friendship of scientists and generously supported their worthy endeavors, such as the *National Geographic Magazine* and *Science*. In 1882, Bell and his father-in-law began the subsidization and reorganization of *Science*, which had been supported earlier by Thomas Edison. They expended at least $80,000 before the American Association for the Advancement of Science provided a subsidy and in 1900 designated the publication as its official journal.

Bruce gives almost half of his well-written and carefully organized biography over to the years "after the telephone." Some readers who come to the book interested primarily in the telephone and the inventor may feel that they are told more than they need to know about other matters. Yet this emphasis upon other aspects should caution textbook writers and others against regarding Bell as a typical inventor of a typical invention that will serve as the basis for generalizations about these subjects. Bell, fully delineated by Bruce, cannot be forced into a Procrustean bed with other leading American inventors of his time, such as Thomas Edison, Elisha Gray, and Elmer Sperry. He was, to offer a distinction, a professor of elocution; they were professional inventors. Also, Bell took out only 30 patents; Edison had more than a thousand. Bruce's scholarly and broadly conceived biography will, it is to be hoped, encourage other biographers to enrich our knowledge of the varieties and subtleties of invention and inventors.

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Galaxy

The Milky Way. An Elusive Road for Science. STANLEY L. JAKI. Science History (Neale Watson Academic) Publications, New York, 1973. x, 352 pp., illus. $14.95.

Early peoples invariably have seen in it the mirror of themselves: to Egyptians, it was wheat spread by Isis; to Incas, golden star dust; to Eskimos, a band of snow; to Bushmen, campfire ashes; to Arabs, a river; to Polynesians, a cloud-eating shark; to Teutons, the way to Valhalla; to Iroquois, the path to Ponemah; to Christians, the road to Rome. The modern astronomer may find the Milky Way less poetic, but it is no less fascinating to him, for it is the visual manifestation of the system of roughly a hundred billion stars to which our sun belongs. The drama of the topic, not to mention the problems it has raised for science, makes the lack of detailed histories of Milky Way research surprising and lamentable. With this book, Jaki attempts to fill that void. The scholarly result is compelling yet disappointing, compendious yet deficient.

The book traces Milky Way studies from Aristotle to Bondi, with one chapter each devoted principally to the Greeks, the Middle Ages, Copernicus, Galileo, Newton, Wright, Herschel, 19th-century cosmology, and early-20th-century breakthroughs. Every chapter is followed by over 100 footnotes; and although the body of the text does not contain illustrations, 24 arresting plates, reproduced from obscure sources, are grouped at the end of the book. But, ironically, this tome on the beautifully photogenic Milky Way does not include a single photograph, historic or modern, of its subject. The index is strictly to persons' names; the reader can easily find entries for Duns Scotus or Pontano yet nothing for distance scale or interstellar absorption.

The strengths of the book are numerous and important, among them being consistently literate prose, extensive research, and frequently perspicacious observations. Jaki has investigated scores of ancient books. The result is unquestionably the most detailed study ever published of pre-Wrightian theories of the Milky Way. The first half of the book is a tour de force on the history of galactic research: it probes Aristotle's theories; uncovers delightfully perceptive astronomical reasoning during the Middle Ages; reveals a baffling lack of interest in or awareness of the scientific significance of the Milky Way on the part of early Copernicans, Galileo, and even Newton; and analyzes the independent yet overlapping discoveries made within a generation by Kant, Lambert, Wright, and Herschel.

But in the latter half, especially the final two chapters, there are significant weaknesses. As a minor point, Jaki, who earlier wrote the intriguing work *The Paradox of Olbers' Paradox*, seems preoccupied with this historic question of why the night sky is dark. *The Milky Way*'s 18 references to Olbers do not make it clear that the actual physical resolution of the paradox is independent of our galaxy; Jaki seems to overestimate its historic significance in Milky Way studies, and today it is a problem strictly of extragalactic cosmology. Also, Jaki uses the term "Milky Way" with unsettling inconsistency, implying meanings ranging from the whitish band on the celestial sphere to general star fields to the entire galaxy.

There are a few errors of fact, but not an exorbitant number for such a detailed treatise. One of them arises from Jaki's misreading of a journal article. In a paragraph on large radial velocities of spirals (p. 290), he claims that Curtis was so perplexed around 1920 by these velocities that he was almost ready to abandon the island universe theory. Actually, in the article to which Jaki is referring, Curtis made that statement about van Maanen's findings of high transverse velocities, not recessional; indeed, the large red shifts found by V. M. Slipher strongly corroborated the island universe theory, as E. Hertzsprung insightfully realized as early as 1914.

But another type of flaw is also present that can be instructive because it demonstrates differences between private and public science plus the desirability of using archival materials in historical research. Jaki's study of published sources—ancient monographs and early journal articles—is impressively thorough. But of his over 1000 footnotes only a handful are to original documents such as unpublished workbooks, manuscripts, diaries, and letters; likewise, there are scant references to the few research articles by other modern authors in which analyses of original sources have been reported.

For the early periods, frequently the only extant materials are secondary sources; however, for the post-Herschelian era and especially the early 20th century, many original documents remain. Although they generally are uncataloged and scattered in diverse observatories, libraries, and attics, the pursuit of them is worthwhile, for they often reveal a richer and more nearly accurate history than do the articles intended for public consumption.

Some examples: Jaki claims (p. 308) that E. Hubble "carefully avoided seeing an evolutionary process" in his classification scheme for nongalactic nebulae, whereas a 1923 letter (now at the Lowell Observatory) from Hubble to V. M. Slipher, in which Hubble wrote, "I have been trying to construct a classification of non-galactic nebulae analogous to Jeans' evolution se-

quence," reveals just the opposite. Jaki asserts (p. 292) that Curtis and Shapley were the "respective leaders" in the controversy over the island universe theory, which culminated in their historic Great Debate in 1920; in fact, surviving letters (now at the National Academy of Sciences) show that the sides in the conflict appeared oblique at the time and that the first participants proposed for the debate were Shapley and W. W. Campbell, not Curtis. Jaki's detailed discussion of the debate rests upon its published proceedings; but the papers actually presented, as well as over two dozen letters between Curtis and Shapley related to the event, still exist, and they show that the published version barely resembles what truly occurred. Jaki repeats (p. 301) the familiar saw that on 1 January 1925, when Hubble's classic discovery of Cepheids in spirals was formally announced at a meeting of the AAAS, both Curtis and Shapley were present and that the finding abruptly ended one era and began a new one; again, private papers show that Curtis was not present, that almost everyone in the field had known of the discovery for many months (the *New York Times* had even run a story on it in November of 1924), and that some distinguished astronomers were not immediately convinced by it.

It would be too much to expect a single author to ferret out every source; and, overall, Jaki has made an admirable effort in that regard. The book's dust jacket boldly claims that this will undoubtedly be "the definitive reference work on the Milky Way's history for many years to come." For the recent periods this is sheer hyperbole; for the early ones, which constitute the bulk of the book, it likely will be true.

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Aquatic Diets

Fish Nutrition. JOHN E. HALVER, Ed. Academic Press, New York, 1972. xii, 714 pp., illus. $32.50.

Mammalian nutrition has for many years been studied systematically by means of synthetic feeds of controlled composition. Use of these methods with fish presents problems, however. A special expertise, which has evolved only relatively recently, is required to prevent the loss of soluble constituents or the breakup of the food in the water and to make sure that the exact amount of test material is actually ingested by the fish. It is therefore a pleasure to find this book summarizing what has been discovered about fish nutrition.

The volume is edited by a pioneer in the field and gives pride of place to the doyen of fish nutritionists, Arthur Phillips, Jr., who has contributed the first chapter. There are 11 chapters in all, each by one or two distinguished contributors, presenting altogether a most useful collection of information. Separate chapters deal with requirements for calories, vitamins, proteins, and lipids. Others show the effects of absorption of excessive or unbalanced proportions of nutrients and of consuming nonnutritive or even toxic materials that happen to be included in the diet. The remaining chapters, apart from one on fish enzymes, are concerned with feed formulation, husbandry techniques, and disease, and the text concludes with an appendix setting out typical diets. A bibliography concludes each chapter, and there is a full author index and a general subject index at the back of the book.

As most of the experimental work in toxicology has been done with mammals, the consequences for fish of eating such materials as soybean and cottonseed can usually only be surmised. Thus Friedman and Shibko's chapter is devoted largely to the responses of mammals, but the advantage of this approach is that it points the way to future studies using fish. L. M. Ashley's chapter on nutritional pathology balances more evenly the findings on mammals and fish and where possible draws valid comparisons between the two.

Hugh Tarr's chapter ("Enzymes and intermediary metabolism") cannot honestly be said to fit into the pattern of the book at all, but it is a superb chapter which gives a biochemical background to the experimental animals. As in standard biochemistry textbooks, the Embden-Meyerhof and hexose monophosphate pathways and the tricarboxylic acid cycle are laid out—but here at each step a reference number shows where the appropriate enzyme has been found in fish.

A consequence of the long time taken to compile this book is that there are few references beyond 1966; one author refers to a paper "recently" published in 1962. Apart from this I have two main criticisms. The first relates to the Latin nomenclature—no fewer than 25 Latin names are misspelled: rainbow trout comes in various chapters as *Salmo iredius* (sic), *S. gairdneri*, and *S. gairdnerii*, and *Thynnus alalunga* on p. 279 appears as *Germo alalunga* on p. 312. In a reference work of such importance these should have been standardized. Second, there is considerable duplication which could have been eliminated by tactful editing: the symptoms of vitamin deficiency in fish have been tabulated independently by three of the authors, and, incredibly, in three separate chapters there are photomicrographs of "clubbed" gill filaments resulting from pantothenic acid deficiency. There are also two independent photographs of goitrous tumors and two of lipoid degeneration of the liver, the latter two apparently borrowed from the same source.

However, these slips detracted little from my enjoyment of a fine book which should be a source of reference material for fish culturists, nutritionists, and biology students for a long time to come. It is beautifully produced and contains a large number of informative photographs and photomicrographs.

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Molecular Biology

The Mechanism of Protein Synthesis and Its Regulation. L. BOSCH, Ed. North-Holland, Amsterdam, and Elsevier, New York, 1972. xiv, 590 pp., illus. $38. Frontiers of Biology, vol. 27.

Control Mechanisms and Protein Synthesis. S. D. WAINWRIGHT. Columbia University Press, New York, 1972. x, 550 pp., illus. $20.

These two books attempt to present a contemporary view of protein synthesis and its regulation. Taking a global view one must say that on the whole they have succeeded, particularly for a reader with access to both of them—an expensive undertaking, by the way. In many ways they are complementary, one dealing mainly with synthesis, most successfully with prokaryotic systems, and the other mainly with regulation, with principal emphasis on eukaryotic systems, specifically of vertebrate animals.

The Mechanism of Protein Synthesis and Its Regulation attempts in 16 chapters to present the state of the art as