ZOOLOGY

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in collaboration with
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COLLIER MACMILLAN INTERNATIONAL EDITIONS

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Macmillan Publishing Co., Inc.
NEW YORK

Collier Macmillan Publishers
LONDON

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Printed in the United States of America

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Macmillan Publishing Co., Inc.
866 Third Avenue, New York, New York 10022
Collier Macmillan Canada, Ltd.

Library of Congress Catalog Card Number: 75-6932

Printing: 1 2 3 4 5 6 7 8 Year: 6 7 8 9 0 1 2

Preface

In an era of emphasis in the life sciences on interdisciplinary programs and the search for broad, unifying generalizations, some people might wonder why this book is about zoology rather than biology. There are two primary reasons.

First, intellectual fashions have not changed what seems to us to be the underlying reality of the living world: plants and animals simply *are* very different from each other in a great many ways. They clearly are quite similar in important respects, but the similarities are largely restricted to phenomena and processes at the molecular to cellular levels of organizational complexity. Thus, with respect to such aspects as organ system and organismic physiology, ecology, behavior, and morphological diversity, there remain distinct fields of zoology and botany. We try in this book to present a modern, comprehensive overview of zoology today.

Second, the trend in recent years towards emphasis on introductory biology courses in colleges and universities has resulted in relative neglect of the development of zoology textbooks of a quality comparable to current norms in biology texts. This book is an attempt at readjusting this imbalance.

This book is composed of a coordinated set of statements by a group of authors, all of whom are actively involved in basic research in aspects of the parts of zoology they write about. The editor has made no effort to impose a single point of view upon his coauthors. Each chapter represents a description of that part of zoology as seen by the chapter's author. We hope that this approach has resulted not only in informed and up to date descriptions of the subject matter but also in a variety of perspectives that will give students some feeling for the range of approaches that are possible in the field.

We have tried to organize and write the book so that it would be as clear and readable as possible. The text emphasizes principles and approaches, with facts as support. It is largely oriented around evolutionary and environmental adaptations of animals to their own world. The aim is to provide an overall picture of animals as intact organisms functioning in a difficult and changing world.

The text will probably be most satisfactory for use with students in their first year of college. By selection of appropriate parts it can serve as a text for

either a one-quarter or one-semester course. It covers enough territory and includes enough material, however, so that it can be used for a full year course if desired. We assume that it will be supplemented by appropriate demonstration or, preferably, laboratory exercises.

All of the authors will be pleased and grateful to receive comments and suggestions from teachers and students who use the book concerning their reactions to it and ways in which it can be improved. Like animals, textbooks can evolve. User comments provide both the mutations and the selective pressures needed to produce that evolution.

Most of the illustrations are original, or only partly based upon previously published figures. Acknowledgments of contributions from specific people or sources are included in the relevant captions (primarily for photographs). We are very grateful to the many friends and colleagues who have permitted us to use original photographs of theirs. The office of the noted designer Charles Eames has made a particularly important contribution in this regard.

Several people have been essential to the completion of the manuscript. These include Carole Graszler, our principal, excellent typist, Jack Samuels, our primary research assistant, and Kathryn Bolles, who has helped greatly with drawings. Others who have helped include Marian Chan, Karen Kan, Denise Neumark, Daniel Costa, and Pamela Blakely.

M. S. G.

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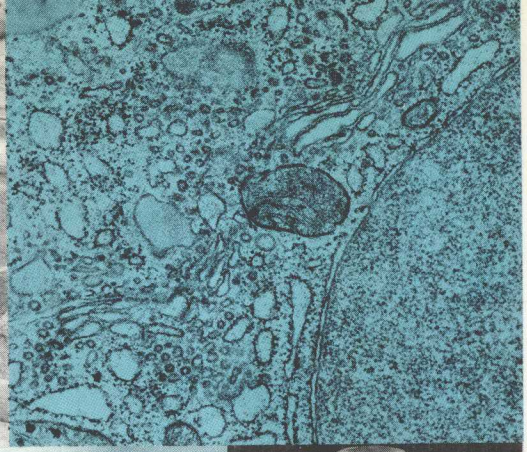

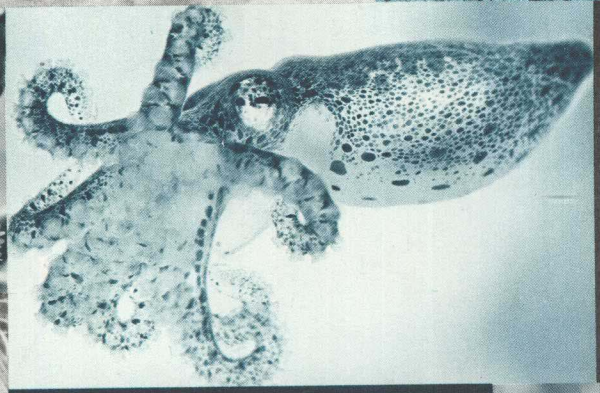

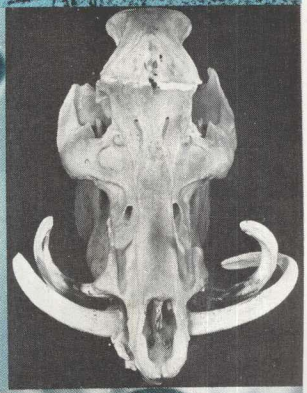

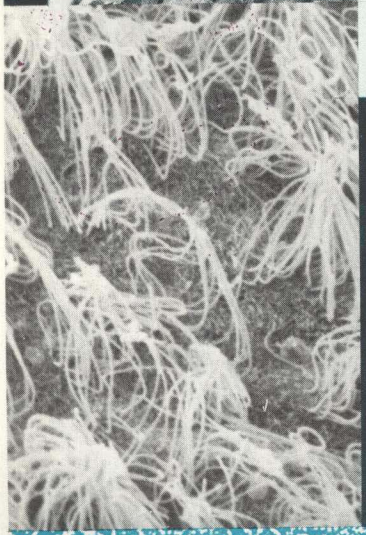

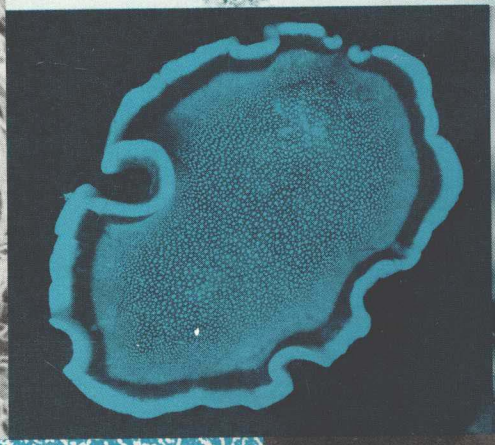

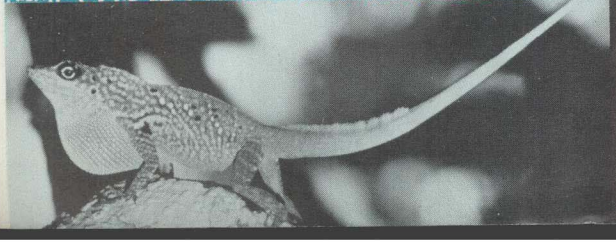

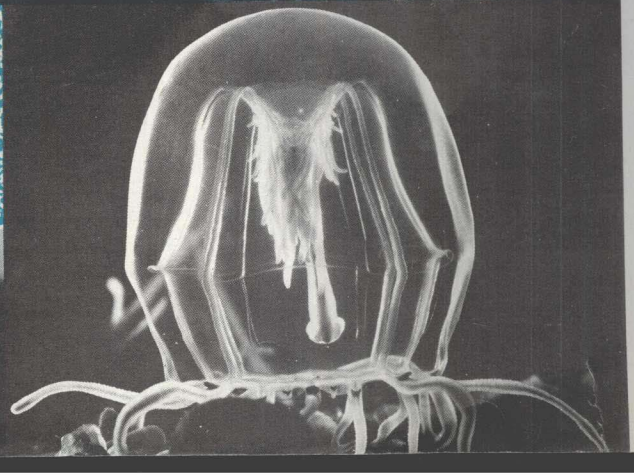

Brief Contents

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1 Introduction

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People beginning their first serious approach to a new and possibly difficult subject, such as zoology, should have some clear understanding at the outset of what they are getting themselves into. A good start is to ask themselves the standard six questions every good journalist asks: What? Who? When? Where? Why? How?

1-1 What Is Zoology?

A winter walk in the woods of the northeastern United States frequently produces meetings with groups of active and noisy small birds. There are often as many as six or eight kinds of birds in these groups, all of which move together through the forest looking for food. A zoologist encountering such a group might well ask some of the following questions: What kinds of birds are in the group? How many of each kind are there? Do different groups in this area vary much in either species composition or numbers? What is each kind of bird feeding on? Do they feed in different places? Do they feed in different ways? Are there any special structural (anatomical) features of the different species that fit in particularly well with either the places they feed or the kinds of food on which they feed? How does the group react to a threat to their safety (like a bird-eating hawk or owl)? What do the different species do in such situations? Is the group real (with its members paying some attention to each other) or is it only a loose and temporary association? How do the different species cope with normal winter problems, such as keeping unfeathered legs and feet from freezing, or keeping the whole bird from freezing during long, cold, dark, foodless nights? How much energy do the different kinds use for different functions, such as keeping warm, food searching and gathering, and flying?

In the deserts of the southwestern United States there are many areas in which 5 cm of rain in a year is a lot and where summer daytime shade temperatures are regularly near 50°C. One does not expect to find aquatic animals in such places. However, when the rare heavy thundershower does come along every couple of years these same areas frequently

become alive for short periods of time with large numbers of toads. The toads appear shortly after the rain dampens the ground, stay visible and active (eating, calling, courting, and mating) for a couple of days, then disappear again. What is going on and how does it happen?

The toads can only live in burrows in the ground during the long rainless periods, despite folk tales about their falling from the clouds. How do they dig these burrows? How do they breathe while underground? Where do they get the food and water they need? How do they know when to emerge? How can they produce young in the absence of ponds in which the tadpoles can live? Why do they occur only in certain areas, not others? How did they get to these places? How long have they been there?

A swim with face mask and snorkel or self-contained underwater breathing apparatus (SCUBA) around and over a tropical oceanic coral reef generally dazzles people at first. There are so many kinds of organisms living there, in such numbers, doing so many different things. After a while, especially after several visits, the strangeness and variety become less confusing and some features start to become apparent.

Particular kinds of animals are often found in specific types of places carrying on specific activities. The reef itself shows regularities. Particular corals grow in different ways in different locations, relating to such things as water depth and clarity, wave action, or current directions and speeds.

If the reef is around an open ocean island, one of the most striking features is the abundance of life on the reef contrasted with the rarity of life in the waters even a short distance offshore. Indeed, many of the best developed coral reefs occur in oceanic areas that biological oceanographers consider to be nearly biological deserts.

How is this possible? Where do the reef organisms find all the food they need? How do the many kinds of reef animals which have drifting, open-sea larval stages manage to maintain their populations when most, if not all, their larvae are carried off by wind-driven currents? What factors are responsible for the different growth forms individual types of corals show in different places? How do these factors control growth?

In each of these three examples the lists of possible questions could be made far longer. The number of examples could also be greatly expanded. However, we hope the main points have been clearly made. *The subject matter of zoology is the animal world in all its variety. One of zoology's major goals is the understanding of animals as intact, functioning organisms.*

The examples we have used are all primarily illustrations of studies of what we might call **basic zoology**—zoology studied for its own sake, as part of humankind's own curiosity about the natural world around itself. They are also examples emphasizing **natural history**—animals observed in and functioning in reasonably natural environments. Basic natural history, however, is far from all there is to zoology.

There are many ways to subdivide zoology. We will discuss a number of these later (see Section 2-2). Here we want to mention only three broad divisions. These are:

1. Basic As Contrasted with Applied Zoology. Most theoretical understanding of zoology has derived from basic studies like those just described. Most of the economically, socially, and politically significant parts of the field are derived from, and are based upon, this theoretical understanding. These applied parts range from much of medicine, through many aspects of agriculture (animal husbandry), to the many effects of man-made pollution and other human influences upon animals. We are sure each of our readers can provide multiple examples for themselves in these applied areas. **Applied zoology,** broadly defined, *is the use of zoological principles and practices in the understanding and solution of human problems.*

2. Descriptive (or Observational) As Contrasted with Experimental Zoology: You can observe the responses of your animals (or your preparations from animals) to naturally occurring changes in the world round about, or, alternatively, you can manipulate the relevant world to some degree (by changing temperature, or light intensity, or other species present, for example) and then observe responses. The first pattern is the observational mode of investigation, the second pattern is the experimental mode.

3. Field As Contrasted with Laboratory Zoology. If you work under more or less natural conditions, at least partly out of doors, your study is a field

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