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Some Similarities between Processes at Biological Membranes and Lipid Bilayers* **

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Abstract. Several processes at biological membranes can be simulated by experiments with artificial lipid bilayer membranes. Three selected examples are discussed: The uncoupler induced proton permeability of lipid bilayers, the initiation of action potential like voltage responses in lipid membranes, and the reconstitution of active cation pumps across planar lipid bilayers or lipid vesicles.

Key words: Lipid bilayer membrane — Uncoupler of oxidative phosphorylation — Action potential — Active cation pump.

The Action of Uncouplers on Lipid Bilayer Membranes

According to Mitchell's chemiosmotic hypothesis for oxidative phosphorylation uncouplers increase the proton permeability of the mitochondrial membrane. This special aspect of Mitchell's hypothesis can be tested by experiments with lipid bilayer membranes. Uncouplers of oxidative phosphorylation strongly increase the conductivity of these artificial membranes. The uncoupler induced conductivity normally is proportional to the uncoupler concentration in the solutions. For the uncoupler TTFB (tetrachloro-2-trifluoromethyl benzimidazole) a bimolecular charge transfer mechanism is observed with an efficiency proportional to the square of the uncoupler concentration. All uncouplers investigated form a proton carrier system in the lipid membrane (Neumcke and Bamberg, 1975).

The Simulation of Nervous Excitation by Model Membranes

Several compounds are known which induce electrical excitability and action potentials in lipid bilayer membranes. These phenomena are observed after incorporation of cation and anionselective channels into lipid bilayers by an excitability inducing material (EIM) plus protamine or by alamethicin plus protamine. By adjusting the membrane composition, ionic gradients, pH, tem-

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perature, and the concentrations of the channel forming materials, a bistable system can be obtained which exhibits voltage responses similar to action potentials at excitable membranes (Mueller and Rudin, 1968).

The Reconstitution of Active Ion Pumps into Artificial Membranes

Upon addition of ATP and fragments of the cortical tissue of rat brain rich in Na, K-dependent ATPase activity to a lipid bilayer, a short-circuit current flow and an open-circuit potential across the membrane can be observed (Jain *et al.*, 1972). The net current flow is inhibited and the open-circuit potential discharged by the addition of ouabain, phospholipase A, or trypsin. This indicates that an active cation pump was incorporated into the lipid membrane. Such possible reconstitutions of active transport units into artificial membranes also were found for Ca-ATPase isolated from rat muscles and added to phospholipid vesicles (Racker and Eytan, 1973), and for the light driven proton pump in the purple membrane of Halobacterium halobium which could be incorporated into lipid membranes (Racker and Stoeckenius, 1974).

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