Fig. 2. Section of external ear and of mastoid portion of temporal bone of same mummy. Heidenhain's iron hæmatoxylin. $\times 14$

the ion-exchange method using 'Zeo-Karb 225/M' (Light and Co., Colnbrook). Satisfactory sections have also been obtained after decalcification with De Castro's fluid. In this way sections have been made of the larger tarsal bones, for example, calcaneus and talus, of entire cervical vertebrae (Fig. 1), of the mandible with teeth *in situ* and of the temporal bone (Fig. 2). The quality of section produced depends, of course, on the state of preservation of the bone in question. Some indication of this may be obtained by preliminary radiography of the material.

It may also be used for the sectioning of large portions of soft tissues and has given excellent sections of the entire external ear, the orbital contents³ and of the vascular bundles of the lower limb. The staining methods which may with profit be employed and the results to be anticipated are discussed in my previous paper¹.

The method should be of value in investigating osseous lesions in Egyptian or other mummies and indeed in any desiccated human skeletal material, especially if associated with skilled radiography. It should also be the method of choice for general palæo-histological work.

A. T. SANDISON

Department of Pathology of the
University and Western Infirmary,
Glasgow.
March 6.

¹ Sandison, A. T., *Stain Tech.*, **30**, 277 (1955).

² Russell, N. L., *J. Med. Lab. Tech.*, **13**, 484 (1956).

³ Sandison, A. T., *Med. Hist.* (in the press).

Shape Discrimination in the Octopus

IN a recent communication¹, P. C. Dodwell raises some doubts about the adequacy of a theory of visual shape discrimination in octopus which I outlined in *Nature*². Dodwell makes four points: (1) He thinks it would be difficult to devise an analysing mechanism which would analyse relative differences in rates of firing at different points over a row of neurons: such a mechanism is necessary on my theory to explain the discrimination of certain figures (for example, a square and a circle). (2) He maintains that the theory fails to account for discrimination of shape irrespective of the locus of excitation on the retina. (3) He writes: "the reason

for postulating the array of cells [in the optic lobes] becomes obscure, because . . . the analyser . . . should enable it to deal directly with information from the retina". (4) He maintains that a theory of shape discrimination which he is putting forward overcomes the difficulties inherent in my own theory by transforming a spatial pattern into a temporal pattern.

Since Dodwell's points involve some misunderstanding of my own position, I would like to reply briefly to these points *seriatim*.

(1) (a) It is known that the nervous system can respond to differences in rates of firing over a row of cells. In discriminating a bright light to the left of a dim light from a dim light to the left of a bright light, the nervous system is performing just that analysis. (b) The analysing mechanism that must be postulated on my theory to account for discrimination between squares and circles is more complex than that which operates to analyse the difference between a vertical and a horizontal rectangle: it is precisely this difference in complexity which explains why the former pair of figures are found to be more difficult for an octopus to discriminate than the latter pair. (c) It is not difficult to design plausible neural analysing mechanisms which will classify separately the outputs given on my theory by squares from those given by circles. For example, a nervous mechanism which analyses changes in the rate of firing at points along a row of cells excited can readily be envisaged, and the difference between the outputs from such figures can be specified in these terms. What is difficult to decide (on the present evidence) is which of the many different possible analysing mechanisms that might be incorporated is the one actually operating.

(2) A mechanism responding to changes in the rate of firing would go some way towards accounting for generalization both to figures projected on different parts of the retina and to figures of different sizes. There is no reason, however, why, on my own theory, temporal coding should not be introduced at this stage. Although temporal coding has often been suggested by psychologists as a way of mediating generalization to figures projected on different parts of the retina, it seems to lack plausibility on neurophysiological grounds and for this reason I would prefer to avoid it.

(3) I do not "postulate" an array of cells in the optic lobes of octopus on to which the retina is projected: they are there. There are many functions such a projection might have—for example, to ensure that only one shape is analysed at a time.

(4) Dodwell's claim to have devised a theory of shape recognition which overcomes the difficulties in my own cannot be evaluated until he publishes his theory. My theory does not attempt to be a completely comprehensive explanation of shape recognition: it is intended primarily to explain my own experimental results. The detailed specification of further analysing mechanisms must wait until the theory has been thoroughly tested at its present stage of development, and until further evidence accumulates which makes it possible to choose between all the theoretically possible further analysing mechanisms.

N. S. SUTHERLAND

Institute of Experimental Psychology,
University of Oxford.

¹ Dodwell, P. C., *Nature*, **179**, 1088 (1957).

² Sutherland, N. S., *Nature*, **179**, 11 (1957).