(for example, depolarizing after-potentials, kindling, correlation dimension) are mentioned without proper introduction, and almost no overview and summarizing diagrams are provided.

Although I admire the Herculean attempt of the authors to understand the working of a small piece of nervous tissue in such detail, I also believe that the book starkly illuminates the limits of a purely bottom-up, physics-like research program in the brain sciences. Unlike a crystal or a galaxy, neuro-biological structures have a teleonomic aspect; that is, they evolved in such a way as to fulfill a particular function, in the case of the brain the processing and storing of information. Neglecting the computational role of the nervous system is like trying to understand the eye-like markings on the wings of a butterfly without taking into consideration that they evolved for reasons of mimicry. This is all the more so for the case of epileptic seizures, a highly degenerate brain state with no computational significance. Thus, though the research program presented in this monograph is a significant stepping-stone toward a "physics" of neural networks and the natural history of epileptic seizures, it tells us very little about the role of the hippocampus in computing and storing our memories.

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Pumping Ions

Electrogenic Ion Pumps. PETER LÄUGER. Sinauer, Sunderland, MA, 1991. x, 313 pp., illus. $44.95. Society of General Physiologists Distinguished Lecture Series, vol. 5.

All cellular life forms establish ionic concentration gradients across their cell membranes by active transport of ions. Apparently proteins that couple ion transport to a source of free energy have arisen several times in evolution. *Escherichia coli* uses an ATP-dependent ion pump that is homologous to the well-known Na^+-K^+, Ca^{2+}, and H^+-K^+ pumps of animals. Halobacteria evolved light-driven pumps for H^+ and Cl^-, and almost all bacteria and eukaryotes have cytochrome oxidase that pumps protons as part of electron transport and coupling proteins (F_0F_1 ATPase) that synthesize ATP at the expense of the proton gradient.

The Na^+-K^+ pump has been studied for half a century. The concept of energy-requiring vectorial transport was introduced more than 50 years ago, and by 30 years ago the energy source (ATP) had been identified, the concept of a strictly stoichiometric coupled transport cycle had been established, and an appropriate ATPase activity had been discovered in broken cell membranes. Subsequently the transport protein was solubilized, purified, and sequenced, and a large number of intermediate steps in the overall cycle were revealed. Perhaps the most interesting intermediates are several "occluded" states in which transported ions seem to be trapped as in an airlock in their transit across the membrane.

Despite a long history of sophisticated observation, we still do not understand the molecular details. How are ions picked up on one side of the membrane and deposited on the other? Peter Läuger's posthumous book provides an admirable distillation of a complex experimental literature and a clean theoretical structure for kinetic analysis. It is exciting to be guided by such a sure hand through what would otherwise be very difficult theoretical and experimental territory. Läuger's legacy will be a paradigm for thinking in this field for many years to come. This is a biophysical masterclass. It will reward repeated study.

The book begins with a short overview of classes of ion pumps and then settles into a serious introduction to physical principles and the theoretical background of each of the methods for studying pumps. We learn about the thermodynamics of state diagrams, energy levels and efficiency, steady-state and transient kinetics, the contribution of pumps to electrical properties of membranes, and the theory of membrane fragments coupled to planar bilayers. This part would make an excellent graduate reading seminar in biophysics, a skillful case study exercising a wide range of physical thinking in a biological context. It will be equally interesting to researchers studying bioenergetics and molecular motors who face the same problems of kinetics and energetics of cyclic state diagrams. The presentation here cuts deftly to the core and is a strong model of a self-consistent kinetic framework achieved through notational simplicity and deep physical insight.

The second half of the book reviews progress made on each of the pumps. This part will be especially useful to those who teach about primary active transport and bioenergetics in classes in cell physiology. The style is refreshingly direct. Sharp conclusions are drawn without waffling over fuzzy data. The greatest amount of space is devoted to the Na^+-K^+ ATPase. The classical Post-Albers cycle is reviewed in detail, together with newer extensions. Results of rapid mixing, filtration, current-voltage, voltage- and ATP-jump, and charge-transient experiments are brought in to establish microscopic rate constants and rate-limiting steps. All is summarized in a reaction diagram with 14 states and 20 reaction steps. Values for 29 rate constants are estimated. At this level tremendous progress has been made in the last 15 years.

As the title implies, active transport of ions moves electric charge as well as making a concentration gradient. In Läuger's earlier field of ion channels, the ability to measure charge movements and voltage sensitivity of elementary steps has been central to rapid progress in understanding. The same powerful approaches are now being applied to ion pumps, and the formalisms developed in this book show how electrical measurements can be used to dissect elementary steps of the transport cycle.

A valuable feature of this well-produced book is the combination into a neat and readable package of both the theoretical background and the observations of a large field of transport research. Experimentalists trained in the use of Ockham's razor may be surprised at the large number of steps, coefficients, and rate constants used to describe the action of one macromolecule. Indeed, the models go well beyond existing observation. However, the book teaches us how to prepare the framework for future analysis by meticulous representation of each anticipated process. Experiment then can determine which steps are rate-limiting or kinetically important. Structural biologists may also be surprised at the relative lack of structural correlates of any of the kinetic events in pumping. This book may be the first and last monographic summary of a great era that will surely stimulate molecular discovery through genetic engineering and possibly atomic-resolution crystallography. It is a great read and a must for all in the transport and bioenergetics fields.

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