bibliographical research will be needed.

The dangers of sole reliance on the official records are now clear. For example, Clark and Stephenson have suggested that a phenomenon similar to the proposed Maunder Minimum may have occurred under the Ming dynasty between AD 1400 and 1600. They argue that since contemporary official records of other astronomical phenomena are relatively complete, the gap in the Ming standard history sunspot records for that period must be regarded as significant. However, as we have seen, an identical argument applied to the Ch'ing standard history would lead to the patently false conclusion that there were no sunspots at all between AD 1662 and 1911. Given the civil and military chaos at the end of the dynasty, a section of the Ming records may simply have gone missing in the same way as under the Ch'ing. The work of Xu and Jiang has shown that such points can only be decided after a search of the literature ranging outside the confines of the official sources. As well as the large number of local histories, such a search must attempt to cover the essays and common-place books, *pi chi*, of private scholars likely to have had astronomical interests; the yield from these will be considerably smaller, but still worth the effort. Until the results of such an arduous undertaking become available, judgment must be suspended. □

The 'blueprint hypothesis' of axon guidance

from David I. Gottlieb

DURING the development of the vertebrate central nervous system axons grow over long distances and bypass vast numbers of neurones to home in on a distinct target region where they form synapses with a characteristic subset of neurones. Although it has long been appreciated that axons have some means of recognising their final destination (see *News & Views* **282**, 672; 1979) it needs to be emphasised that axons also take a sterotyped route to their destination, they do not, for example, branch extensively and resorb the collaterals which fail to hit the target. How are these routes through the developing brain marked? Some recent anatomical investigations by M. Singer and his colleagues suggest that certain non-neuronal cells of the regenerating and developing central nervous system may have a crucial role.

Evidence for this view first emerged from anatomical studies of the regenerating lizard spinal cord. Egar *et al.* (*J. Morphol.* **131**, 131; 1970) showed that during the early stages of regeneration the cord consists of an epithelial tube formed predominantly of a single layer of cells called ependymal cells surrounding a central canal in continuity with the original spinal canal. An unexpected and exciting finding was that the distal portions of the ependymal cells (that is, the surface away from the lumen of the central canal) were arranged to form large extracellular channels which contained only an electron lucent amorphous material. During subsequent stages of regeneration these channels became choked with axons growing along the length of the cord and presumably originating from neurones located more rostrally. Similar ependymal channels were found in the regenerating cord of the newt (Egar & Singer *Expl Neurol.* **37**, 422; 1972).

Numerous anatomical investigations of the central nervous system during early development have revealed the presence of large, cell free spaces but these have usually been written off as fixation artefacts. However, in studies of the embryonic newt cord Singer *et al.* (*J. comp. Neurol.* **185**, 1; 1979) found large channels between ependymal cells that bore a striking similarity to those of the regenerating cord. As in the regenerating cord, the empty channels became filled with growing axons as development proceeded. In both regeneration and development the anatomical impression was clear: ependymal channels seemed to guide bundles of growing axons. Singer *et al.* proposed what they call the 'blueprint hypothesis', the central tenet of which is that ependymal channels provide the important cues which guide developing axons and result in the characteristic route taken by the major pathways of the brain. Along similar lines Katz and Lasek (*J. comp. Neurol.* **183**, 817; 1979) have performed experiments in which eyes were grafted onto the trunk of developing frog embryos; axons from these eyes enter the spinal cord and grow for long distances in a highly circumscribed tract near the lateral margin of the cord. Some substrate clues must channel these aberrant axons and ependymal channels seem like reasonable candidates. Evidence for cellular channels has also been found in the embryonic mouse retina (Silver & Sidman *J. comp. Neurol.* **189**, 101; 1980). In this case the channels appear transiently during development and seem to be situated in a way that would guide ganglion cell axons back into the optic stalk as they grow. Doubtless such cellular channels will be found in other regions of the embryonic central nervous system.

Do the channels actually guide growing axons in a way which can explain the characteristic paths of the major tracts in the central nervous system? One problem with this idea is that developing tracts in the embryo are relatively long (from several to tens of millimetres) while we don't really know how long the channels are. Serial reconstruction studies are needed to settle this point. Another is that a clean test of the idea such as altering the channels to see what happens to the tracts seems impracticable. Thus it may be a long time before we know whether ependymal cells carry some of the elusive molecular markers for specificity. Whatever the final outcome, ependymal cells and channels will be objects of lively experimental interest as neurobiologists try to understand how tracts find their way. □

David I. Gottlieb is Associate Professor of Neurobiology, Department of Anatomy and Neurobiology, Washington University School of Medicine, St. Louis.

How plants exploit animals

from Peter D. Moore

THE ecological position of most green plants, at the base of food chains, has placed them in what seems to be a rather vulnerable position. It is natural that many of their adaptations during the course of evolution have been defensive; both morphological and biochemical features have frequently been modified so that the grazer should regard them with more respect than relish. Notable exceptions exist, of course, such as the use of animals as vectors in the transport of seed and pollen. Here the plant is at pains to excite an animal's greed in order to exploit its freedom of movement, thus rendering more effective the dispersal of the species and the free exchange of genes. The ecological and evolutionary rewards of these processes have evidently justified the necessary energetic investment.

In view of the advantages gained by plants in these mutualistic associations with their mobile dependents, it would be surprising if their response to direct grazing were entirely passive. In a systems analytical approach to this question, Lee and Inman (*Ecology* **56**, 1455; 1975) concluded that although grazers consume only a very small proportion of primary production (see *News & Views* **282**, 443; 1979), they exert a dampening effect on the fluctuations in plant production which result from environmental oscillations. In this way they may contribute to the stability

Peter D. Moore is a Senior Lecturer in the Department of Plant Sciences, King's College, London.

0028-0836/80/05428-03$01.00