ies. This seems to be particularly true for the contributions in the section Topics in Cancer. Here it is stressed that several environmental factors have been implicated as important agents in carcinogenesis among vertebrates, including fish, where hepatomas, epithelial papillomas, and other neoplasms have now been studied. Fish offer several advantages for the experimental investigation of cancer: their total environment can be readily altered; they are poikilothermic and growth and metabolism often depend on temperature; growth is normally slow and often continues throughout life; large numbers of animals can be obtained from a single mating. Except for melanomas in killifish hybrids, epitheliomas in catfish, and hepatomas in trout, there is little detailed work on neoplasms in fish, and the comparative approach may prove to be very productive. Parallel comments can be made with respect to the other topics considered.

Even though some of the contributors did not deal with the specific question raised by the sponsors of the symposium, each of the authors is a leader in his field, and these reviews of recent findings should prove valuable to comparative biochemists, physiologists, and geneticists. This book is a useful addition to the fisheries literature. Moreover, it may direct the attention of some scientists working on the higher vertebrates to novel systems for comparative study; at the same time it provides worthwhile reviews of the literature in the areas considered.

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Proteins and Small Molecules

Multiple Equilibria in Proteins. JACINTO STEINHARDT and JACQUELINE A. REYNOLDS. Academic Press, New York, 1969. xii, 396 pp., illus. $15. Molecular Biology.

The understanding of the factors governing the interaction of proteins with small molecules is of central importance in enzymology, immunology, pharmacology, and diverse other areas of study. The appearance of a book that attempts a synthesis of the knowledge in this field is therefore of particular interest. This is a well-written compendium dealing with those compounds for which multiple binding sites on proteins have been observed. This category encompasses the interaction of proteins with hydrogen ions, detergents, urea, guanidine, organic solvents, hydrocarbons, dyes, and metal ions. The major strength of the book lies in the clear treatment of the thermodynamics of complex formation and in the exploration of the practical aspects and pitfalls of the various methods used for the determination of binding isotherms and hydrogen ion titration curves. The extensive reference lists should prove to be of considerable help to those who are interested in protein-small-molecule interactions.

The authors account with some success for the stabilizing and cooperative unfolding effects of certain ligands in terms of the interplay between the forces involved in complex formation and those responsible for maintaining the native protein structure. In this context, it is interesting to note that the more recent studies have forced little revision of the mechanisms of protein denaturation elegantly presented by Kauzmann in 1954 (in *The Mechanism of Enzyme Action*, W. D. McElroy and B. Glass, Eds., Johns Hopkins Press).

Not unexpectedly, considerations of binding phenomena involving bovine and human serum albumins dominate the discussion. However, despite an abundance of experimental data, few satisfying answers to the questions as to the nature of the binding sites and the apparent "configurational adaptability" of these proteins have been provided. The suggestion that "compared to other proteins, the surface of bovine serum albumin contains many hydrophobic patches or sites, and . . . fewer or smaller stabilizing clusters will be found in the interior of the molecule" has considerable appeal.

Specific complexes of antibodies with antigens, or of enzymes with cofactors, substrates, or inhibitors, are excluded from detailed consideration as not representative of multiple equilibria. One would be more readily reconciled to this arbitrary restriction if the authors adhered to it fully. Thus, specific complexes involving enzymes are examined, but in a purely descriptive and fragmentary manner, with little use of the results of recent x-ray crystallographic studies.

Aside from hydrogen ion equilibria, the attempt to interpret multiple equilibria in proteins is complicated by the lack of knowledge of the structure of the complex formed, the possible contribution of ligand-ligand interactions to the observed energy changes, and the changes in the distribution of conformational forms that the protein can assume at different ligand concentrations. Clearly, these factors will differ from one protein to another. Ultimately, the understanding of protein-small-molecule interactions, as well as the interpretation of the thermodynamics of complex formation, requires knowledge of the details of the interaction at the atomic level. Such information is available for a limited number of cases, principally those of enzyme-inhibitor complexes, or unproductive complexes of enzymes with substrates. Consideration of these complexes falls beyond the deliberately restricted scope of this book.

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Virology

The Chemistry and Biology of Viruses. HEINZ FRAENKEL-CONRAT. Academic Press, New York, 1969. x, 294 pp., illus. $9.

The author of this book has set himself the task of introducing students in biology, biochemistry, bacteriology, and the premedical sciences to the chemistry and biology of viruses. The book is also intended to help research workers in these fields broaden their specialization. As the author mentions in the preface, he has handled the material in a fairly elementary manner, avoiding especially higher mathematics and physics.

As tools of the molecular biologist, the geneticist, the biochemist, and more recently the immunologist, viruses have often been as well studied as the systems they are being used to explore. Assembling this information into a readable book is a worthwhile venture, and Fraenkel-Conrat has succeeded in nearly accomplishing the objective that he set for himself.

The book includes the methods used in isolation and purification of both viruses and subviral components and contains excellent chapters on the properties of viral proteins and nucleic acids, a subject on which the author is a recognized authority. A good background in biochemistry, however, is helpful in understanding these chapters. The relation of subviral structure to function is well described, as is the replication of plant and bacterial vi-

ruses. In general, the biology of the various virus systems is somewhat less well developed than the chemistry (representing perhaps part of the 5-percent personal bias in the choice of literature quoted that the author acknowledges in his preface). It is difficult, for example, to understand how the development of molecular virology was more enhanced by the crystallization of poliomyelitis virus (table 1.1) than by the earlier (and unmentioned) discovery that this virus can be replicated in cell culture, an observation by Enders and his colleagues that really opened the door for the development of the science of virology. The one page reserved for the replication of DNA-containing animal viruses also would have benefited from expansion of the information presented.

Throughout the book the diagrammatic presentations are excellent and greatly simplify the complex problems and theories presented. The electron micrographs and charts have also been well selected to demonstrate the points made.

This book should prove useful to undergraduate students and to those who are especially interested in general information about plant and bacterial viruses. It is less valuable for those in other fields interested in information about animal viruses, but those working with these viruses would be well advised to read the book to enhance their own perspective.

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Photochemical Reactions

Energy Transfer and Organic Photochemistry. A. A. LAMOLA and N. J. TURRO. With chapters by P. A. Leermakers and T. R. Evans. Interscience (Wiley), New York, 1969. xii, 388 pp., illus. $18.50. Technique of Organic Chemistry, vol. 14.

Our understanding of the photochemical transformations of organic molecules has increased tremendously in both scope and sophistication during the last decade. This rapid advance was made possible by the development of a powerful method for analyzing photochemical reaction mechanisms. The method, which is largely the creation of G. S. Hammond and his co-workers, involves a judicious blending of solution kinetics, spectroscopic techniques, and chemical intuition and has the considerable advantage of not requiring elaborate apparatus. Its key feature is the exploitation of triplet (and sometimes singlet) excitation transfer in solution as a powerful probe for determination of the number and spin multiplicity of excited-state intermediates in a photochemical system. With this information available, a knowledge of the probable nature of these excited states —obtained from theoretical or perhaps spectroscopic studies—permits shrewd guesses to be made about the primary photochemistry to be observed for particular systems. Using this approach, organic photochemists have discovered large numbers of new photochemical reactions, and have succeeded in dispelling much of the mystery surrounding previously discovered processes such as photosensitized oxygenation reactions. Many important problems concerning, among other things, chemiluminescence, certain biological phenomena affected by light, photodegradation of materials, and lasers have been attacked profitably with this method. The growth of organic photochemistry has had considerable impact on the development of spectroscopy, the development by Lamola and Hammond of a convenient method for measurement of intersystem crossing yields being only one of many important contributions.

This volume, the latest in the Weissberger series on physical methods in organic chemistry, is about modern methods for determining photochemical reaction mechanisms. The heart of the book is two elegant articles illustrating principles and practice in determination of photochemical reaction mechanisms. Lamola gives a pellucid treatment of the transfer of electronic excitation in fluid media and its relationship to determination of photochemical mechanisms. A crisp and refreshingly clear presentation of theoretical and experimental spectroscopic preliminaries is followed by the most important part of the presentation for the organic chemist: a fairly complete exposition of applications of electronic energy transfer to the spectroscopy and photochemistry of organic molecules. In the following chapter, Turro gives a chromophore-by-chromophore account of the photochemical transformation of organic molecules. An attractive feature of his article is the mode of presentation. For each chromophore, the expected nature of the electronically excited states is discussed and then related to observed photochemical reactions. In combination, these articles provide the best text available today for learning about modern methods for elucidation of photochemical reaction mechanisms.

Only two real criticisms of this book may be made. The first is that it was published two years after completion of the literature surveys. Interscience should do better. The second is that there are some techniques for mechanistic investigations—such as matrix isolation of highly reactive primary photochemical products—that receive less mention than they deserve.

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A Ciliate

The Anatomy of Paramecium aurelia. A. JURAND and G. G. SELMAN. Macmillan, London, and St. Martin's, New York, 1969. xiv, 218 pp., illus. $18.

Jurand and Selman have presented the community of protozoologists with an excellent comprehensive account of the morphology of *Paramecium aurelia*. Their book gives a detailed, illustrated description of the ultrastructure of this ciliate. Its pages contain a narrative on the structure of *Paramecium*, excellent diagrams, and electron micrographs of great esthetic and scientific value.

Discussed in detail are the ultrastructure of the pellicle and its associated organelles, the gullet (buccal apparatus), food vacuoles, contractile vacuoles, the cytoplasm and its organelles, the nuclei, binary fission, conjugation, and the cytoplasmic symbiotic inclusions. Some of the plates accompanying these sections are superb, especially plate 52 (first published in the *Journal of General Microbiology*), which shows the extraordinary sophistication of the endosymbiote particle lambda.

It comes somewhat as a surprise that no electron microscopic studies have been made of autogamy. This process is fleetingly described on page 3, and it is stated there that the nuclear changes are the same as those associated with sexual reproduction. This may be so, but autogamy is an important aspect of the life cycle of *P. aurelia* and deserves more attention than it is given by the authors.

Jurand and Selman cautiously approach the problems inherent in electron microscopy. They warn of the pitfalls and the disastrous results of