(together with Wyatt) of a novel pyrimidine, 5-hydroxymethylcytosine, which completely replaces cytosine in the DNA of the T-even phages, provided a "handle" for studying the metabolism of a small island of phage DNA in a large pool of bacterial DNA. On the other hand, it posed the question, Where do the enzymes come from which must be involved in the synthesis and interconversions of this unique pyrimidine base? That Cohen is not unaware of the impact this discovery had on virology in general and biochemical virology in particular is evidenced by the headings of his first three chapters—"Biochemical virology before 5-hydroxymethylcytosine," "From virus pyrimidines to virus-induced acquisition of function," and "Deoxycytidylate hydroxymethylase and thymidylate synthetase, two virus-induced enzymes"—which are followed by three more chapters describing other "early" proteins, the life cycle of some virulent DNA phages, and the expression of a viral genome. The personal involvement of Cohen in the early discoveries, and his continued productivity in this field, must have created an excitement in the audience for these lectures, and the excitement carries over to the reader. The prose has more of a narrative than a didactic character, which I found refreshing. This informality belies the thorough treatment of the subject matter, which is well organized, thoroughly referenced, and adequately indexed.

Although the title "Virus-Induced Enzymes" may have been appropriate for the series of lectures, I think it is an unfortunate choice for the book, because in one sense it is too broad and in another too narrow. The discussion is confined almost exclusively to a particular group of viruses, the bacteriophages. Second, much more is covered than the enzymes themselves. The author has used the induction of the phage-specific enzymes as a hub from which radiate discussions of the coding problem, colinearity of gene and polypeptide, the rII product, virus-induced RNA, the problem of gene selection, and the turning on and off of viral functions. A more descriptive title would be "The Biochemistry and Molecular Biology of Phage Infection," although I am aware of the agitation that might be provoked by putting these two disciplines together on one book cover.

This book will be appreciated by the graduate student, the lecturer, or the researcher. An outstanding feature is the clear distinction Cohen makes between what we know, what some workers think we know, and what we certainly do not know. Cohen leaves us with the feeling that, far from being worked out, the study of the biochemistry of bacteriophage-host relationships will be instrumental in clarifying our notions of enzyme induction and repression and of biological differentiation and development, but he warns us that in order to discover these secrets we will have to transcend the narrow confines of biochemistry and genetics and "become organic chemists, polymer chemists, electron microscopists, cytologists, and cell physiologists." Wow!

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Putting a Science Back on the Track

General System Theory. Foundations, Development, Applications. LUDWIG VON BERTALANFFY. Braziller, New York, 1969. xvi + 290 pp., illus. Cloth, $8.95; paper, $3.95.

This volume consists of 10 essays and a short appendix dealing with general system theory, its role in the study of biological and social organisms and in the unification of science as a whole. All but one of these essays have appeared previously in one form or another, most of them being less than ten years old but the earliest dating from 1940.

Bertalanffy felt impelled to prepare this book in large part because, as he indicates in the foreword,

> . . . systems theory—originally intended to overcome current overspecialization—[is becoming] another of the hundreds of academic specialties. Moreover, systems science, centered in computer technology, cybernetics, automation and systems engineering, appears to make the systems idea another—and indeed the ultimate—technique to shape man and society ever more into [a] "megamachine" . . . .

It is his hope that a restatement of the general character of system theory as he originally envisioned it, in the original words and in historical perspective, may in part counteract this trend, a trend all the more deplorable to Bertalanffy because, as he explicitly and repeatedly states, he regards his holistic system-theoretic views as an ethically as well as scientifically preferable alternative to simple-minded reductionistic mechanism:

> The mechanistic world view, taking the play of physical particles as ultimate reality, found its expression in a civilization which glorifies physical technology that has led eventually to the catastrophes of our time. Possibly the model of the world as a great organization can help to reinforce the sense of reverence for the living which we have almost lost in the last sanguinary decades of human history.

These words were written in 1955.

For pointing out and emphasizing the original motivations of system theory—the deep homologies that appear as if of themselves between different sciences concerned with organization—and for meeting a variety of philosophical objections to system-theoretic viewpoints, a more eloquent discussion could hardly be imagined. This is not surprising, since there is probably no one better qualified to write on the integrative aspects of system theory than Bertalanffy, who was among the first to notice them and who has been developing them consistently for nearly 30 years. The reading, however, is by no means easy; many essays are as much concerned with philosophy as with science, and the text is densely sprinkled with further references which must be consulted to clarify the often terse exposition (the bibliography, characteristically, runs to more than 25 pages) on a plethora of subjects ranging from atomic physics through Hopi linguistics. Nevertheless, there is a wealth of knowledge and insight to be gained from these pages.

Despite the long period of time over which the chapters in this volume were composed, the editing is such that there are surprisingly few anachronisms in need of correction. There are a number of minor lapses, as for instance on page 57, where it is apparently suggested that an arbitrary dynamical system must have "steady states," and even that a system will have only one "steady state." More serious, in the reviewer's opinion, and in fact partly comprising the only important shortcoming in the book, are the repeated distinctions made between dynamical systems and systems with feedback, and between dynamical system theory and automata theory. For it is one of the major insights of dynamical system theory that the distinction between feedback control systems and dynamical systems is only one of emphasis, both kinds of system being essentially comprised within the mathematics of stability theory; likewise it is another important insight drawn from system theory that automata theory, far from being different in kind from dynamical system theory, is actually as close a paraphrase to a discrete setting of the formalism of dynamical system theory as possible. These are very important unifying insights, and come from the technical development of system theory itself.

More important even than these insights is the more general fact that the further development of system theory is likewise, of necessity, going to be technical in character. It is one thing (a most important thing, to be sure) to draw attention to dynamical homologies and analogies between systems at different levels of organization, and quite another to formally exploit these analogies and homologies to obtain information about a particular class of systems. This is already being done in biology; to learn in detail how and when it may be done in general terms is perhaps the most exciting vista in system theory. This technical development of system theory itself is essential if it is to play the integrative role envisaged by Bertalanffy; but (perhaps partly owing to Bertalanffy's dislike of technical specialization) the role of these developments seems to have been deliberately minimized. In the reviewer's opinion, this failure to emphasize or even to recognize the role of the technical side of system theory and its application from today's vantage point almost unbalances the entire book.

Despite this important caveat, Bertalanffy's book is an authoritative and noble volume, and the scientific literature is richer for having his contributions assembled in this definitive form.

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Describing Life Processes

Mathematical Ideas in Biology. J. MAYNARD SMITH. Cambridge University Press, New York, 1968. viii + 152 pp., illus. Cloth, $5; paper, $1.95.

The purpose of this book is to show that mathematical reasoning can sometimes illuminate biological processes. The author points out that many biologists are likely to suppose that the mathematics applied to biology is mainly statistics, and since there are many books covering this area of mathematics it is not included as a topic in this one. Emphasis is on the use of mathematics as a tool in the development of concepts and in the formulation of quantitative models which give insight into biological processes. A brief rationale for the importance of this approach is well stated in the introduction. The book is not meant to be a text or treatise. The intention is to treat a variety of problems in order to illustrate the utility of various branches of mathematics. The author is able to present many of the arguments in an intuitive way that can be of benefit to the biologist without a background in mathematics. Concise mathematical appendices are included to help make this possible.

The chapter "Some consequences of scale" emphasizes the importance of dimensional analysis. It introduces the principle that certain minimum design requirements restrict the sizes of animals and their organs. Thus the tensile strength of bone, the maximum tension that can be developed by muscle, and its rate of development limit the size of animals, restrict their shape, and limit their rate of movement. Very simple arguments give insight into the observation that the height to which an animal can jump is relatively independent of its size. The concept of optimality is touched on. Several additional topics are brought up in this chapter.

While one might feel that too many ideas are presented in so short a chapter, a more serious criticism is that the ideas have not been adequately related to work in the literature. Most of the topics have been treated in detail (for example, by Rashevsky in *Mathematical Biophysics*, ed. 3, 1960), but no reference is made directly to such work, and there are only a few general references listed at the end of the book. Thus the reader is given little assistance in finding out what work has been done on a particular topic. For example, the statement "Therefore V, the velocity of flow in the aorta, will not vary with size [of the animal]" is in the nature of a prediction. The addition of a sentence stating that the velocity of blood in the aorta of mammals is about 24 centimeters per second [W. R. Stahl, *Science* **137**, 205 (1962)] would have made it clear that the prediction is borne out. This case should have been presented in greater detail, and the example would have been more complete had a discussion of how the thickness of the ventricle wall should increase with heart size been included.

The next four chapters give a good introduction to population regulation and interaction and to the genetics of families and populations, with adequate references. The opportunity is taken to introduce a number of important and useful concepts and methods. Among these are conditional and inverse probability, recurrence equations, stability and instability of equilibria, and the solution of problems by means of both difference and differential equations. In these and other chapters many interesting questions are raised and hints for finding their answers are often given.

In a chapter on regulation and control, one of the examples treated is the control of protein synthesis. This example was chosen from the literature in part to illustrate a system that can exhibit maintained oscillations. In the model the gene produces messenger RNA, which in turn produces an enzyme capable of converting a precursor into a product. The product then acts as a repressor on the gene activity through competitive inhibition. If the system is linear and irreversible, except for the repression, one obtains three equations for the rates of change of the three substances. Analog computer simulations of the solutions, showing the amounts of the three substances as functions of time, are given. The concept of phase space is discussed and the amount of enzyme is plotted against the amount of product to illustrate a limit cycle. (Note that the notation used in the legend follows the original reference, not that used in the book.) However, since this system does not in fact show oscillations, the oscillations obtained presumably being introduced by the analog simulation procedure, the author suggests modifying the equations by introducing a time delay to allow for travel of mRNA from gene locus to ribosome. Unfortunately the system given cannot give maintained oscillations even with the time delay. However, this difficulty can be overcome by assuming second-degree inhibition or by assuming that there is an enzymatic removal of mRNA at a sufficient rate, the enzyme affinity being high.

The last chapter, on diffusion and similar processes, gives the author an opportunity to introduce the notion of partial differentiation. Some brief examples illustrate the utility of dimensional arguments. This discussion