plete and somewhat removed from the remaining contributions, which are devoted largely to genetically mediated effects. This is unfortunate, because the title of the book would lead one to expect extensive coverage of general cytotoxicity testing. Perhaps more important, the question of the relationship between general cytotoxicity and genetic toxicity is not effectively addressed except in a paper by Kurt W. Kohn, "The significance of DNA-damage assays in toxicity and carcinogenicity assessment."

The book's strength is in excellent review chapters on various short-term bioassay procedures, including DNA repair assays, cytogenetic methods, various mutagenicity test systems, cell transformation assays, and tests for tumor promoters. The mammalian cell mutagenesis assay systems are particularly well represented in concise but informative reports by Chu, David F. Krahn, David E. Amacher and Gail N. Turner, and Donald Clive. Langenbach *et al.* report interesting data on the cell-mediated mutagenesis of V-79 cells and *Salmonella*, wherein some of the deficiencies of S-9 metabolic activation are obviated. Probst and colleagues summarize extensive results on 252 chemicals using bacterial mutation and rat hepatocyte DNA repair assays. Follow-up testing is performed in the L5178Y mammalian cell mutagenesis assay and in an in vivo assay for sister chromatid exchange. Probst and his co-workers noted that the bacterial mutation and L5178Y assays tended to agree for nitro compounds and that findings for induction of sister chromatid exchange could not be exclusively linked to the role of enteric bacteria in metabolic activation.

This reviewer particularly enjoyed the innovative and insightful papers "Adaptation of the DNA-repair and micronucleus tests to human cell suspensions and exfoliated cells" by Hans F. Stich, Richard H. C. San, and Miriam P. Rosin, "Mutagenicity and carcinogenicity correlations between bacteria and rodents" by David Brusick, and "Approaches to comparative mutagenesis in higher eukaryotes: significance of DNA modifications with alkylating agents in *Drosophila melanogaster*" by E. W. Vogel.

Williams once again raises the debatable issue of genotoxic versus epigenetic carcinogens. His paper follows a report by Trosko *et al.* on promoters and intracellular communication. Williams states that "if it is established that a membrane effect is the basis for tumor promotion, this would represent a true epigenetic effect." That epigenetic effects may not always be as expected is suggested by the studies on asbestos-induced cell transformation reported by Barrett *et al.*

In a concluding section, C. A. Schreiner deals with the application of short-term tests for purposes of safety evaluation from the industrial perspective. Governmental programs are provided equal time as the National Toxicology Program is described by Errol Zeiger, and the impact of short-term tests on regulatory action is discussed by W. Gary Flamm and Virginia C. Dunkle. As with many recent conferences on short-term tests, the final full-length paper concerns the place of such tests in carcinogen risk assessment in humans. Robert Kroes concludes on the positive note that short-term tests are very important in classifying genotoxic and non-genotoxic compounds and also seem to be useful in the detection of promoter activity. Numerous short reports at the end of the volume represent the posters presented at the conference.

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Ion Channels

Membrane Potential-Dependent Ion Channels in Cell Membrane. Phylogenetic and Developmental Approaches. S. HAGIWARA. Raven, New York, 1983. x, 118 pp., illus. $29.50. Society of General Physiologists Distinguished Lecture Series, vol. 3.

There is scarcely a cellular function that does not have at its heart the operation of ionic channels. Perhaps the best-known example is the action potential that is produced by the activation of sodium and potassium channels in axonal membranes. The seminal description of this process by Hodgkin and Huxley has led to the discovery of many other channels in a wide variety of species. It is fitting, therefore, that Hagiwara, who has contributed so much to the ionic channel catalog, dedicates his book to his "animal colleagues."

The book is composed of six chapters written in a semihistorical, semididactic style. The history is largely, but not exclusively, autobiographical; virtually all the 48 figures have their origin in the laboratories of Hagiwara or his collaborators. Being a personal history, the book provides a glimpse of the creative process complete with wrong turns and surprising discoveries. The scientific descriptions themselves are written in a nontechnical manner accessible to the lay person. A practicing biophysicist may well be frustrated by the superficial treatment of certain topics that such a short book entails. For those wishing more, a thorough bibliography is provided, however.

The first substantive chapter describes the properties of calcium channels. These channels have some novel properties not found in classical sodium channels. The inactivation process for some preparations appears to be sensitive to internal calcium concentration. Inactivation in other preparations has the more classical voltage dependence. The conductance saturates with permeant ion concentration. The blockage of the channel by certain divalent cations as well as the selective permeation by alkaline earth cations can be neatly explained by a simple model containing binding and mobility parameters. Data on fluctuations and single-channel recording are presented without an explanatory model because "the lifetime of a model's usefulness is usually only one or two years."

The next chapter discusses the distribution of sodium and calcium channels. The ubiquity of calcium channels is illustrated in a three-page table. Calcium channels always seem to be present at the effector ends of systems, as in excitation-contraction, excitation-secretion, and fertilization. This list will, no doubt, be extended in future editions. Spatially sodium and calcium channels are not necessarily distributed in parallel. Moreover, during development the relative contributions of different channels change in complex ways. The function of these changes remains an intriguing mystery.

The sodium and calcium channels of different preparations provide still another source of diversity. Some preparations have two different calcium channels. Even the classical vertebrate sodium channel reveals different sensitivities to the potent channel blocker tetrodotoxin. Puffer fish that produce the toxin are immune. Related species show a spectrum of sensitivity perhaps related to concentration of the toxin.

Even more impressive is the diversity of potassium channels. Early outward current, the delayed rectifier, the calcium-activated potassium conductance, and the inward rectifier, not to mention synaptic channels of various sorts, create a bewildering array. The channels have markedly different biophysical properties, thus being interesting subjects for channel mechanics.

The concluding chapter describes a fascinating group of developmental

changes in egg cell membranes. Sperm can initiate a potential change that somehow blocks polyspermy. That this is essentially an electrical phenomenon in certain invertebrate eggs can be shown by inducing polysperms with repolarization. Phylogenetically fertilization potentials seem to be generally similar, but not identical. During the subsequent maturation of the cells, marked changes in the electrical properties are observed that are due to changes both in the relative numbers of channels and in the properties of the channels themselves.

In short, here is a brief, readable introduction to the diversity of the ontogeny and phylogeny of membrane physiology.

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Relativity

The Mathematical Theory of Black Holes. S. CHANDRASEKHAR. Clarendon (Oxford University Press), New York, 1983. xxii, 646 pp., illus. $110.

In the early 1930's Chandrasekhar investigated the fate of stars that have reached the endpoint of nuclear burning. At that time the only fate known for such stars was as white dwarfs. Chandrasekhar made the momentous discovery that white dwarfs have a maximum mass, which is a little more than the mass of the sun. Since stars much more massive than this were known to exist, the question of their ultimate fate arose. We now know of two further endpoints of stellar evolution: neutron stars and black holes.

The astrophysical community did not readily accept Chandrasekhar's work, partly because it did not wish to confront the existence of objects so far removed from everyday reality. Chandrasekhar wrote a monograph on his work and moved on to other fields. There is a certain fittingness in Chandrasekhar's receiving the Nobel Prize for his work on white dwarfs some 50 years later, at the same time that his sixth book, on the subject of black holes, is published.

Chandrasekhar's books have a distinctive style. He pursues research on a topic for a period of years, until he has achieved a coherent understanding of it. He is then able to give a complete exposition of the material from a unified point of view. This book begins with some mathematical preliminaries on differential geometry, including the Newman-Penrose formalism. Though this material is essentially self-contained, the reader will benefit from some previous knowledge of tensors.

The discussion then moves on to the metrics (gravitational fields) of black holes. A remarkable fact is that the most general metric for an isolated black hole is completely known analytically and is specified uniquely by the mass and angular momentum of the black hole. Chandrasekhar gives the proof of this important result and describes in detail the properties of such isolated black holes.

A large part of the book deals with perturbation theory for black holes, which is concerned with how a black hole interacts with its environment. The problem can be reduced to understanding how the black hole scatters and absorbs incident waves of various kinds. Mathematically, the problem is analogous to the familiar quantum-mechanical problem of finding reflection and transmission coefficients for potential barriers. At this point the reason for the fascination of the subject for all those who have worked on it becomes evident. At each stage of the investigation, starting with the simplest nonrotating case (Schwarzschild black hole), one uncovers unexpected interconnections and miraculous simplicity. For example, the potential barriers for scattering of the two different polarization states of a gravitational wave by a Schwarzschild black hole are different, yet the reflection and transmission coefficients are the same. Chandrasekhar dextrously weaves the threads of the connections to inverse scattering theory and to the Newman-Penrose formalism. One is left with a sense of wonder that all the pieces fit together the way they do.

Rotating black holes present even more surprises. Although there is no longer spherical symmetry, a "miracle" allows one to separate variables and reduce the problem to simple barrier penetration again. This separation requires one to introduce a new set of "special functions," which generalize the well-known spherical harmonics. Certain consistency requirements of Einstein's theory lead one to discover mathematical identities satisfied by these functions, identities virtually impossible to discover otherwise. The list goes on: How does a potential barrier "know" how to allow energy extraction from the black hole for certain frequencies? How is this "superradiance" turned off for spin-1/2 particles?

This book will certainly be read by professionals and graduate students in relativity. I am afraid that others will be deterred by its apparent complexity. Though some of the calculations are lengthy, most involve only upper-level calculus and could in principle be reproduced by the reader with a conventional "mathematics for physicists" background. Those readers who do venture into the book will have the opportunity to ponder the two quotations in its epilogue: "There is no excellent beauty that hath not some strangeness in the proportion" and "Beauty is the proper conformity of the parts to one another and to the whole."

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Cosmology

The Big Bang and Element Creation. D. LYNDEN-BELL, Ed. The Royal Society, London, 1982. vi, 148 pp., illus. £20.20. First published in *Philosophical Transactions of the Royal Society of London*, series A, vol. 307. From a meeting, March 1982.

Remarkable recent advances in theories of elementary particle physics have greatly increased our ability to study the very earliest stages of the big bang. These theoretical advances have come at a time of equally remarkable advances in observational cosmology. We have gathered improved information about the primordial abundance of the elements, the spectrum and distortions of the microwave background radiation, and the distribution of galaxies in the universe in recent years.

The Big Bang and Element Creation is a collection of 12 papers almost unique in its balance of theory and observation. Such a mix is particularly useful for understanding the significance of the observational work reported in the book. For instance, a theoretical paper by Hogan, Kaiser, and Rees on the interpretation of anisotropy in the cosmic background radiation is crucial to an understanding of importance of the measurements.

The book does an excellent job of reviewing the observational and theoretical status of primordial nucleosynthesis (the production of light elements in the primeval bang) and the spectrum and anisotropy of the cosmic microwave background radiation (the remnant of the big bang discovered by Penzias and Wilson in 1965).

A paper by Ellis on grand unified theories and cosmology is an excellent introduction to a subject that is often difficult for the nonspecialist to under-