bridge) outlined the geological aspects of reef biogenesis. External form has been used to infer both history and internal structure, without itself being precisely defined. To understand variation in time and space, reefs must be considered as volumes or three-dimensional shapes, as opposed to the commonly-used profile diagram, which is well-adapted to describe zonation but unable to demonstrate spatial variability. New advances in describing reef form have included the use of nearest-neighbour techniques for studying patch-reef distribution, the use of spectral analysis of bottom roughness to describe groove-and-spur formations, the application of the hypsometric integral to describe lagoon basins, and the development of various indices of topographic diversity to describe reef communities. Such quantitative morphometric techniques can be applied on different scales, from entire reef complexes to individual coralla. Until three-dimensional reef forms have been described more precisely in this way, the heavy theoretical loading given to highly simplified reef descriptions must be misleading. □

Spatial contrast vision

from a Correspondent

A Workshop on Spatial Contrast Vision was held in Amsterdam on 9–14 January 975. It was sponsored by the Commission for Biophysics and Biochemistry of the Netherlands Royal Society of Arts and Sciences.

VISUAL scientists tend to be divided into two camps on the question of how patterns are perceived. One view is that visual information is processed by one or more frequency-selective channels; a strong statement of this theory is that the visual system performs a two-dimensional Fourier analysis. The opposing camp holds that the fundamental building-blocks are the responses of single neurones, the receptive fields of which are sensitive only to specific features of the stimulus; the strong statement is that more central neurones are increasingly selective, and that an individual percept depends ultimately on activity in a single high-order neurone.

This dichotomy could be found in much of the discussion at the Amsterdam meeting. L. H. Van der Tweel (University of Amsterdam) criticised misapplications of Fourier theory: in particular, the tendency to ignore the question of how phase information is preserved in vision. It was later shown by Ü. Tulunay-Keesey (University of Wisconsin) that phase information can be lost by frequency-selective channels, because equal adaptive effects are found when adapting and test gratings are present in phase or out of phase. This finding raises the question of how spatial channels can ever specify the position of an object.

J. Nachmias (University of Pennsylvania) considered whether vision could be mediated by a single channel, the sensitivity of which varied with the spatial frequency of the stimulus. He concluded that such a model cannot account for known data; a multiple-channel theory is needed. This problem was discussed further by J. G. Robson (University of Cambridge), who described problems in the interpretation of human psychophysical data in terms of the properties of neural receptive fields. The classic concept of a receptive field is of a centre, within which all like stimuli elicit similar responses, and a surround, within which the same stimuli have an opposing effect. New evidence that this is an oversimplification was presented by P. O. Bishop (Australian National University), who described local differences of function within receptive fields. Sensitivity to the direction of stimulus movement can be found in small areas of the receptive field, and cells that exhibit directional sensitivity within the centres of their fields often have non-selective surrounds.

The convention of classifying retinal ganglion cells as X and Y cells was proposed by Enroth-Cugell and Robson in 1966, on the basis that X cells perform a linear summation of light within their receptive fields. The distinction has proved to be useful: neurones with X and Y characteristics have now been found in other parts of the visual system, and they differ in several characteristics. C. Enroth-Cugell (Northwestern University) reported that X and Y cells have different profiles of spatial sensitivity, and may have different neurochemical transmitters. R. M. Shapley (Rockfeller University) showed that only X cells respond linearly to temporal modulation of light. The central projections of X and Y cells differ, as shown by K.-P. Hoffman (Gutenberg University, Mainz). The X cells project only to area 17 of the visual cortex, whereas Y cells project to areas 17 and 18. Hoffman also described a third major category of visual neurones, the W cells, whose only unifying characteristic is their slow conduction velocity.

The ability of many neurones to respond to a limited range of spatial frequencies was examined by R. L. DeValois (University of California) and L. Maffei (Laboratorio di Neurofisiologia, Pisa). In general, tuning curves become more sharply peaked as one ascends in the visual system. Considerable interest (and perhaps some scepticism) greeted Maffei's conclusion that all neurones that are located in the same column of visual cortex (that is, in a line perpendicular to the surface) tend to respond most vigorously to gratings that have the same orientation, but their preferred spatial frequency changes in a regular pattern as the recording electrode is advanced. Conversely, cells in hypercolumns (tangential to the surface) have different preferred orientations, but all respond to the same spatial frequencies.

Most of these findings emphasise spatial interactions of an inhibitory nature. A. Fiorentini (Laboratorio di Neurofisiologia, Pisa), however presented compelling data that both facilitatory and inhibitory interactions can be found in human vision.

During a 'critical period' in early life, the visual system of many animals is labile and its function can be modified substantially by depriving or distorting the visual input. This phenomenon has been studied extensively because of its implications in the treatment of human amblyopia. C. B. Blakemore (University of Cambridge) described recent experiments in which occlusion of one eye resulted in a selective loss of afferent fibres to the visual cortex from those parts of the lateral geniculate nucleus to which the occluded eye projects. J. Atkinson and O. J. Braddick (University of Cambridge) reported that the contrast vision of human infants can be tested as early as 1 month, and that a rapid improvement in sensitivity occurs during the second month of life. This raised the question of the age at which the critical period begins in man. Bishop stated that the literature suggests 5 months, but Atkinson and R. A. Crone (University of Amsterdam) argued for an earlier onset.

A wide gap still exists between experimental data and an understanding of visual perception. This was emphasised by E. H. Land (Polaroid Corporation), who gave a dramatic demonstration that knowledge of the properties of a discrete physical stimulus is not sufficient to predict its appearance, and by N. S. Sutherland (University of Sussex), who attacked the notion that the central nervous system analyses visual information in a passive manner. In so doing, Sutherland seems to have questioned the meaningfulness of the two popular models of contrast vision that are stated at the beginning of this report.