plained on the basis of a few color-controlling genes and the hybrid-zone effect explained on the basis of a few coadaptive modifiers together with clinal selection patterns between the differing habitats of the frogs.

In the final chapter Endler discusses the problems of distinguishing between primary and secondary intergradation: the problems of interpreting step clines and hybrid zones. He examined studies on over 60 such phenomena for estimates of cline width, gene-flow distance, selection gradients, and age of interaction. Only a few of the studies contain enough data to permit rough tests of the hypotheses developed, but the agreement between quantitative theory and nature is surprisingly good. Endler shows that it will be impossible to distinguish between primary and secondary intergradation because they result in the same types of geographic phenomena and may evolve from gradient clines in the same order of magnitude of time. He concludes with a discussion of hybrid zones involving birds, reptiles, and insects in tropical South America. He notes that because the time courses to extremely steep clines are short enough to have evolved since the last glaciation it is not necessary to postulate Pleistocene forest refugia to explain existing hybrid zones. In marked contrast to prevailing practice, he argues that they might be explained in terms of contemporary selective gradients and dispersal patterns.

Given that this volume will (and should) be widely cited it is unfortunate that it was not better written. Endler makes extensive use of jargon: step clines become "more and more linear" and may even move "off of the species' range." There are more than 60 errors of a grammatical or typographical kind, including such gems as "more complete," "more continuously," and the inexcusable "data is." Poor sentence construction results in numerous annoying ambiguities. A large portion of the volume is devoted to mathematical modeling, and more care might have been taken with the choice of symbols: some have different uses on adjacent pages, and one even has two different meanings in the same table. Some help is provided in the form of a short glossary, but definitions of 11 algebraic symbols are omitted (including K, which has four different uses). Also found in the glossary are some terms whose meanings are unique to this volume and whose definitions are left out of the text. I shall not comment on the mathematical models themselves beyond noting that they are generally sound (four errors were detected) and that there have been some important contributions made to the theory of clines by Karlin, Nagylaki, and others in the three years since this book was completed. There is an extensive bibliography (758 references) on geographic variation and clines. The wealth of citations is, however, a little deceptive, as many of the "classic" cases reported during the 1940's and 1950's have proved invalid. For example, the Californian salamander, *Ensatina eschscholtzi*, is not a good example of a ring species, as the overlapping populations hybridize, and the continued presentation of all Moore's experimental crosses of "*Rana pipiens*" as cases of intraspecific hybridization is unacceptable.

How appropriate are oligogenic models in simulating the processes of speciation? Although Endler never asks this question, many readers will. Twelve years of biochemical genetics suggests that these models may be appropriate; electrophoresis, even when we allow for cryptic variation within electromorphs, provides no evidence for extensive reorganization of gene pools during speciation. There is every indication that changes at a few loci are sufficient for speciation and that geographic variation rather than genetic revolution may be the critical prerequisite.

How well does existing population genetics theory allow us to interpret nature? Unfortunately, as Lewontin has noted, it is neither empirically nor dynamically equal to the task. Furthermore, it is an equilibrium theory and consequently the role of history is constantly denied. One of Endler's main contributions is to confront theory with history and show how the two might interact. The encounter underscores the fact that theory far outpaces verification in this area of science. We will be unable to assess the relative importance of the various modes of speciation until we develop a methodology for distinguishing between their products in nature. While Endler's requirements for the interpretation of a natural cline (measurement of gene flow and all components of fitness, and a knowledge of the history of the interaction) are simply unrealistic, much can be done to improve the present situation. The measures of gene flow and natural selection, for example, need refining in both empirical and theoretical studies. The extent to which gene flow varies with direction, population density, and position within the species range has yet to be established. Endler's efforts point to the need for more critical studies of carefully chosen situations in nature. Until these are done and the various hypotheses are tested, it is likely that clines and hybrid zones will remain taxonomists' nightmares and evolutionists' delights.

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Achievements and Prospects

International Cell Biology, 1976–1977. Papers from a congress, Boston, Sept. 1976. B. R. BRINKLEY and KEITH R. PORTER, Eds. Rockefeller University Press, New York, 1977. xvi, 694 pp., illus. $30.

Cell biology, as George Palade reminds us in the introduction to this volume, is a science reborn. Out of general physiology and by way of ultrastructure, it arose from an intelligent selection of problems appropriate to the time and to the emerging technologies of investigation. The exceptional advance of cell biology has been due in no small part to general adherence by those who work in the field to a generative program: the integration of ultrastructure and chemistry with the physiological function of cells and their organelles. This volume places on display several outcomes of the program—obviously enough, the more successful outcomes were selected for emphasis—but it does more than that. Already evident in the contents is an emerging new program, one that is to deal with regulation, operating not only within organelles and at a level indistinguishable from the structures and molecules themselves, but also at a distance: from the genome in cells and from the assemblage as a whole, or from the integrative systems, in tissues, organs, and organisms.

It is in no way a slur on the discipline to note that some of its unique preoccupations of one or two decades ago, for example, mitochondria, ribosomes, and chloroplasts, have been taken over by other, and sometimes more self-contained, scientific enterprises, such as biochemistry. These take-overs are a measure of success. By the same token, a measure of the power and maturity of cell biology as it is now practiced is the pervasive concern with regulatory mechanisms. Many of the contributions of this volume give evidence of that maturity and of the centrality of cell biological concepts and techniques to genetics, biochemistry, and developmental biology as they are now practiced.

Symposium volumes tend, of course, to be ephemeral, but the useful ones provide a sort of snapshot of the arts and ideas that dominate a field of inquiry at a particular time. Good snapshots and good symposium volumes are rare: excellent ones, with equal attention to physical and compositional requirements, are potentially archival. *International Cell Biology, 1976–1977* is of archival quality. More than that, it approaches as closely as any recent publication the ideal of a serious and representative textbook of the field.

The book adheres to the high standard of publication established by the Rockefeller University Press and the *Journal of Cell Biology*. It is a standard that most other scientific publications have difficulty in meeting. Brinkley and Porter, who are experts at it, have seen to it that application of the standard was rigorous throughout. It is evident also that equal care has been lavished on those other matters over which editors have some control. The result is a fine snapshot indeed: easy to look at, artfully composed, and with a very high information content.

The symposia treat a comprehensive, although by no means exhaustive, set of the problems to which cell biologists currently attend: the molecular organization, ultrastructure, interactions, specializations, physiology, and pathology of cell surfaces and intracellular membrane systems; the structure and function in the secretory processes of plant and animal cells; contractility and motility, and the molecules involved in those activities of cells; cellular growth-division cycles; chromosomes, chromatin organization, molecular cytogenetics, and nucleocytoplasmic interrelations; gametogenesis; cell transformation and the expression of infectious genomes in higher cells; photoreceptors; atherosclerosis and cells of the arterial wall.

To attempt a selection of such a selection for purposes of comment would be presumptuous. Suffice it to say that for each of these subdisciplines there are several distinguished contributions of data from current research and that the papers are generously supported with bibliography. To enhance their value for nonspecialists and for students, the papers are accompanied in most sections of the volume by introductory or concluding commentaries, or by both.

To the editors, to George Palade and the American Society for Cell Biology, who were the hosts, and to Daniel Mazia and the International Federation for Cell Biology, who did nothing more (as he reports) than to nucleate the 1976 International Congress of Cell Biology, thanks are due for the volume. Quite independently of the success of the meeting, their labors have yielded in this book a model for such publications. The cost and effort that so manifestly underlie its production should be repaid by the efficiency with which the book will broadcast the message that cell biology is alive, flourishing, and invasive—although or course benignly so.

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Prehistory of Quantum Physics

Early History of Planck's Radiation Law. HANS KANGRO. Translated from the German edition (Wiesbaden, 1970). Taylor and Francis, London, and Crane, Russak, New York, 1976. xviii, 282 pp., illus. $39.50.

The history of Planck's law for blackbody radiation—the law that first suggested the quantum discontinuity—has usually been presented as that of a problem for physical theory: how could experimentally observed deviations from Wien's and Rayleigh's theoretical laws be reconciled with electromagnetic theory and thermodynamics? Kangro sees more to the matter than that simple problem situation, however, and wants to draw a living, breathing picture of the complexities both of doing experiments and of evaluating them. As he writes,

> Partial aspects, such as infra-red spectroscopy, calibration by dispersion, the type of detector apparatus for radiation, accuracy of measurement and difficulties of measurement, the estimation of errors or the problem of realizing a black body belong just as much as conformity with laws and their interrelationship with thermodynamics, mechanics, statistics or the electromagnetic theory of light to the picture of the course of development which should be delineated in greater relief in that way [p. 181].

To the degree that Kangro has succeeded in his goal of historical enrichment his book can only be welcomed. He shows, for example, just how problematic was the judgment of irremediable deviation from Wien's relation for the distribution in wavelength of heat from a blackbody. Friedrich Paschen and Heinrich Rubens, two most expert investigators of long-wavelength radiation, supported the Wien law as late as the end of 1899. Though Lummer and Pringsheim had already begun to claim systematic discrepancies, Paschen could easily ascribe them to problems with the blackbody source. Only during the course of 1900 were experimental conditions realized that forced Planck's reformulation, in October, of the radiation law and ultimately forced a fundamental reevaluation of physical theory on the basis of the quantum.

More important than Kangro's description of the actual onset of crisis is his story of 15 preceding years of complex interaction between experiment and theory. Repeatedly, he argues, the development of ever more sensitive experimental techniques was prerequisite to the possibility of more incisive theoretical questions about the nature of heat radiation and its laws. (Indeed, Kangro makes this point so often that one wonders why he does not go on to examine the degree to which theoretical concepts had meaning only in terms of concrete experimental realities.) Though the strength of Kangro's account lies in the description of the experimental problems, his discussion is not limited to that realm but includes very interesting sections on successive theoretical derivations: by E. Lommel, V. A. Michelson, H. F. Weber, R. V. Kövesligethy, and Wilhelm Wien. Wien's theoretical approach is particularly important for its similarities to and differences from that of Planck, notably in the application of entropy considerations to radiation and to the relation between radiation and resonators. Planck's particular concerns, however, will be found more cogently treated elsewhere (see M. J. Klein, *Archive for History of Exact Sciences* **1**, 459 [1962], and T. S. Kuhn, *The Black Body Problem and the Quantum Discontinuity: 1894–1912*, Clarendon, in press).

Early History of Planck's Radiation Law adds a significant dimension to the prehistory of quantum physics, but the prospective reader should be warned that he or she is expected to know beforehand the meaning of "thermopile," "bolometer," and "black body," as well as Stefan's law, Kirchhoff's law, and the traditional questions and answers of heat radiation. One not so prepared will find little enlightenment here. The reader must be prepared to cope also with inconsistent notation, unmotivated formulas, and major results (for example Planck's radiation law, p. 203) buried in the flow of details. Now all of this might be easily surmountable by the average physicist if it were not for the fact that this translation of *Vorgeschichte des Planckschen Strahlungsgesetzes* often requires the reader to supply punctuation, to complete sentences, to rearrange word order, and even to supply different words. (See the quotation above.) The book is to be recommended