Recent meetings

CRYO'90 –An Adventure in the low temperature sciences: State University of New York, Binghamton, New York, 17–23 June 1990

The Meeting was most ably organised by the Center for Cryobiological Research at the Binghamton SUNY campus. It was unique as the first occasion on which three scientific groups had met: the Society for Cryobiology, the Cryogenic Society of America and the Symposium on Invertebrate & Plant Cold Hardiness. It provided an unusual interdisciplinary base for scientific discussion on all aspects of low temperature life sciences and engineering. The international Society of Cryobiology is concerned with the biomedical sciences and focuses on problems related to cell, tissue and organ preservation, the behaviour of 'biologics' at sub-ambient temperatures, and the biophysics of water. The Cryogenic Society of America is a scientific and engineering group in low temperature physics and engineering, especially superconductivity and its applications, cryogenic heat transfer, low temperature materials properties, storage of cryogens and cryogenic fuels and propulsion systems. In contrast, the International Cold Hardiness Symposium, holding its fourth meeting (the first in the USA), brings together an interdisciplinary group of biochemists, ecologists, physiologists and cell and molecular biologists to discuss topics related to biological adaptations to extreme environments. Both the Arctic and Antarctic figure prominently in this area.

A primary goal of the meeting was to stimulate a better understanding of the fundamentals of each scientific speciality and to provide a forum for interdisciplinary interaction. It certainly achieved this by having symposia with invited speakers, contributed papers in both oral and poster formats, plenary lectures, a workshop (Applications of differential scanning calorimetry in the physical and life sciences), a conversazione and an exhibition of techniques and commercial equipment for use in the cryosciences. Throughout the week, there were some 181 oral presentations and 56 posters displayed. Symposia were held on topics such as proteins at low temperature, effects of low temperatures on lipids and membranes, aqueous glasses and cryobiology, protein-ice interaction, and biochemistry of and at low temperatures. A scientific feast indeed, with something to suit everyone's taste! If these were not sufficient, the many other sessions covered topics from cryoinjury and cryopreservation of organs to cryoprotective agents and cryogenics, and vitrification. On the biological side, there were sessions on the ecophysiology of low temperature adaptation, freezing tolerance, together with applied aspects of invertebrate and plant cold hardiness.

This is not the place to report in detail on the presentations (full abstracts are to be published in Cryobiology later), but it is appropriate to single out a few personal highlights, which to me as a biologist, are some of the areas where recent advances have been made. The indication that water relations and cold hardiness in certain insects are closely interrelated (a fact not widely appreciated) came across clearly, whilst the beginnings of a breakdown of the established 'dogma' of an organism being either freezing tolerant or intolerant were heard in some of the lecture halls. An interesting applied note was reported by scientists who had manipulated ice nucleating agents, such as bacteria, to alter the supercooling and freezing characteristics of arthropods (following in the footsteps of Stephen Lindow, ice-minus bacteria and strawberries). The idea that the glassy state could form the basis of an alternative strategy of cold hardiness in some plants and poikilothermic animals is gaining ground, whereas studies on the freezing tolerance of small cold-blooded vertebrates such as frogs, turtles and snakes proceed apace. Who could resist attending a lecture by Ken Storey anyway, even if it had the title "Frozen vertebrates - life in the slow lane"?Of particular interest to polar biologists were the clutch of papers on the theme of water relations, cold tolerance and desiccation resistance in insects by R A Ring (Victoria), R Lundheim (Trondheim) and P M Harrisson (Cambridge), whilst metabolic adaptations of polar and alpine arthropods were considered by L Sømme (Oslo) *et al.* Freezing tolerance and intolerance was reported in Antarctic nematodes by J Pickup (Cambridge), whilst the mechanisms of invertebrate survival at sub-zero temperatures were considered by W Block (Cambridge). On the applications side, J Bale (Leeds) spoke on the implications of cold tolerance for insect pest management. Finally, a discussion group held by the Cold Hardiness Group at the end of this intensive week considered the opportunities for future research co-operation in the Arctic. The lead was taken by Canadian biologists outlining the logistic and research facilities which are available in their area of the Arctic (over 50 field stations can be accessed for summer work). They are currently formulating a programme in Arctic terrestrial biology and seek international research support (interested workers should contact Dr R A Ring, Department of Biology, University of Victoria, B.C., Canada). In the UK, the Natural Environment Research Council has initiated a Special Topic Programme in Arctic terrestrial ecology centred primarily at Svalbard and beginning in 1991, whilst Denmark, the Federal Republic of Germany and many other nations were developing biological programmes at other Arctic locations.

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Role of the Polar Regions in Global Change. Fairbanks, Alaska, 11–15 June 1990

The International Conference on the Role of the Polar Regions in Global Change was hosted by the Geophysical Institute and Center for Global Change and Arctic System Research of the University of Alaska, Fairbanks. This was a timely multidisciplinary meeting drawing on almost all aspects of the physical and natural sciences in polar regions. Well over 300 scientists attended and this necessitated division of the programme into seven technical sections; titles ranged from "Detection and Monitoring" to "Paleoenvironmental Data". There was a series of informal workshops too, and the meeting closed with an attempt to summarize the proceedings in a series of panel discussions.

Historical aspects

Intuitively, one would expect the polar regions to be good places to investigate climatic changes through time. Their massive ice sheets fluctuated demonstrably in response to the Quaternary glacial cycles and both they, and their attendant sediments and biotas, should bear clear traces of major climatic events. And yet it should always be remembered that these events were global phenomena, with many leaving clear traces in lower latitude regions. Even in the tropics there are detailed records of Quaternary climatic changes and some might argue that our resources would be better spent on investigating glaciers, lake cores, palynological records etc. in more accessible localities. In particular, it is important to bear in mind that Pleistocene climatic records from both deep sea sediments and uplifted coral reef tracts have been used with great success to test the astronomical theory of climatic change.

If, first of all, we go back in time in terms of hundreds of years, one of the most intriguing phenomena to be investigated is that of the Little Ice Age (LIA). Perhaps the first point to be made here is that it followed a less well publicised Medieval Optimum (circa 1000-1200 AD); were the Crusaders concerned about global warming?! Anyway, it would appear that the effects of the ensuing "Ice Age" were well marked at high latitudes. P.E. Calkin and G.C. Wiles (Buffalo, N.Y.), using both lichen and tree-ring dating techniques, have been able to document a pronounced glacial advance between 1350–1500, a recession at ~1600 and marked retreat by the mid-1700's. The latest re-advance was in about 1890 and since then the story has been one of continual retreat. It is readily apparent too that the LIA was a truly global event whose imprint was even recorded in the Antarctic ice cap. E. Mosley-Thompson and L.G. Thompson (Columbus, Ohio) have ice core samples from both Siple and South Pole stations that enable $\delta^{18}O$ and dust particle records to be traced back in detail over the last 500 years.

Tree-rings would seem to be another good bet for investigating the recent past, but their study is necessarily restricted to the northern high latitudes. Somewhat alarmingly, G.C. Jacoby and R.D. D'Arrigo (Palisades, N.Y.) used North American data to suggest that there had been an unusual warming over the past century relative to the last 400 years. Particular importance is now attached in tree-ring studies to the analysis of maximum latewood densities, a feature which may well be more sensitive to temperature than ring widths *per se*. L.J. Graumlich (Arizona) also concentrated on high latitude tree-rings, showing how they documented valuable information on ecological responses to climatic change. Processes such as population expansions and contractions, for example, may well have important implications for atmosphere-biosphere exchanges of CO_2. Recent studies have shown that seasonal variations in tree growth in the North American boreal forest are correlated with CO_2 draw-down at Point Barrow, Alaska. Palynological studies should not be forgotten either, as P.M. Anderson (Seattle) showed how various pollen types were sensitive palaeoclimatic indicators within tundra and boreal forest ecosystems.

Even more intriguing phenomena can be discerned if we go back in time over periods of tens of thousands of years. This is the time span covered by ice cores and it is perhaps this technique, more than any other, that has revolutionised recent approaches to palaeoclimatology. In an important review paper, C.Lorius (St Martin d'Hères, France) reminded the audience of the major advances that had been made by studying two deep cores from Greenland; collectively these cover a full glacial-interglacial cycle of some 150 kyr. The long Vostok core in particular was instrumental in demonstrating that, over this period of time, earth surface temperatures had fluctuated by as much as 10°C. Moreover, these fluctuations were cyclical and had periodicities strongly indicative of Milankovich orbital forcing. However the story does not end there, for it is now known, from analysis of trapped air bubbles within the ice, that concentrations of certain greenhouse gases have covaried with temperature. There is a truly remarkable correlation between glacial-interglacial temperature changes and the inferred atmospheric concentrations of both CO_2 and CH_4.

If there has been a weakness with the orbital forcing theory then it is that the changes involved hardly seem to have been strong enough to account for some of the very large, and rapid, changes in temperature. This has led to the idea that greenhouse gases in some way amplify the astronomical shifts. It is quite obvious, from the Vostok core, that large temperature changes are precisely linked to large shifts in both CO_2 and CH_4, but quite how this is accomplished is still uncertain. It must surely involve processes such as marine production of CO_2, oceanic circulation and production of CH_4 from natural wetlands (see below).

And what of the world's smaller ice caps; how useful are they for palaeoclimatology? R.M. Koerner (Ottawa) and collegues have been investigating Canada's ice caps, and have cores that may go back 100 kyr. Unfortunately, these caps are comparatively thin and resolution in ice older than 5–10 kyr is poor. Nevertheless, this is compensated for by the fact that it is comparatively easy to retrieve pollen from all stratigraphic levels, and this has enhanced considerably palaeoenvironmental interpretations. R. Vaikmäe's (Estonia) studies have centred on intermediate depth cores from Svalbard, Severnaya Zemlya and the margins of the Antarctic ice sheet. He has been using $\delta^{18}O$ to delineate climatic events over the last 8 kyr, and finds a reasonable degree of correlation between northern and southern hemisphere sites. N. Reeh and colleagues from the Alfred Wegener Institute (Bremerhaven) have been looking into alternative ways of studying ice sheet history. Working in Greenland, they have discovered that pre-Holocene ice is present extensively around the ice sheet margins. At one West Greenland locality they have a long $\delta^{18}O$ record which may extend as far back as the penultimate glacial period (the Illinoian). It can be used, in conjunction with drillcore material, to extend the Greenland temperature record back 150 kyr.

Finally, we can go back in time over spans of millions of years; how useful then are the polar regions for assessing climatic change? D.H. Bromwich and colleagues at the Ohio State University took as their starting point a recent General Circulation Model (GCM) which concluded that elevation and polar position, rather than thermal isolation by a circum-polar current, led to the onset of Antarctic glaciation. Now, such a theoretical prediction seemed to these authors to conflict with certain geological evidence from the centrally located Transantarctic Mountains (TAM). This major topographic feature seems most likely to have been the product of progressive elevation over the last 50 Myr (at an estimated average rate of 100m/Myr). However, as recently as the late Pliocene period (approx. 3 Ma) there is evidence to suggest that there were open marine conditions across parts of East Antarctica and *Nothofagus* macrofloras within the TAM. In other words, substantial elevation did not lead to complete continental glaciation and other factors must be involved. Alternative GCM's, based on atmosphere-ocean interactions may be more appropriate.

The importance of a significant late Pliocene global warming may have been underestimated in the geological record. P.F. Barker and C.J. Pudsey (BAS) have been investigating the climatic record of Antarctic ocean sediments and have taken a series of piston-cores through prograded deposits on the continental shelf and slope. These can be used to track glacial/interglacial changes in ice volume and some of the deepest records bear testament to a Pliocene "greenhouse" world. Even more spectacularly, late Pliocene sediments from Peary Land, Greenland ("the northernmost land on earth") have been shown by J. Böcher (Copenhagen) to contain a well-preserved forest-tundra flora and rich boreal insect fauna.

Some biological aspects

One of the most stimulating themes for biological discussion was potential geosphere-biosphere interactions. If greenhouse gases are amplifying changes produced by astronomical cycles, then precisely how is this achieved?; can the rate of production of gases such as CO_2 and CH_4 be directly attributable to organic activity? One way in which the atmosphere and biosphere could interact significantly in polar regions is through the activity of a global carbon pump. Antarctic seas, for example, may account for some 35% of the total oceanic CO_2 flux, with phytoplankton (principally diatoms), faecal pellets and invertebrate moults contributing particulate carbon material from the euphotic zone to deep water. H.J. Marchant and A.T. Davidson (Tasmania) reviewed biogenic carbon flux in the Southern Ocean and found that the most productive region is the marginal ice edge zone. However, the timing of the near-shore phytoplankton bloom coincides with stratospheric ozone depletion and it is apparent that certain species could now be under considerable UV stress. The importance of sea ice zones to polar marine productivity was further underlined by C.W. Sullivan (Los Angeles). Major tropho-dynamic and biogeochemical cycles are housed within this extensive, but fragile, environment.

The Arctic plays a special role in the global carbon budget too, and talks by W.C. Oechel (San Diego) and W.S Reeburgh and S.C. Whelen (Fairbanks) indicated that some 30% of the terrestrial soil carbon reservoir is contained within tundra and boreal forest environments. A large fraction of this carbon is immobilised within permafrost and peat, but exposure to warmer and wetter climates could lead to biogeochemical conversion to CO_2 and CH_4. Detailed field measurements have shown that certain tundra sites consume methane during the autumn and that emission of it virtually ceases during frozen periods.

Observational and modelling studies of change in the atmosphere/ocean/ice system

Studies concerned with the detection of change in atmospheric/ocean temperatures, circulation patterns and in the extent of sea ice have received much coverage in the literature over the last few years. At this meeting there were many papers concerned with reviews in these areas and presentations of the latest results. Sea ice has often been cited as a sensitive, high latitude indicator of temperature change and there were several presentations on observational work using *in-situ* and satellite data. Peter Wadhams (Scott Polar Research Institute) gave an invited paper on sea ice thickness changes and concluded that the very limited amounts of data on sea ice thickness did not show any systematic decrease that could be attributed to greenhouse warming. He suggested that the variations seen may be due to changes in atmospheric flow from year to year. C.L. Parkinson and H.J. Zwally

(NASA Goddard) considered the role of remote sensing data in sea ice studies, using mainly passive microwave imagery. Parkinson said that the data had shown a decrease in Southern Hemispheric sea ice during the 1970s but an increase in the 1980s. Zwally noted that the total 15 year record of Antarctic sea ice data had shown no overall trend.

Computer models are some of the most powerful tools for investigating the complex interactions between the atmosphere, ocean and cryosphere. They also provide a means of examining the possible impact of man's actions on the system. Yet the very complexity of the environment and the small scale of many of the processes involved makes great demands on computer resources. Results from one modelling experiment were presented by W.F. Budd (Melbourne). He had used a linked atmosphere/ocean/sea ice GCM to study the impact on the Antarctic of doubling CO_2. He reported a 20 to 40% increase in precipitation over the Antarctic due to the greater number of cyclones reaching the coast when the sea ice extent had decreased. With increased atmospheric temperatures sea level was predicted to rise, although this was reduced because of the greater precipitation over the Antarctic. The net rise was forecast to be 240 mm.

This review has necessarily been somewhat eclectic and biased by the authors' own particular interests and expertise. We hope, nevertheless, that it has managed to convey something of the fundamental importance of the polar regions to a proper understanding of global change. Of course, climatic changes can be studied at almost any point on the earth's surface, but there is a whole series of fundamental physical and biological processes that can only be fully investigated in the Earth's highest latitude regions.

In a plenary address to the recent "Britain in the Arctic" meeting (held in Cambridge, UK in April 1990), Professor E.R. Oxburgh estimated that it was 10-20 times more expensive to conduct scientific research in polar regions than elsewhere. This high cost can only be justified if there are scientific phenomena within these regions of truly global significance. On the evidence of this meeting, this would certainly seem to be the case.

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