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BIOLOGY

Third Edition

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PREFACE TO THE THIRD EDITION

Ever since I was a child, biology has fascinated me because of the glimpses it gives of what it means to be alive—of how living matter works. This is still what attracts me irresistibly to the subject, and I derive great satisfaction from watching and writing about the continuing rapid progress being made toward understanding the nature of life. And so, in preparing this edition, I have described many of the advances that have been made since the last edition, especially in such areas as how genetic controls work and the operation of the nervous, endocrine, and immune systems.

But today's students have another, equally valid, reason for studying biology. We are now faced in every part of the world with problems that are, at least in part, biological in nature. To attempt to solve these problems (pollution, agricultural productivity, population growth, etc.) requires that we gain the best understanding we can of the biological principles that underlie them. Therefore, in this edition I have not only attempted to deal with some of these problems but have also tried to place the topics alongside the fundamental biology that relates to them. In so doing, it no longer seemed appropriate to sequester "ecology" as a terminal appendage to the book. Instead, I have taken that material, enlarged upon it in many areas (ecosystem productivity, dynamics of soil and water, etc.), and interwoven this material throughout the book.

With new knowledge comes new power. Since the last edition, substantial strides have been made in our understanding of the reproductive process: the determination by somatic cell hybridization of which genes are on which chromosomes, the transfer by reverse transcriptase of genetic information from RNA to DNA, the control of tissue growth by chalcones, the direct demonstration of the genetic code, to name a few. But with these fundamental advances, which I have described, have come new possibilities of manipulating the reproductive process. Techniques for isolating genes and introducing them into new cells are advancing rapidly. Sperm banks, embryo transfer, and prenatal diagnosis of genetic disease are already with us. The implications of these technological developments fully justify, I believe, their inclusion in a book of this sort.

A similar tension between new knowledge and the possible applications of it occurs in the area of the responsive systems. Accordingly, I have introduced new material on the processing of information by the central nervous system, on the effect of different drugs on that system, and on a few of the insights that other primates have given us about our own behavior. Included in this section of the text is an entirely new chapter on the immune system which, like the nervous system, learns from experience and helps us to cope with a variety of assaults on the body.

Users of the previous editions will note that the survey of living things that used to begin the book has been reworked in an evolutionary context and placed in the part of the book devoted to evolution. Its former location has now been taken by a new chapter designed to introduce the student to the various ways in which life is studied. This is done through an examination of several facets of a single problem: how atmospheric nitrogen is made available to living things. I hope this chapter will serve as a bridge to the various levels of analysis (including biochemical) that are used later in the book.

Introductory biology texts tend to be compilations of conclusions. For many students, this is a congenial arrangement: they prefer to learn answers and not be concerned with the uncertainties that surround them. It is also the only way to keep a book that tries to survey the entire field to a manageable size. But it is not good science. The pursuit of science has some of the characteristics of a detective story: the gathering of evidence, the weighing of alternative explanations in the light of that evidence, and the testing of alternative hypotheses in new situations. Throughout this edition, I have tried to place greater emphasis on the observations and experiments that form the basis of our present understanding and, where the evidence is weak or contradictory, of alternative hypotheses as well.

I am greatly indebted to many people for their help in the preparation of this edition: to the users of previous editions who took the trouble to give me their suggestions of ways to improve the book; to those who graciously allowed me to reproduce some 80 new photographs and electron micrographs taken from their work; to Ruth Godfrey for typing the manuscript and for her help in keeping my files operating efficiently; to Harper Follansbee and James Funston who read and evaluated the entire manuscript; to Bob Trevor for producing some three dozen new drawings, graphs, and tables; and to the staff at Addison-Wesley for their expert help in every phase of producing this revision.

Andover, Massachusetts
January, 1974

J.W.K.

PREFACE TO THE SECOND EDITION

The rapidity with which knowledge in biology is advancing dooms any book on the subject to early obsolescence. This edition represents an attempt to narrow the gap momentarily. Literally every section of the book has been reworked in an attempt to bring it more nearly up to date. In particular, the material on the genetic code and gene action has been revised to better reflect the rapid strides being made in that area. The discussion of embryonic development has been rewritten in terms of the selective and sequential unlocking of the genetic code. In this section, the Jacob-Monod theory and its implications for the problems of embryonic development are also examined.

Perhaps the most drastic alteration in the book has been the placing of the material on responsiveness *after* the section on reproduction. This has made possible the rewriting of the chapters on hormones—plant as well as animal—in terms of their action on the transcription and translation of the genetic code.

Among the many other alterations are updated discussions of cell structure and function, nerve and muscle physiology, and new material on the mechanism and control of enzyme action, plant growth and growth regulators, and animal behavior. There are 20 new photographs, photomicrographs, and electron micrographs as well as many new drawings and diagrams.

Material has been deleted as well as added. The survey of organisms in Part II has been made somewhat less formidable by the dropping of some minor groups and the substitution of common names for technical ones in many cases. In fact, the number of technical terms in this edition is substantially lower than in the first.

Many people have assisted with the preparation of this edition. My colleagues and students have been most helpful with their suggestions for improvement. Thanks are due also to the many teachers at colleges and junior colleges across the country who have offered their suggestions and whose acceptance of the first edition has justified the publication of a second. I want to thank also the members of the staff at Addison-Wesley who have worked so hard to make this edition attractive in its appearance.

I am especially grateful to Dr. Jonas Salk and his staff, not only for making their splendid facilities at the Salk Institute for Biological Studies available to me during the preparation of this edition, but for giving so generously of their time and knowledge as well. And, as before, my deep appreciation to my wife, Margaret, for her uncounted hours of typing and proofreading and for her moral support throughout.

La Jolla, California
March 1968

J.W.K.

PREFACE TO THE FIRST EDITION

This book grew out of an introductory course in biology for students who were fairly mature and showed promise of being well motivated. However, most of the students in the course had had no prior exposure to biology and consequently the book presupposes none. Those occasional students with a taxonomically oriented course in their background have found that the chapters of Part II provided them with a quick refresher and that the remainder of the book duplicates their earlier course little in content, still less in approach. While some participants in the course have gone on to further work in biology, for many it was their only formal exposure to biology and, in a few cases, to science.

The book is organized along *functional* lines; that is, the various aspects of biology are examined from the point of view of the features and problems shared by all living things. These range from their molecular and cellular organization to their features of metabolism, responsiveness, reproduction, evolution, and ecology. It is hoped that this organization will provide a framework upon which the many facts of biology can be placed in a way that makes sense and makes them easier to remember. Perhaps, too, from it will grow a better appreciation of the unity underlying the diversity of life. Such a system seems to have the advantage of interspersing botanical topics among zoological ones, thus reducing the too-common student antipathy to the former.

Just as a scientist builds upon the work of the past, so students can better understand the significance of the recent discoveries in biology if they first learn the classical statements of the problems. Furthermore, the earlier interpretations are more closely related to what the student can see about him with the aid of the relatively simple tools and techniques of the elementary laboratory. Therefore, the older knowledge is examined first in the chapters. Only then are the discoveries of electron microscopy, biochemistry, and modern physiological techniques discussed.

No attempt has been made in this book to single out just a few areas of biology as illustrative of the materials and techniques of the field as a whole. Most beginning students seem to want the opportunity to see the

whole panorama of the subject. All of the topics of the Advanced Placement Program Syllabus are included as well as a good many others.

One of the most important aspects to teach of any science is the *process* by which knowledge in the field is gained. The interplay of experimentation and reasoning in the growth of science should be made explicit. Unfortunately, to explain the process by which conclusions are reached is far more time-consuming than to describe the conclusions themselves. I have, however, attempted to do it wherever practical. In particular, the chapters on photosynthesis and the work of Mendel are especially designed to impart some appreciation for the process of scientific investigation.

Problems are included at the end of each chapter. These vary from some requiring simply a one-word answer to some for which a sizable essay will have to be outlined. For the student who is interested in pursuing any subject further, additional readings are listed at the end of each chapter. In many cases, the books are available in relatively inexpensive paperback editions. Most of the *Scientific American* articles referred to can be secured in inexpensive reprints from the W. H. Freeman Company of San Francisco. Generally, the references are listed in the same order as that in which the topics they amplify are developed within the chapter.

A great many people have helped me with the preparation of this book. For two years each of my students returned to me—chapter by chapter—his comments and criticisms on the manuscript. In addition, each of the following read the manuscript, in whole or in part, and gave me the benefit of his professional judgment on ways to improve it:

John E. Dowling, Harvard University; Mrs. Frank Eccles, Andover, Mass.; Harper Follansbee, Phillips Academy; Edward Herbert, University of Oregon; Johns Hopkins, III, Harvard University; Herman W. Lewis, National Science Foundation; Alfred Novak, Stephens College; Joseph D. Novak, Purdue University; George K. Sanborn, Phillips Academy; Vincent Sil-luzio, Newton South High School, Newton, Mass.; Jonathan J. Westfall, University of Georgia; Edward O. Wilson, Harvard University.

Mr. Follansbee deserves special thanks for his constant encouragement and assistance during the years this book was in preparation.

I also wish to thank the many people who so graciously supplied photographs and electron micrographs for the book. Their names appear by their contributions. (The photographs for which no credit is given are my own.) Thanks are due also to Gerard Piel and the editors of *Scientific American*, not only for their helpfulness with this project but also for having done so much to bring new scientific discoveries out of the laboratories and technical journals to the layman. Their efforts have perhaps done more to bring and keep the teaching of introductory biology up to date than any other single force.

The line drawings are the work of William A. Davis. Tirelessly, he worked to match them to the text and to make them not only effective teaching devices but esthetically pleasing as well.

To the staff of Addison-Wesley go my thanks for their cooperation in all aspects of producing the book. And, to my wife, Margaret, my gratitude for the endless hours she spent typing and proofreading version after version, preparing the index and glossary, and for her unfailing support.

All who have participated in the preparation of this book have worked hard to make it as useful and accurate as possible. We hope that its readers will communicate to us any suggestions they may have for its improvement.

*Andover, Massachusetts
November 1964*

J.W.K.



Our planet as seen from the moon by the crew of
Apollo 8. (Courtesy of NASA.)

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