (e.g.thick layers of paper or cloth) around the base and sides of the container, to reduce melting at these surfaces.
3. Place a teaspoon of soil, a stone, a coin or metal washer on the icy surface and leave in the sun for five to twenty minutes.



Extension: In Antarctica a cryconite can form in a few days. Using cycles of freeze and thaw investigate what factors are required to produce a water filled column that has sediment at the base and a lid of ice.

Adapted from material by *Paul Broady, University of Canterbury* by *Donald Reid, iMatters.co.nz* in association with *Gateway Antarctica, University of Canterbury.*
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