

ZOOLOGY

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in collaboration with
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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

Preface

PREFACE

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.

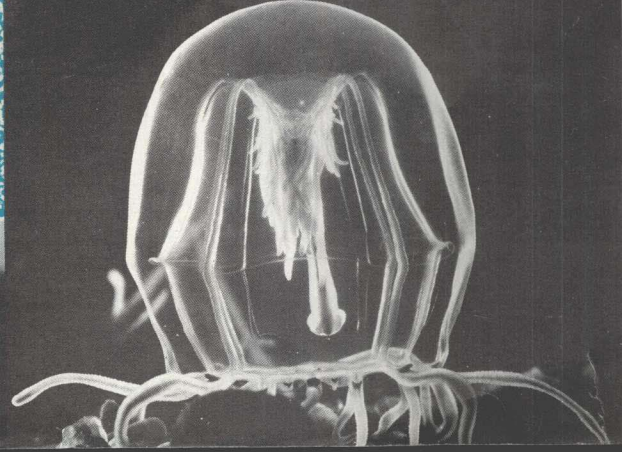
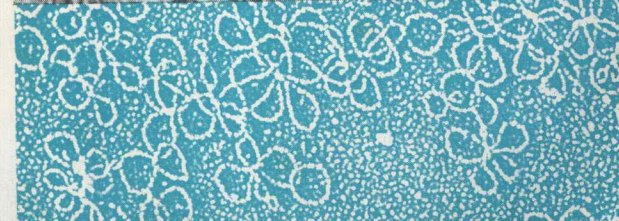
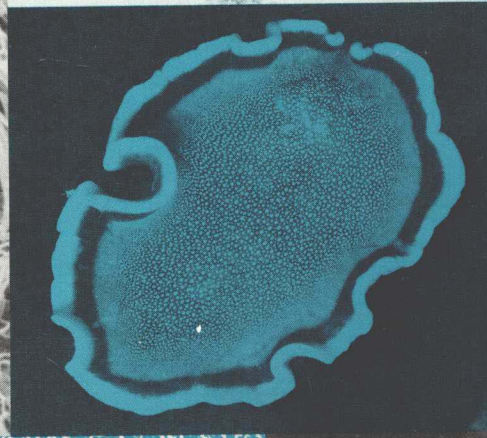
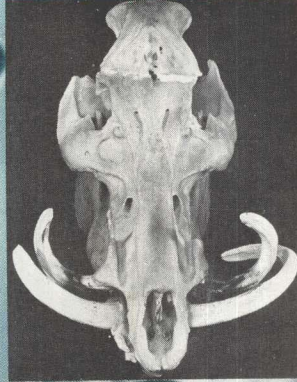
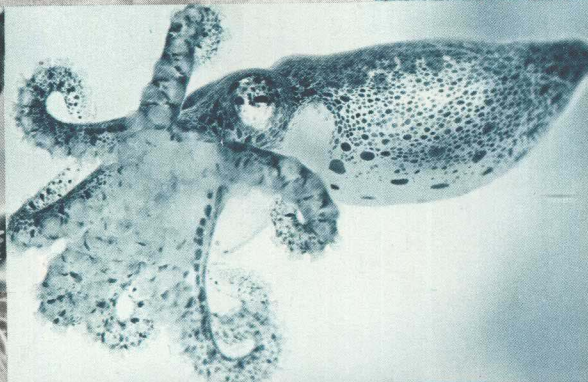
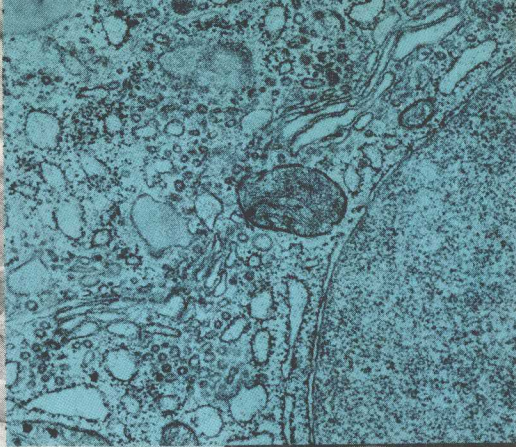
All of the authors will be pleased and grateful to receive comments and suggestions from teachers and students who use the book concerning their reactions to it and ways in which it can be improved. Like animals, textbooks can evolve. User comments provide both the mutations and the selective pressures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



1	Introduction	1
2	Some Important Ideas and Approaches	8
3	Animals Today	15
4	Cellular Constituents	38
5	Information Flow in Animal Cells: Macromolecular Synthesis	56
6	Transmission of Genetic Information	78
7	Differential Gene Expression: Development	90
8	Introduction to Physiology	111
9	Energy and Work	120
10	The Internal Environment	149
11	Information Processing, Coordination, and Control	191
12	Ecology	229
13	The Genetics of Populations and Mechanisms of Evolutionary Change	273

Brief Contents

BRIEF CONTENTS

14 Animal Behavior 284

15 The Major Groups of Animals 320

16 The Early Evolution of Life 344

17 Radiations of the Metazoa I 366

18 Radiations of the Metazoa II: The
Annelid Superphylum 382

19 Radiations of the Metazoa III: The
Echinoderm Superphylum 414

20 Man and the Primates 458

Glossary 477

Index 487

1

Introduction 1

- 1-1 What Is Zoology? 1
- 1-2 Who Are Zoologists? When and Where Have They Worked? 3
- 1-3 Why Study Zoology? 3
- 1-4 How Zoology Is Studied 4
- References for Additional Reading 6

2

Some Important Ideas and Approaches 8

- 2-1 Basic Questions 8
- 2-2 Other Ways of Looking at Zoology 10
- 2-3 What Is the World Like to Different Organisms? 11
- 2-4 Major Features of Animal Life 13
- 2-5 What Comes Next? 14

3

Animals Today 15

- 3-1 The Diversity of Kinds 15
 - 3-1-1 Numbers of Known Animal Species 17
 - 3-1-2 Estimates of the Total Numbers of Species 19
- 3-2 The Classification of Kinds 20
 - 3-2-1 The Nature of Classification 20
 - 3-2-2 The Structure of Modern Classification 21
 - 3-2-3 Classification and Evolution 23
- 3-3 Distributions of Animals 28
 - 3-3-1 Major Groups 28
 - 3-3-2 Distributions of Numbers of Species 28
 - 3-3-3 Distributions of Kinds of Species 33
- 3-4 Summary Overview of Animals Today 35
- References for Additional Reading 37

4

Cellular Constituents 38

- 4-1 Biochemicals 38
 - 4-1-1 Fats 38

Contents

- 4-1-2 Carbohydrates 42
- 4-1-3 Proteins 44
- 4-2 Cell Structure 48
 - 4-2-1 The Nucleus 48
 - 4-2-2 Cell Membrane 50
 - 4-2-3 Internal Membranes 53
 - 4-2-4 Other Organelles 54
- References for Additional Reading 55

5

Information Flow in Animal Cells: Macromolecular Synthesis 56

- 5-1 The Genetic Material 56
 - 5-1-1 Introduction 56
 - 5-1-2 Chemical Nature of the Genetic Material 56
 - 5-1-3 The Structure of Nucleic Acids 57
- 5-2 The Behavior of the Nucleic Acids 63
 - 5-2-1 Replication of DNA 63
 - 5-2-2 Synthesis of RNA 66
 - 5-2-3 Classes of RNA 66
- 5-3 Protein Synthesis 70
 - 5-3-1 Protein Synthesis and the Nature of the Code 70
 - 5-3-2 Assembly of Polypeptides 72
 - 5-3-3 Molecular Mutations 73
 - 5-3-4 Control of Protein Synthesis 75
 - 5-3-5 Extranuclear DNA 77
- References for Additional Reading 77

6

Transmission of Genetic Information 78

- 6-1 The Structure of a Chromosome 79
- 6-2 Mitosis 80
- 6-3 Meiosis 82
- 6-4 Spermatogenesis 84
- 6-5 Oogenesis 86
- 6-6 Mendelian Genetics 86
- References for Additional Reading 89

7

Differential Gene Expression: Development 90

- 7-1 Problems in Development 90
 - 7-1-1 Determination 91

- 7-1-2 Differentiation 91
- 7-1-3 Morphogenesis 91
- 7-1-4 Growth 91

- 7-2 Fertilization 91
- 7-3 Cleavage 92
- 7-4 Gastrulation 95
- 7-5 Organogenesis: The Development of Vertebrate Organs 98
 - 7-5-1 Neurulation: Development of the Brain and Central Nervous System 98
 - 7-5-2 Epithelial-Mesenchymal Interactions 101
- 7-6 Postembryonic Development 102
 - 7-6-1 Insect Metamorphosis 102
- 7-7 Control Mechanisms in Development 104
 - 7-7-1 Totipotency of Somatic Nuclei 104
 - 7-7-2 Levels of Regulation 107
- References for Additional Reading 110

8

Introduction to Physiology 111

- 8-1 Questions and Problems 111
 - 8-1-1 Internal Workings 111
 - 8-1-2 External Workings 112
 - 8-1-3 Group Workings 112
 - 8-1-4 Applied Physiology 113
 - 8-1-5 Medical Physiology 114
- 8-2 General Principles 115
 - 8-2-1 Universal Problems 115
 - 8-2-2 Diversity of Solutions 115
 - 8-2-3 Physiological Taxonomy 116
 - 8-2-4 Patterns, Mechanisms, Controls 116
- 8-3 Methods 117
 - 8-3-1 Experimental Design 117
 - 8-3-2 What Kind of Animal? 117
 - 8-3-3 Experimental Methods 118
 - 8-3-4 Statistics and Data Analysis 118
- 8-4 Overview 119
- References for Additional Reading 119

9

Energy and Work 120

- 9-1 Nutrition and Assimilation 120

- 9-1-1 Food and Feeding Mechanisms 120
- 9-1-2 Ingestion and Digestion 124
- 9-1-3 Absorption 127
- 9-1-4 Nutritional Requirements 128
- 9-2 Metabolism 130
 - 9-2-1 General Concepts 130
 - 9-2-2 Other Important Ideas 130
 - 9-2-3 Cell Metabolism 131
 - 9-2-4 Whole Animal Metabolism 135
- 9-3 Movement 139
 - 9-3-1 Intracellular Movements and Pseudopodia 140
 - 9-3-2 Cilia and Flagellae 141
 - 9-3-3 Muscles 142
- References for Additional Reading 148

10

The Internal Environment 149

- 10-1 The Respiratory System 149
 - 10-1-1 Introduction 149
 - 10-1-2 Gases in the External Environment 150
 - 10-1-3 Respiratory Organs 151
 - 10-1-4 Respiratory Mechanisms 152
 - 10-1-5 Factors Affecting Respiration 153
 - 10-1-6 Gas Transport 154
 - 10-1-7 Control of Respiration 156
 - 10-1-8 Special Adaptations 157
- 10-2 The Circulatory System 159
 - 10-2-1 Introduction 159
 - 10-2-2 Types of Circulatory Systems 160
 - 10-2-3 Blood and Lymph 161
 - 10-2-4 Hearts 162
 - 10-2-5 Peripheral Circulations 163
 - 10-2-6 Control of Circulatory Functions 166
 - 10-2-7 Special Adaptations 167
- 10-3 Water and Solute Metabolism 168
 - 10-3-1 Introduction 168
 - 10-3-2 Definitions and Principles 168

- 10-3-3 Structures and Processes 170
- 10-3-4 Freshwater Animals 170
- 10-3-5 Marine Animals 173
- 10-3-6 Amphibious Animals 175
- 10-3-7 Terrestrial Animals 177
- 10-3-8 Controls 181
- 10-4 Body Temperature 182
 - 10-4-1 Introduction and Definitions 182
 - 10-4-2 Energy Exchanges with the Environment 182
 - 10-4-3 Ectotherms 183
 - 10-4-4 Endotherms 185
 - 10-4-5 Heterotherms 188
 - 10-4-6 Controls 189
- References for Additional Reading 190

11

Information Processing, Coordination, and Control 191

- 11-1 Nervous Systems 192
 - 11-1-1 Organizational Patterns 192
 - 11-1-2 Structural Elements 193
 - 11-1-3 Electrical Properties 194
 - 11-1-4 Integration 199
 - 11-1-5 Reflexes 201
- 11-2 Sensory Systems 201
 - 11-2-1 Introduction 201
 - 11-2-2 Principles and Properties 201
 - 11-2-3 Chemoreception 202
 - 11-2-4 Mechanoreception 204
 - 11-2-5 Temperature Sensing 205
 - 11-2-6 Vision 207
- 11-3 Central Nervous Coordination and Control 209
 - 11-3-1 Evolution of Central Nervous Systems 209
 - 11-3-2 Vertebrate Brains 211
 - 11-3-3 Motor Systems 213
 - 11-3-4 Autonomic Nervous System 214
 - 11-3-5 Nonelectrical Functions of Nerves 216
- 11-4 Chemical Coordination and Control 216

- 11-4-1 Endocrine Glands and Hormones 216
- 11-4-2 Important Concepts 218
- 11-4-3 Hormone Evolution 221
- 11-4-4 Hormone Action 221
- 11-4-5 Hormonal Integration 223
- 11-4-6 Reproduction 224
- 11-4-7 Other Important Processes 227
- References for Additional Reading 228

12

Ecology 229

- 12-1 Introduction 229
 - 12-1-1 The Nature of Ecology 230
 - 12-1-2 Organism and Environment 230
- 12-2 Energy Flow in Ecological Systems 231
 - 12-2-1 Thermodynamic Considerations 231
 - 12-2-2 Open Versus Closed Energy Systems 231
 - 12-2-3 The Major Energy Transformations 232
 - 12-2-4 Kinds of Energy 233
 - 12-2-5 Heat Versus Temperature 233
 - 12-2-6 Heat Transfer 233
- 12-3 Solar Radiation, the Energy for Life 233
 - 12-3-1 Temperature and Wavelength 234
 - 12-3-2 Modification by the Atmosphere 235
 - 12-3-3 Ultraviolet Absorption 235
 - 12-3-4 The Greenhouse Effect 236
 - 12-3-5 Solar Radiation in the Aquatic Environment 237
 - 12-3-6 Temporal and Spatial Variations 237
 - 12-3-7 Capture and Conversion 238
- 12-4 Biological Production of Chemical Energy 239
 - 12-4-1 Ecological Cycling and Energy Flow 239

- 12-4-2 Trophic Levels 240
- 12-4-3 Energy Transfer Between Trophic Levels 241
- 12-4-4 Ecological Efficiencies 244
- 12-4-5 Biological Concentration of Pesticides and Pollutants 245
- 12-5 Energy Use in Nutrition: Animal Versus Technological Man 246
 - 12-5-1 Energetics and Man's Future 246
- 12-6 Ecological Groupings 248
 - 12-6-1 Communities and Associations 248
 - 12-6-2 Biomes 250
 - 12-6-3 The Oceans 250
 - 12-6-4 The Nature of Ecosystems 251
- 12-7 Adjustments to the Physical Environment 251
 - 12-7-1 Extreme Environments 252
 - 12-7-2 Selective Participation 252
 - 12-7-3 Macroclimate Versus Microclimate 253
 - 12-7-4 Biological Rhythms 254
- 12-8 Interactions Between Organisms 255
 - 12-8-1 Introduction 255
 - 12-8-2 The Ecological Niche 255
 - 12-8-3 Competition 256
 - 12-8-4 Predation 257
 - 12-8-5 Symbiosis 258
- 12-9 Population Growth and Control 261
 - 12-9-1 Introduction 261
 - 12-9-2 The Nature of Populations 261
 - 12-9-3 The Primary Variables 262
 - 12-9-4 Population Change 262
 - 12-9-5 Human Populations 266
 - References for Additional Reading 272

13

The Genetics of Populations and Mechanisms of Evolutionary Change 273

- 13-1 Evolution: Past, Present, Future 273
 - 13-1-1 What Is Evolution? 274

- 13-1-2 Evolutionary Theory 274
- 13-2 Genetic Variation 275
 - 13-2-1 Mutations 275
 - 13-2-2 Recombination 276
 - 13-2-3 Stability of Gene Frequency 276
- 13-3 Changes in Gene Frequency 276
 - 13-3-1 Mutations 277
 - 13-3-2 Gene Flow 277
 - 13-3-3 Natural Selection 277
 - 13-3-4 Drift and the Founder Effect 280
- 13-4 Species and Speciation 281
 - 13-4-1 What Is a Species? 281
 - 13-4-2 How Do Species Originate? 282
 - 13-4-3 Subspecies and Geographic Races 283
- References for Additional Reading 283

14

Animal Behavior 284

- 14-1 The Biological Setting 284
 - 14-1-1 What Is Behavior? 284
 - 14-1-2 Anthropomorphism and Teleology 285
 - 14-1-3 The Machinery 286
 - 14-1-4 The Evolutionary Point of View 286
 - 14-1-5 Some Guidelines for Interpreting Behavior 286
 - 14-1-6 Some Adaptive Functions of Behavior 287
- 14-2 Machinery and Functions 287
- 14-3 The Elements of Behavior 289
 - 14-3-1 Reflexes 289
 - 14-3-2 Orienting Movements (Taxes) 289
 - 14-3-3 Modification by Experience: Learning and Memory 290
 - 14-3-4 Motivation: Why Do They Do It? 291
 - 14-3-5 The Problem of Instinct 292
- 14-4 The Patterns of Behavior 293
 - 14-4-1 Organization of Behavior 293
 - 14-4-2 Ontogeny of Behavior 295
 - 14-4-3 Major Adaptive Functions 297
- 14-5 Key Adaptive Patterns 297
 - 14-5-1 Predator-Prey Recognition 297
 - 14-5-2 Species Identification and Sex Recognition 299
 - 14-5-3 Imprinting and Species Identification 300
 - 14-5-4 Imprinting and Responses to Environment 301
- 14-6 Social Behavior 303
 - 14-6-1 A Biological Setting 303
- 14-7 Social Organization of Vertebrates 305
 - 14-7-1 Introduction 305
 - 14-7-2 Social Communication 305
 - 14-7-3 Aggressive Behavior 307
 - 14-7-4 Reproductive Behavior 312
 - 14-7-5 Evolution of Displays 314
 - 14-7-6 Play 315
- 14-8 Social Organization of Insects 316
 - 14-8-1 Introduction 316
 - 14-8-2 Termites 316
 - 14-8-3 Ants and Bees 318
- References for Additional Reading 319

15

The Major Groups of Animals 320

- 15-1 Some General Matters 320
- 15-2 What Is an Animal? 322
- 15-3 The Phylogeny of the Animals 324
- 15-4 The General Course of Animal Evolution 326
 - 15-4-1 The Acellular Level 328
 - 15-4-2 The Simple Multicellular Level 328
 - 15-4-3 The Radiate Phyla 329
- 15-5 The Bilateria 332
 - 15-5-1 Protostomes and Deuterostomes 332
 - 15-5-2 The Coelom 334
- 15-6 Biochemical Evidence 337

- 15-7** Animals in Time 341
References for Additional
Reading 343

16

The Early Evolution of Life 344

- 16-1** Origin of Life 344
16-2 The Cell and Neodarwinian
Evolution 351
16-3 The Evolution of Prokaryotes 352
16-3-1 The Evolution of
Bacteria 353
16-3-2 The Evolution of Blue-Green
Algae (Cyanophyta) 354
16-4 Evolution of the Eucaryote Cell 355
16-5 The Origin of Metazoans 357
16-5-1 Why Metazoa? 358
16-5-2 Possible Phylogenies 359
16-5-3 The Fossil Record 362
References for Additional
Reading 365

17

Adaptive Radiations of the Metazoa: I 366

- 17-1** The Nature of Adaptive
Radiations 366
17-2 Patterns of Adaptive Radiations 367
17-3 Fossil Records of Adaptive
Radiations 371
17-4 Phyla Without Fossil Records 373
17-4-1 The Acoelomates 373
17-4-2 The Pseudocoelomates 377
References for Additional
Reading 381

xiv

18

Radiations of the Metazoa II: 382 The Annelid Superphylum

- 18-1** General Composition 382
18-2 The Annelid Worms (Phylum
Annelida) 383

- 18-2-1** Polychaetes 385
18-2-2 Oligochaetes 385
18-2-3 Hirudinea 386

18-3 The Arthropods (Phylum Arthropoda) 386

- 18-3-1** Origin and Bases for
Radiations 387
18-3-2 Radiations of the
Arthropods 390

18-4 The Molluscs (Phylum Mollusca) 397

- 18-4-1** Origins of the Molluscs 400
18-4-2 Radiations of the
Molluscs 402
18-4-3 The Problem of Massive
Extinctions 406

18-5 The Lophophorates 409

- 18-5-1** The Brachiopods 409
References for Additional
Reading 412

19

Radiations of the Metazoa III: The Echinoderm Superphylum 414

- 19-1** Phylum Echinodermata 416
19-1-1 Radiations of the
Echinodermata 417

19-2 Chordata 423

- 19-2-1** Origin of Chordates and
Vertebrates 425

19-3 Vertebrata 428

- 19-3-1** Major Features 428
19-3-2 Beginnings of Vertebrate
Radiations 431
19-3-3 Radiations of Fishes 433
19-3-4 Amphibia 439

19-4 Reptilia 442

- 19-4-1** The Nature of Reptiles 442
19-4-2 The Radiations of
Reptiles 443

19-5 Aves 447

19-6 Mammalia 449

- 19-6-1** Characteristics 449
19-6-2 Origins 449
19-6-3 Radiations of Mammals 450
References for Additional
Reading 457

20

Man and the Primates 458

- 20-1** The Place of Man (*Homo sapiens sapiens*) in Nature 458
- 20-2** The Major Groups of Primates 460
- 20-3** The Nature and Origin of Primate Features 463
- 20-4** Apes and Man 464
 - 20-4-1** Physical and Behavioral Features of Man 465
 - 20-4-2** The Time of Divergence of Man and Apes 467

- 20-5** The Hominids 470
 - 20-5-1** *Australopithecus* 470
 - 20-5-2** *Homo erectus* 471
 - 20-5-3** *Homo sapiens* 473
- References for Additional Reading 475

Glossary 477**Index** 487

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

1

Introduction

M. S. Gordon

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