biophysics

Gathered at the annual meeting of the Biophysical Society last week in Baltimore

MEMBRANES

Hypothesis explains semipermeability

Many important biological functions—respiration, nerve transmission and photosynthesis among them—take place on subcellular membranes about 80 to 100 angstroms thick. These protein-lipid membranes are semipermeable. They permit certain ions to pass through but not others. To accomplish this they distinguish between ions which are chemically very similar such as sodium, potassium and rubidium.

A group of compounds called ionophores provide insight into how semipermeability might work. These molecules form very specific complexes with metal ions and enable them to dissolve in nonpolar solvents that are chemically similar to membranes. Nobel laureate Manfred Eigen and Dr. Ruthild Winkler of the Max Planck Institute for Physical Chemistry on Goettingen, Germany, studied a class of ionophores called actins. The first molecule of the class is called monactin and is a circular chain in the shape of the seam of a tennis ball. The molecule is folded into a spherical ball with nonpolar groups outside and polar groups inside.

The molecule can open like a pair of jaws to admit into its central cavity a sodium ion and its associated water molecule. The polar groups of the monactin then replace the water molecules one by one, a process which is completed in 20 billionths of a second.

The potassium ion and its shell of water molecules are larger than the sodium ion and its water molecules. The sodium complex fails to fill the cavity. The potassium complex fits perfectly. Rubidium is too large. This then explains the specificity of the system.

PHOTOSYNTHESIS

Missing electron found

Most workers in the field believe that the first event in bacterial photosynthesis is the loss of an electron from a bacterio-chlorophyll molecule. The best evidence for this is from electron spin resonance measurement that detects the unpaired electrons that remain behind. In this technique, a magnetic field is applied and the spin of the unpaired electron is flipped from clockwise to counterclockwise (spin "down" to spin "up") by a microwave field of a particular frequency.

Until now, however, detection of the electron lost from the bacterio-chlorophyll has eluded the most careful experiments. Presumably this electron is captured by another molecule, producing a strong reducing agent that drives a series of reactions that store energy for later use by the bacterium.

Measurements by Drs. George Feher of the University of California at San Diego and David Mauzerall of the Rockefeller University in New York, have finally traced down the elusive electron. Drs. Feher and Mauzerall did an electron spin resonance measurement with modulated light of 1.5 degrees K., a temperature at which helium is superfluid. They detected a weak signal which they attribute to the first electron acceptor. Previous experiments by these and other workers had never gone below 4 degrees K., the temperature of boiling helium liquid. At that level they could not detect the missing electron because of noise problems.

The experiment leaves open the question of the identity of the molecule on which the electron is trapped. From the weakness of the signal Dr. Mauzerall speculates that the electron acceptor is an iron derivative.

SLIME MOLD

New focus of attention

Thirty-three years ago Dr. Max Delbruck began a revolution in molecular kinetics by an intensive study of bacteriophage, a virus that infects bacteria. Dr. Delbruck reasoned that phage had practically no functions other than genetics and would make it possible to study genetics in its simplest form.

Now a Nobel laureate, Dr. Delbruck has a new love, a slime mold called phycomycetes, which he says displays sensory responses in their simplest form. Phycomycetes detects blue and yellow (but not red) light, then grows toward it. It grows away from an object that is touching it. Most remarkably, phycomycetes detects and avoids nearby objects by detecting a disturbance in the circulation of air around itself. These properties, Dr. Delbruck says, are a simple form of sensory transduction that should repay intensive study just as did the genetics of bacterial viruses.

VISION

Effect of light on retina

In most sensory nerve cells, stimulation produces a sudden increase in the permeability of the cell membrane to sodium ions. Sodium ions then rush across the membrane to the cell's interior, creating a change in voltage across the membrane. These changes control the firing of a signal in the same or an adjacent cell.

Until last year, scientists thought that the retina produced its impulse in more or less the same way. Then, Dr. William A. Hagins and his colleagues of the National Institutes of Health in Bethesda, Md., measured the conductance of the external membrane of the outer segment of the rod cells of rat retina. Unlike other sensory cells, he says, stimulation of the retina leads to a decrease, rather than increase, of membrane permeability to sodium ions, and thus a decrease in the flow of sodium ions.

The current circulating in the rat rod outer segments consists of sodium ions flowing spontaneously from a region of higher to one of lower concentration. Experiments with the metabolic poison, ouabain, indicate that metabolic energy is needed to pump the ions from this outer segment into the intercellular space to maintain the concentration gradient.

A small increase in the concentration of calcium ions reduces the current in the dark in a way analogous to the action of light. This suggests that light may cause the rods to release calcium to stop the sodium currents.