of Botany, Nottingham University; and Miss S. A. Bonanou, at the National Institute for Medical Research, London.

During the year EMBO has sponsored five summer courses in molecular biology. These covered separation methods, immunology, steroid biochemistry, ribonucleic acid and electron microscopy.

Depth Perception

from a Neurophysiology Correspondent

FOR several years Julesz has studied binocular interactions in human vision using pairs of patterns which give a depth percept, when fused binocularly, exactly as in a normal stereoscope, but in which no structure is apparent monocularly. The stimuli are patterns of equal numbers of black or white square picture elements generated by computer and arranged at random in square arrays 100 elements square. The two members of a pair are identical except for the central array (40×40 squares) of which one is shifted horizontally by an integral number of elements with respect to the centre of the other. When the two patterns are fused binocularly in a stereoscope, this disparity leads to the percept of a central square. At first, subjective development of the square may be slow; when it is seen it appears in a plane in front of or behind the surround, depending on the direction of the disparity. This demonstrates that depth perception and the cross-correlation necessary to establish the disparity of two images can be an entirely central process, independent of monocularly visible structure and complex pattern recognition and of eye movements and vergence, but a function of time. The experiment therefore provides an ingenious technique for investigating purely central mechanisms, as any structure apparent in the fused image is a central percept (*Science*, **145**, 356–362; 1964).

In recent publications, Julesz and his colleagues describe extensions to their first experiment. When there is a monocularly apparent structure in one of a pair of random dot patterns which also contains a shape only visible when binocularly fused, the binocular "central" percept entirely predominates. This is true for patterns containing strong bilateral or higher order symmetries seen monocularly, as well as for patterns containing familiar words (Julesz, *Bell Syst. Tech. Journal*, **46**, 1203; 1967). Thus, when binocular interactions occur, they dominate the perception of monocularly perceived symmetries.

Julesz and Spivack (*Science*, **157**, 563; 1967) describe experiments with patterns made up of thin straight line segments. These, too, are drawn by computer, and consist of grids of thin vertical or horizontal lines. The lines are black, one dot thick and ten apart. For a vertical grid each line segment is in the vertical meridian of a 10 dot square element, or is displaced horizontally by two dots. The two types of segment are arranged at random, so that the monocular percept is of a grid of narrow lines with random breaks at intervals of ten dots, or an integral multiple of ten. As before, the two images of a pair are identical except for the central array of 40×40 picture elements which in one is shifted horizontally by a single (10-dot) element. Even when the targets are viewed at a distance at which the breaks subtend only 16 seconds of arc at the retina, perception of a square in depth occurs on fusion.

This is below the limits of normal visual acuity, but within those for vernier acuity. The authors suggest that the process used in vernier acuity is used in the cross-correlation on which global stereopsis depends. They also demonstrate an anisotropy for global stereopsis with these targets: stereopsis with horizontal line grids was stronger than with vertical grids, withstanding a disparity of the central square up to three times larger. This suggests that global stereopsis does not depend on local fusion, which is roughly isotropic (disparities in any direction between two retinal images less than about 6 seconds of arc are fused easily), but on local stereopsis, which is anisotropic, occurring for disparities only in the horizontal plane shared by the two eyes. Another interesting feature of these results is that even though horizontal displacement of the central square in one image will produce, by chance, 50 per cent of lines with zero disparity and 25 per cent each of lines with two dot disparity in either direction, a locally acceptable depth percept in terms of these disparities is rejected in favour of a more global percept, which must require more central processing for its detection.

Fender and Julesz (*J. Opt. Soc. Amer.*, **57**, 819–830; 1967) have further investigated the limits of fusion, using pairs of images stabilized on the retinae. With their stabilization technique, the two images of a stereoscopic pair can be moved apart without the possibility of the movement being counteracted by vergence movements of the eyes. Under these conditions, once fusion is established within Panum's fusional area (that is, with a binocular disparity of less than 6 seconds of arc for foveal vision), the two targets can be separated—literally pulled apart on the retinae—without loss of fusion for a distance of up to 2° provided that the pulling is not too fast and that the stimuli are never occluded. If the pulling velocity is above a certain limit, or the stimulus is occluded, fusion breaks down and can only be re-established within Panum's fusional area. With random dot patterns fusion is maintained for a greater distance of movement than with a pair of single lines. The authors interpret their results as follows: a labelling process, operating within Panum's fusional area, establishes correlations between corresponding points of the images on the two retinae. This process takes time, but once labels are established they can be preserved by a "cortical registration process", allowing the images to be pulled apart, within limits, without loss of fusion. Finally, there is a process preserving labelling against saccadic eye-movements, which do not destroy fusion in normal vision.

Julesz' work emphasizes the relation between the spatial and temporal aspects of fusion, while showing that in some ways it is a simpler process than had been thought. In normal vision, eye movements and vergence as well as object movements might all upset fusion without the hysteresis phenomena characteristic of binocular interaction.

Cold Star

from an Astronomy Correspondent

RECENT interest in quasars has somewhat obscured the extraordinary development that has been occurring in