ponding to the variable part of pilin. The enzymatic mechanism that effects the required intragenic recombination events is also unknown. It will be interesting to discover whether specific enzymes exist for this purpose or whether the normal generalized recombination system of the gonococcus is sufficient.

It should be remembered that pili are only one component of a complex armoury of virulence determinants expressed by the gonococcus. One such determinant is principal outer membrane protein II (PII or Op), which also undergoes both a phase change and antigenic variation. Interestingly, *opa*, the structural gene for this protein, is located within 1 kilobase of *pil*E1, although the two genes do not seem to be coordinately regulated nor are gross genome rearrangements involved in the modulation of expression[6].

The genetic mechanisms used by *N. gonorrhoeae* for alteration of pilus type have parallels in other parasites that exhibit antigenic variation and in processes such as the generation of immunoglobulin diversity. Much of the evolutionary success of this pathogen, which has no host other than man, may be attributed to its complex devices for ensuring variation in its major surface antigens. □

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Polar studies

History of an Antarctic lake

from David A. Peel

DESPITE its immense ice-cap, Antarctica is in fact a polar desert where extremes of cold and aridity have created several unusual features. Since the earliest days of exploration, scientists have been fascinated by more than 20 ice-free areas or oases, which are now known to occur where local weather conditions determine that the overall rate of ice sublimation from the surface exceeds the annual rate of snowfall. These areas are completely free of ice providing that local geographical barriers prevent ice flow from a neighbouring area where it is accumulating. Within these dry regions, perennially ice-covered lakes are fairly common, but in many cases satisfactory models of their histories and physical characteristics have yet to be developed. On page 131 of this issue, Hermichen *et al.*[1] present new isotope data from a large freshwater lake in East Antarctica and demonstrate that the present-day lake is the concentrated residue of a body of water originally more than 50 times larger.

The perenially ice-covered lakes of the Antarctic show some unusual chemical and physical properties[2]. Normally highly saline, although basically of freshwater origin, they occur in areas where the mean annual air temperature is around minus 20°C. They are usually covered by a relatively thin layer of ice overlying water which is at least 20°C, and sometimes up to 50°C, warmer than their surroundings. As the occurrence of life depends on the presence of liquid water, the lakes have been a focus of interest for biologists seeking to understand the adaptation of organisms to extremes of temperature[3]. Although the general morphology of the lakes has been understood for some time, they are individually a result of often quite complex histories.

One basic physical characteristic that has a direct bearing on the biological productivity of a lake, the thickness of the ice cover, has been modelled recently[4]. It has long been known that for lakes that are not frozen to the bottom, the ice thickness is relatively constant from place to place despite wide variations in the temperature and chemistry of the water. More than two decades ago it was suggested[5] that solar heating was probably the main source of energy for the Antarctic lakes, with a skin of exceptionally transparent ice at the surface of the lake acting rather like greenhouse glass. Each summer, melt water flows into the lakes beneath the ice, balancing water lost by evaporation from the ice on the surface. Under steady-state conditions, it has been suggested that each winter a thickness of ice freezes onto the base of the floating ice, generating latent heat which balances the loss of sensible heat through the ice cover.

McKay *et al.*[4] have recently developed a simplified model of the energy balance at the surface of Antarctic lakes based on analysis of annual average heat fluxes. The thickness of the ice cover is apparently sufficient to damp out most of the seasonal variations in the fluxes of heat from sources and sinks. Using actual measurements of solar flux and albedo values from one of the best-studied lakes (Lake Vanda, southern Victoria Land), and direct measurements of the typical light-transmission characteristics of the ice, these authors have been able to predict the equilibrium ice thickness as a function of the surface ice ablation rate. They found that this rate of ablation is the prime control of ice thickness; measured ablation rates of around 30 cm per year lead to predicted equilibrium ice thicknesses in the range of 3-4 m, in good agreement with what is observed. Lakes at higher altitudes lie closer to the snow line and suffer less ablation; moreover, the ice is often anchored to the bottom and hence the latent heat contribution from refreezing melt water ceases to be an important factor. In these lakes much greater thicknesses of ice can be maintained under a given air-temperature regime.

Analysis of the stable isotope composition of lake waters has proved to be a valuable tool in deciphering the evolution of present-day water systems[6]. Lake Untersee, the subject of the study by Hermichen *et al.*[1], was first probed by a Soviet team in 1969. The lake has an area of about 10 km^2 and lies in an region of high ablation (about 20 cm per year). Refreezing of melt water supplied by the adjoining glacier leads to an equilibrium ice cover which is 2.5 m thick. It is difficult to envisage how such a large volume of fresh water could have accumulated under present-day climatic conditions (the average temperature is roughly minus 20°C). Both the stable isotope data and the lack of any evidence for modern tritium indicate that the water has originated from the melting of old glacier ice. In this case, the concentration of salts in the relatively saline water now found can be accounted for if the present-day body of water is the residue resulting from the evaporation of a volume originally more than 50 times larger. The new isotope data provide some additional support for this idea. The present-day water is isotopically lighter than the snow that currently falls in the catchment area of the lake. Furthermore, the composition with respect to the Meteoric Water Line (a steady relationship between $\delta^{18}O$ and $\delta^{2}H$ generally observed in atmospheric precipitation, which reflects mainly equilibrium fractionation of the isotopes) is displaced in the direction of preferential depletion of ^{18}O. Both results can be explained satisfactorily if it is assumed that the water has been lost from the lake by sublimation of ice from the upper surface. The isotope composition of the sublimating water is then determined by isotope exchange during the freezing of water where ^{18}O is preferentially deposited. The indications are that this process has been proceeding more or less continuously since a period of warmer climate in the early Holocene. There are signs of biological primary production in Lake Untersee; future studies of organic deposits on the lake bed may help to trace the lake's evolution. □

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