present, it is unclear whether it infects the proliferating spindle cells which make up the bulk of a KS lesion, or another cell population, thus inducing the proliferation of endothelial cells in an indirect manner, perhaps comparable to that of Tat. The role of the virus in KS could also be similar to that of EBV in some cases of Hodgkin's disease: the persistence of EBV in a latent stage in Reed Sternberg cells may be related to the pathogenesis of this disease, although there remains a possibility that it is a passenger. Finally, in view of the particularly aggressive course of KS in AIDS patients, it may be that HIV and the new virus act additively during the development of KS lesions.

HIV thus appears to make two distinct contributions to the emergence of KS, immune suppression and Tat secretion; yet by itself it is not sufficient to cause KS, as KS seldom occurs in HIV-infected haemophiliacs with AIDS. The new virus may therefore be viewed as a sexually transmitted virus which is relatively common in gay men and is an opportunist in HIV infection. Epidemiological surveys using serology and PCR will determine whether that view is upheld. □

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CLIMATE CHANGE

# Ice sheets and sea level

*David Bromwich*

THE great ice sheets covering Antarctica and Greenland lock up vast quantities of water extracted from the world's oceans, and so have the potential to affect global sea levels considerably. In the short term, it is the precipitation rate over the ice sheets that determines their varying impact on sea level. On page 52 of this issue, Kapsner *et al.*[1] look at the records of past precipitation and temperature changes from a Greenland ice core, and conclude that temperature changes alone cannot explain the changing rates of snowfall seen in the core. Changes to the dominant storm track, on the other hand, could easily have produced the differences in precipitation.

## Quick change

The ice sheets are roughly in balance between ice input from precipitation and ice loss in the form of run-off and iceberg calving from the margins[2]. The exact state cannot yet be determined for either ice sheet. Ice-sheet precipitation removes about 7 mm $yr^{-1}$ per year from the ocean, and is large in relation to the present 2 mm $yr^{-1}$ per year of global sea level rise[3] (the relative contributions of thermal expansion, melting of valley glaciers, ice sheets, and so on, to sea level rise are uncertain). There is no contradiction here — precipitation rates can change quickly whereas the ice sheets' response to the changed mass input takes much longer.

On timescales of years to decades, the precipitation changes determine the variations of ice-sheet impact, with those over Antarctica apparently dominating[4]. So, when considering the consequences of the steady atmospheric build-up of greenhouse gases such as carbon dioxide, we should also consider what controls precipitation rates over the polar ice sheets.

To examine the controls on precipitation over Greenland for the past 18,000 years as an analogue for the future, Kapsner *et al.*[1] analysed the annual accumulation rate of snow (nearly equal to precipitation) over central Greenland derived from the thickness of annual layers in the GISP2 deep ice core. The time control is particularly good for this interval, so a reasonably accurate annual time series of layer thicknesses can be derived. After correction for the thinning of the layers by the gravity-driven flow of ice, the annual accumulation rate results. The record shows moderate variability within climate epochs such as the Holocene (the past 10,000 years) and the Last Glacial Maximum (more than 15,000 years ago). Rapid transitions of accumulation rate between climate states take place in a few years, particularly from 'cold' to 'warm' states. The transition from warm to cold is not nearly so large or rapid.

Next Kapsner *et al.* considered the relationship between temperature variations and snowfall variations. Temperature is inferred from the stable oxygen isotope composition of the ice ($\delta^{18}O = (^{18}O/^{16}O)_{sample}/(^{18}O/^{16}O)_{standard} - 1$), as these are closely correlated for the present climate at high latitudes[5]. Because $\delta^{18}O$ is actually a consequence of the atmospheric hydrological cycle (evaporation from the ocean, transportation to and recycling along the path to the ice sheet, and the precipitation processes), problems with the correlation appear on close examination[6]. In other words, correlation does not necessarily imply cause and effect. When the climate states change, varying moisture sources become a real and complicating possibility[7]; thus, the oxygen isotope changes are more reflective of source changes than temperature variations. Nevertheless, Kapsner *et al.* convincingly argue that their basic conclusions are not affected by such uncertainties, at least within climate epochs.

According to simple ideas, the limiting factor on snowfall is the amount of water vapour that the air can hold on average. This certainly holds at least in a very broad sense, as today the annual precipitation amounts decrease by a factor of 20 or more from the Equator to the poles in conjunction with the total atmospheric moisture content decreasing by a factor of roughly 15 (ref. 8). But the comparison made by Kapsner *et al.* showed that average temperature variations alone could not explain the accumulation variations seen on a timescale of decades to centuries in the GISP2 core. We have to look elsewhere for the cause of these changes.

## Storm tracks

Locally, and for a limited range of precipitation change, the situation is essentially one of moisture turnover rather than the amount of moisture the atmosphere holds on average. After all, precipitation generally takes place only a small fraction of the time and often under atypical conditions of temperature and pressure. Precipitation variations may bear little relationship to the average temperature, as modern observations from many middle-latitude areas readily show[9]. Kapsner *et al.* concluded from their comparison that the explanation for the accumulation changes seen in the GISP2 ice core could lie in changes in the behaviour of cyclones affecting Greenland, manifested by shifts in the dominant storm track that today passes close to the island's southern tip.

This conclusion is consistent with studies of the modern variations of precipitation over Greenland, which, because of limited accumulation data and problems with direct precipitation measurements, must be determined indirectly. For instance, my colleagues and I put daily atmospheric analyses from 1963 to 1988 into a simple model and derived a precipitation distribution that matched the pattern and magnitude of most of the main features in the long-term accumulation record[10]. Strikingly, the modelled precipitation showed big year to year increases and decreases that resulted from changes in the position and intensity of the main storm track near Greenland. And, as Kapsner *et al.* found, these changes were not explicable in terms of temperature variations.

Applying these results to the time period studied by Kapsner and colleagues, one finds that it is relatively easy to explain the large accumulation changes between climate states by consistently shifting and changing the intensity of the storm track. Little systematic change within climate epochs would be expected. The between-state changes would probably have been accompanied by dramatic changes in the air temperatures and in the sea surface temperatures and sea ice conditions in the North Atlantic Ocean.

Hall *et al.*[11] last year used a general circulation model to simulate the impact of double the present atmospheric carbon dioxide content on the winter climate of the Northern Hemisphere. In essence, they modelled the global warming problem with an emphasis on the storm track changes. The most marked impact was on the storm track over the North Atlantic Ocean, which was shifted northward and intensified — probably with greater precipitation — in the general area of Greenland, even though only nominal warming was simulated in this region.

The limited accuracy of their model in this area, the concentration on the winter season instead of the summer and autumn when precipitation is at its greatest, and their omission of oceanic changes leave plenty of room for further research and altered conclusions. But this work does provide general support for Kapsner and co-workers' inference that, in a 'greenhouse-warmed world', atmospheric circulation changes may be more important than direct temperature effects in controlling accumulation over Greenland, and thus its impact on global sea level. And, although I have largely been discussing Greenland, storm processes also dominate precipitation formation over Antarctica[4].

The realization that precipitation variability over the polar ice sheets depends on far more than just temperature changes means that predicting the effects of 'global warming' on sea level is not as straightforward as attempted in the report by the Intergovernmental Panel on Climate Change[2]. As implied by Hall *et al.*[11], the precipitation prediction is subtle and involves competing effects. As the spatial variability is high, better predictions will need regional as well as global atmospheric modelling, and many more time series providing representative spatial coverage of Antarctica and Greenland. Glaciological and atmospheric studies need to be integrated, as together they clearly provide far greater insight than either discipline working in isolation. □

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NEUROBIOLOGY

# Cold, pain and the brain

*Wm D. Willis Jr*

THE localization of functions within the brain has been a matter of interest and controversy ever since the debates over phrenology in the early nineteenth century. Modern anatomical, electrophysiological and imaging techniques have allowed the identification of many of the pathways that mediate sensory, motor and cognitive functions. Among the sensory modalities, however, the pathways that mediate pain and thermal sensation remain relatively poorly described. For this reason, the identification of a thalamic nucleus specific for pain and thermal sensation, as described by Craig *et al.* last month[1], represents a notable advance.

Pain and thermal sensations are both conveyed to the brain through the spinothalamic tract, a large bundle of axons running the length of the spinal cord. These axons receive inputs from pain- and temperature-sensitive sensory neurons, and they project to the thalamus, a forebrain structure involved in relaying sensory information to the cerebral cortex. The thalamus contains many nuclei specific for various sensory inputs, but the exact pathways for pain and temperature are poorly defined.

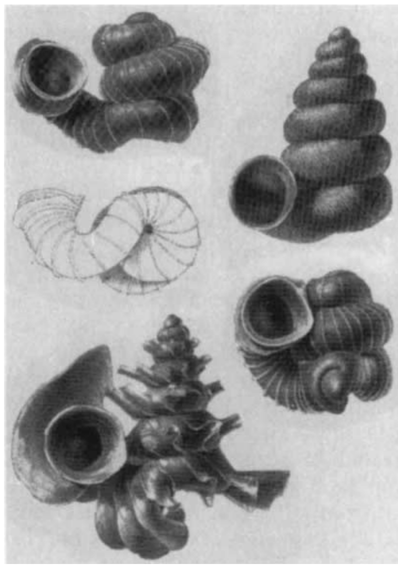
Working with macaque monkeys, Craig *et al.* have identified a nucleus within the thalamus, termeu the posterior ventral medial nucleus (VMpo), that seems to be specific for painful and thermal stimuli. They show by anterograde tracing that VMpo is a target for direct axonal projections from lamina I of the dorsal horn, a region of the spinal cord that is responsive to pain and temperature. They also demonstrate that the great majority of neurons within VMpo respond to painful or cold stimuli. The VMpo is known to project to the insular cortex, which in turn has connections with the limbic system, consistent with the idea that this nucleus conveys the affective component of noxious stimuli.

The VMpo nucleus contains a dense plexus of nerve fibres that express the calcium-binding protein calbindin, and

## On the one hand ...

**THESE snail shells are remarkable snail shells, for they display a hitherto unregarded type of coiling. They are not entirely right-handed (dextral) or left-handed (sinistral), but display elements of both. The specimens are described by J. J. Vermeulen in *Basteria* (58, 73–191; 1994), in a paper dealing with molluscan biodiversity in terrestrial microgastropods of the genus *Opisthostoma* in Borneo.**

**Thirty-one congeneric species had already been identified, and Vermeulen found a further 36 on the island. In shape and sculpture, their shells are among the most bizarre known. The final whorl is not coiled in line with the preceding whorls but is curved in such a way that the shell has the impression of being sinistral even though the rest of it is dextral. Until now, four kinds of snail-shell coiling have been distinguished, because (although this is rare) the soft body parts can be coiled in the opposite direction to the shell: dextral shells containing sinistral bodies and sinistral shells containing dextral bodies are known. Indeed, things are more complicated still, because the larval shell (which is often retained at the tip of the adult shell) and adult shell can have different hands. R. Robertson has discussed in detail the variations possible in theory, and their occurrence in nature (*Natn. Geogr. Res. Explor.* 9, 120–131; 1993).**



J J Vermeulen

**Vermeulen's specimens provide yet a further twist. One might call their coiling 'sinistroid', to contrast with the term 'pseudosinistral' which is used for a sinistral shell containing a dextral body. But why should this odd form become apparent only now? The reason is that these snails are tiny — the specimens shown here are just 1–3 mm wide.**

Edmund Gittenberger

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