inheritance is: (i) there may be hereditary units in the cytoplasm that are not necessarily connected with organelles; (ii) these hereditary units may consist of only a single gene; (iii) the gene may consist of DNA or of RNA; and (iv) viruses with protein coats have been considered the simplest infectious agents. The metagon may be an example of the simplest infectious nucleic acid known, and its properties suggest a new area for investigation of disease-inducing agents.

In addition to the symposium lectures, the American Society of Naturalists was addressed at a luncheon by its president, Albert Tyler, on the topic "biology and chemistry of fertilization." This comprehensive review, illustrated by excellent electron microscope pictures of the steps in the penetration of the sperm into the egg and including a discussion of the biochemical sequences that occurred, was a fitting climax to a day replete with the revelation of new findings and ideas.

The symposium was a success as judged by the large audience and the active discussion that followed each of the papers presented. It is hoped that the symposium will appear in press in about 4 months in a monograph published by the American Society of Naturalists.

S. GRANICK, *Program Arranger*

Vertebrate Color Receptors

The Montreal meetings of the AAAS included reports (29 December 1964) of rapid progress in four laboratories toward the solution of the age-old problem of color vision. A key feature of the new work is the measurement of the effects of light on individual receptor cells. Paul Liebman (University of Pennsylvania Medical School) contributed the first paper on "Detection of color-vision pigments by single cell microphotometry—the method and its efficiency." He described incredibly sensitive recording techniques that have enabled the symposium participants to identify individual blue-sensitive, green-sensitive and red-sensitive cone cells of the kind predicted by Young, Helmholtz, and other 19th-century theorists. He made no attempt to minimize the difficulty of these methods. They require, first, that the cone receptor cell be separated from neighboring retinal units and placed in a favorable position to receive a test beam of light. This beam must come to a focal point less than one micron in radius in order to absorb the number of photons necessary for a rapid measurement of relative spectral sensitivity. The light-receiving element is a specially sensitive photomultiplier unit that permits a comparison of the beam traversing the cell with a reference beam nearby. The entire microspectrophotometer must scan the cell at a rate of about 10 mμ per second in order to avoid artifacts due to pigment bleaching or to uncontrolled movements of the cell. Some of the more successful experiments on goldfish cones reveal three basic classes with peak sensitivities in the blue, green, and red regions of the spectrum. Experiments on other receptor cells, including those of humans and infrahuman primates, have been carricd out by P. K. Brown (Harvard), W. B. Marks (Johns Hopkins), and other investigators. With minor variations they also support the hypothesis of three classes of color receptor.

Edward F. MacNichol, Jr. (Johns Hopkins University) carried the analysis of color vision one step further. He reported on "Neural coding of color information in the retina." He and his associates have penetrated individual retinal cells with microelectrodes and recorded their activity in relation to colored light. An important feature of these experiments is the fact that the electrode location is pinpointed by the use of a dye-marking technique. In this way they have localized a region close behind the cone receptors in which diverse electrical responses result from stimulation by various colors of light. The response waves in this region are the S-potentials originally thought by Svaetichin to lie within the cone cells themselves. Even at this early stage in the color information channels it is found that complementary colors often produce potential waves of opposite electrical sign. This sort of color opposition was in fact predicted by Ewald Hering—and found unacceptable by other physiologists—nearly a century ago.

David H. Hubel (Harvard Medical School) described experiments conducted with Torsten N. Wiesel on "Interrelation of form and color in lateral geniculate cells of the rhesus monkey." Their microelectrodes also revealed opponent color responses, but these responses took many forms depending on the particular cell and the nature of the stimulus pattern. Their findings, all the more interesting because of the similarity of the rhesus to the human visual system, showed extremely complex interactive effects among cells in the "way station" between retina and cortex.

Finally, "An analysis of human color vision and color blindness" was presented by George Wald (Harvard University). He told of a kind of temporary color blindness that can afflict a normal human after exposure to intense light of certain wavelengths. He said a strong mixture of blue and red light, for example, has the effect of bleaching out the photosensitive pigments in the retina that are normally sensitive to these colors, so that only the third (green-sensitive) pigment remains active. The color vision that remains can be measured, and this gives a quantitative description of the green color mechanism of the normal eye. Intense lights of other colors can similarly be used to isolate the red or the blue color mechanism, and these results can be compared with the light absorption measurements on single cone cells. The various forms of color blindness can be understood as forms of dichromatism or two-color vision in which there is either a loss (achromia) of one of the three types of color mechanism or a fusing (dyschromia) of two of them.

Clarence H. Graham (Columbia University) was chairman. He closed the symposium by pointing out that the new techniques for measurement of color responses have emphasized the wisdom of the old "zone" or "stage" theories. These theories maintain that no single concept accounts for color discrimination but that selective absorption by particular pigments at the receptor level is followed by processes of opposition and enhancement at higher levels. The successful measurement of single-unit activity at all levels has provided a new understanding of the phenomena of human color vision.

Immediately before the symposium, Lorrin A. Riggs (Brown University; vice president of the AAAS and chairman of the Psychology Section) described his experiments in which electrical records were made of the ways in which the human eye responds to different forms and colors.

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