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.

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 Change². 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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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 month¹, 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 fore-brain 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, termed 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 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.

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