fill 600 meters of library shelving. That bulk is far below the capacity of some existing libraries of evolutionary biology. The library of Harvard University's Museum of Comparative Zoology, for example, occupies 4850 meters of shelving.

The *Catalog of Hymenoptera in America North of Mexico* represents a landmark in the ongoing taxonomic exploration of the North American fauna, the third of its kind during the past century. From 1892 to 1902 K. W. Dalla Torre listed the hymenopteran fauna of the world. In 1951 C. F. W. Muesebeck and a group of associates provided a complete taxonomic record of the species of North America north of Mexico, with summaries of natural history data. Important syntheses always work toward their own obsolescence, and so it was that the Muesebeck catalog stimulated a rush of new systematic and biological studies. In 1971 a group of hymenopterists from the Smithsonian Institution and the U.S. Department of Agriculture laid plans to summarize the information once again. The present three-volume work is the long-awaited result.

The *Catalog of Hymenoptera in America North of Mexico* represents an innovation in methodology. The entire body of information is stored in a computer in a form that permits continuous data retrieval and updating. The revised edition was produced by a computer-driven Linotron in the Government Printing Office. Yet despite this amount of automation, the result is a well-arranged and readable set of conventional books. As should be expected from the reputation for competence and expertise of the authors, the material appears to be accurate. I pored over the entries for every one of the 580 species of ants without noticing an error. A similar favorable impression has been registered by several other hymenopterists with whom I discussed the catalog.

I am sure that others will share the feeling I have experienced of wanting to pursue studies of the little-known but potentially interesting and significant species now made more visible. Widely scattered notes in the literature have been turned into coherent but preliminary and tantalizing characterizations. The authors are to be congratulated for a large and difficult job well done, the benefits of which can only grow with time.

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A Segment of Biochemical Research

A History of Biochemistry. Part 5, The Unravelling of Biosynthetic Pathways. MARCEL FLORKIN. Elsevier, New York, 1979. In two volumes. Part A, xx, 434 pp., illus. $68.25. Part B, xx, 320 pp., illus. $52.75. Comprehensive Biochemistry, vols. 33A and 33B.

The twin volumes constituting Part 5 (chapters 53 through 74) of Marcel Florkin's history of biochemistry trace the complicated development of an important segment of recent biochemical research, namely the unraveling of biosynthetic pathways. This history, starting with early isotope studies at the Columbia laboratory during the late 1930's, documents in detail the progress of studies on biosynthesis primarily of the smaller molecules—the sugars, nucleotides, pyrroles, vitamins, and amino acids—during the succeeding two or three decades. The story builds on the contents of volume 32 of this series, in which the early history of research on biosynthesis is explored. In this early period biochemists attempted with great difficulty and often frustration to define even the simple outlines of metabolic pathways without the use of the modern armamentarium of enzyme technology, bacterial mutants, and isotopes, the latter two being major contributions of genetics and physics, respectively, to biochemical research. The strong influence of organic chemists, whose early efforts led to hypotheses concerning possible precursors of simple molecules, in shaping the infant discipline of biochemistry is evident. Although it was H. A. Krebs, a biologist, who in 1932 first developed in his ornithine cycle the concept of a biosynthetic pathway as a discrete succession of enzyme-catalyzed reactions, the unraveling of biosynthetic pathways by a new cadre of biochemists was undoubtedly closely allied to chemistry and to a chemist's understanding of experimental design.

Florkin has organized his treatment to show how the great revolution in biochemical research during the '30's depended not only on the development of specific methology but also on the clarification of the structures of important biological constituents, for example, that of adenosine triphosphate (ATP), which is the currency of all energy exchanges in living systems. The role of phosphorylation in the activation of metabolites that enables them to participate in biosynthetic reactions is illustrated in chapter 53 by the discovery of coenzyme A (CoA) and its participation with ATP in the activation of acetate and higher fatty acids as the CoA derivatives. Thereafter, in chapter 54, Florkin explores the issue of whether biosynthetic reactions are the simple reverse of catabolic reactions as a function of the mass law. This prevailing idea was challenged by the realization that the ordered sequence of amino acids in proteins could not be achieved through the action of proteases or by transpeptidation reactions. The synthesis of the simple tripeptide glutathione was recognized as an exception to this generalization and also as not typical of the reactions of protein biosynthesis. As is illustrated even more lucidly by examples in carbohydrate and lipid synthesis, biosynthetic pathways, although sometimes using enzymatic systems common to catabolism, always require their own specific energy-yielding reactions to overcome the thermodynamic differential between precursors and products.

Chapters 55 and 56 explore the discovery of the pentose pathway as a major channel of carbohydrate metabolism, which provides not only the five carbon sugars for nucleotide synthesis but also the complement of reduced triphosphopyridine nucleotide needed for reductive biosynthetic reactions, as in the case of lipid synthesis. The interplay of research in this area and research on photosynthesis led ultimately to an understanding of how carbohydrates may be formed from CO_2 and how the reducing potential is developed.

Chapter 57 logically moves on to the topic of CO_2 assimilation by heterotrophic bacteria and by animal tissues. The isolation of ^{14}C and its availability after World War II provided a quantum jump in the study of the metabolism of carbon compounds. As one of the first and easiest candidates for studies of this kind, CO_2 was shown to participate in glyconeogenesis and indirectly in lipid synthesis. The discovery of the nucleotide sugars, in particular uridine diphosphoglucose and its role in the synthesis of glycogen and other carbohydrate structures, is discussed in chapter 58. The synthetic function of glycogen synthase as opposed to the degradative role of phosphorylase is chosen as one of the best examples of the diversity of enzymatic systems in anabolic and catabolic processes.

Chapter 59 reviews the succession of experiments that proved that lipid synthesis was not a simple reversal of β-oxidation of fatty acids. The participation of a whole different set of enzymes, including a novel carboxylation of acetyl CoA by ATP to yield malonyl CoA as the active participant in fatty acid chain elongation, was indeed one of the most noteworthy surprises of biochemical research. Here the decarboxylation of the reactant is the driving force of the biosynthetic direction of the reaction. The complex reactions of triglyceride and phospholipid synthesis are also reviewed.

Chapter 61 continues the narrative of acetate utilization for the synthesis of the sterols and related natural products. Here, as was often the case, the initial experiments originated in the Columbia laboratories under the guidance of Rudolph Schoenheimer and his exceptional group of collaborators. The analysis in cholesterol of the carbon atoms derived from the carboxyl and methyl carbons of acetate implicated an isoprenoid unit and squalene in sterol biosynthesis and helped in the prediction of the correct pattern of the folding of squalene in these reactions.

The account of extensions of the isoprenoid pathways includes reviews on the biosynthesis of terpenes, carotenoids, tocopherols, ubiquinones, dolichols, rubber, steroid hormones, bile acids and alcohols, arthropod hormones, and insect pheromones.

The remaining chapters of volume 33A deal with the heterocyclic compounds, the porphyrins, the purine nucleotides, and the vitamins. Chapter 60 contains a detailed summary of how the complex pyrrole and corrinoids are formed. Again deductions from the origins of the carbon and nitrogen atoms of the pyrrole ring from labeled acetate and glycine provided the clues for demonstrating the central role of δ-amino levulinic acid in the synthesis of the pyrrole ring.

Volume 33B is devoted entirely to reactions of amino acid synthesis. In the 11 chapters of this volume the amino acids are classified into families according to metabolic origin. For example, ornithine, arginine, and proline are treated as part of the glutamate family, and urea and the pyrimidines are treated as extensions of this family because their ureido groups are formed by a pathway common to arginine. Thus, although pyrimidine biosynthesis is placed out of context with purine nucleotide synthesis, the vitamins folic acid and riboflavin are considered as extensions of the latter.

These two volumes cover such recent work that it is hard for this reviewer to relegate it to history. However, the period in question is rapidly passing as the emphasis in biochemistry is clearly shifting from clarification of metabolic pathways to investigations of complicated interactions at the macromolecular and cellular level.

Florkin's history does not include the biosynthesis of the macromolecules other than glycogen. Surprisingly, there is no mention of the synthesis of the deoxynucleotides, nor is appropriate space devoted to control mechanisms. This material may be taken up in a further volume projected before Florkin's death in the summer of 1979.

Florkin's history is undoubtedly the most complete treatise of its kind. It is detailed almost in the manner of a textbook, including valuable references and above all photographs of leading investigators. It avoids the personal and sometimes gossipy treatment of Judson's account of molecular biology, *The Eighth Day of Creation*. Yet Florkin's chapter on carbon dioxide fixation by heterotrophic organisms is outstanding because of the inclusion of letters and assorted information arising from previous historical research. Although documentation of the history of a discipline by the participating scientists themselves may yield at times a biased version of the story, it is indeed important that such personal histories be written, including anecdotes together with the investigators' accounts of their motivations and insights into their research. In many instances there is a certain urgency that these autobiographies be written to complement the straightforward approach that distinguishes Florkin's remarkable effort.

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DNA Studies Brought Up to Date

DNA Replication. ARTHUR KORNBERG. Freeman, San Francisco, 1980. xii, 724 pp., illus. $32.50. Revision of *DNA Synthesis* (1974).

A comparison of Arthur Kornberg's *DNA Replication* and the 1974 edition, *DNA Synthesis*, amply substantiates the author's prefatory statement that extensive new information warranted a new book. The first edition reflected Kornberg's focus on DNA polymerases and nucleases of *Escherichia coli*, and although it was an excellent treatment of nucleic acid biochemistry it suffered from some difficulties inherent in the presentation of up-to-date research in a rapidly moving field. The volume also appeared prior to the harvest reaped from nearly 20 years of research on DNA molecular biology. This bumper crop was presented at the Cold Spring Harbor symposium on DNA replication in 1978 (Watson-Crick model + 20 years). As a participant in that meeting, I recall my excitement and awe as new discoveries were presented that transformed problems hitherto unapproachable into those that had been solved, those that were being solved, and those that could be solved. Kornberg's decision to revamp the previous edition clearly reflects this enormous progress in DNA research.

The new edition is excellent. It is divided into 17 chapters, each of which covers a particular subject relevant to DNA synthesis. The organization of the book is logical; the first two chapters deal with the structure and function of DNA and the biosynthesis of DNA precursors (including the various pathologies resulting from deficiencies in some of these enzymes). The chapters dealing with DNA synthesis, DNA polymerase I of *E. coli*, and other prokaryotic DNA polymerases are similar to those in the 1974 edition. The only other chapter resembling one in the previous edition is the chapter on deoxyribonucleases. Even here, new nucleases are discussed and their modes of action presented and tabulated. The rest of the chapters are either new or so filled with up-to-date information that they are virtually new. The chapters on binding and unwinding proteins, replication mechanisms, and operations are clearly written, as are the chapters on eukaryotic replication. Because nature has devised different ways of initiating DNA replication, each system—T4, T7, and so on—is presented individually. Though our knowledge of the mechanism of eukaryotic DNA replication is limited, the new edition has an excellent summary of recent studies of