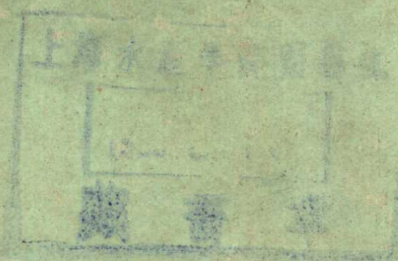


PRINCIPLES OF ZOOLOGY

JOHN A. MOORE



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ILLUSTRATED BY RUSSELL FRANCIS PETERSON



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Preface

THE TREATMENT OF ZOOLOGY in this book is based on my experience in teaching undergraduate students at Barnard College, Columbia University, for the past fourteen years. The primary interests of most of these students lie in subjects other than science and for this reason a careful selection of zoological facts and concepts has been necessary. Such a selection is called for since time is short and zoology is broad.

The course on which this volume is based has the aim of teaching zoology and of teaching science and whenever possible doing both. Naturally, I am using the word 'science' in a rather special way, namely, to signify the methodology, philosophy, and what Dr. Conant calls the 'strategy of science.' It is for these special features that science is thought necessary in a liberal arts education.

If these aims are to be realized, I have found it necessary to alter considerably the conventional first-year course in zoology. Superficial treatment of a wide variety of topics must be sacrificed for a meaningful consideration of a few. There is little point in presenting a university student with an array of scientific facts and then telling him that *the* scientific method consists of (1) stating the problem, (2) formulating a hypothesis, (3) making deductions from the hypothesis, (4) testing the hypothesis, and letting it go at that. Such a treatment is no more than a caricature of science's methods. If one is to accomplish the aims as stated, it is necessary to develop the topics to such an extent that the student will have the data and the background for making judgments for himself and for seeing how the scientists reach their conclusions.

The subject matter of this book is divided into six parts. Part A is an elementary introduction to general zoology, using the frog as an example, followed by a brief survey of the animal kingdom. This material will be somewhat repetitious for students who have previously taken a course in high-school biology. It is necessary to begin in this manner, however, because of the varied science backgrounds of college students. In a sense the book gets started in Part B, which

consists of an analysis of man's attempts to understand the nature of inheritance. The concept of the gene, which is central to an understanding of modern biology, is developed in its historical perspective. In Part C the problems of embryonic development and differentiation are traced from the views of the preformationists to the present era of organizer theory. Part D is zoology at a grand level, namely, the evolution of animals. The Phylum Chordata is selected as a case history and the current version of neo-Darwinian evolution theory is discussed. Part E is a treatment of vertebrate physiology with emphasis on man. Part F is a short chapter in which some aspects of scientific methodology are reconsidered.

The sequence of topics correlates with a laboratory in which the frog, representative invertebrates, and embryology are studied during the first semester, and ammocoetes, the dogfish, and the pig are studied the second semester.

I have been fortunate in having the advice of many friends in the preparation of this book. Betty Moore, John R. Gregg, and Donald McPherson read the entire manuscript or major portions of it. In addition, sections of Part A were read by E. S. Hodgson and A. W. Pollister; Part B was read by Th. Dobzhansky, Lucena Barth, E. P. Volpe and, in an earlier version, by Sally Schrader; Part C was read by Lester Barth and Lucena Barth; Part D was read by Aubrey Gorbman and Bobb Schaeffer; Part E was read by Ingrith Deyrup and Lucena Barth and sections by Aubrey Gorbman.

Franz Schrader translated the long quotations from Schwann. M. J. Buerger supplied the photograph used as Fig. A2-1 and A. W. Pollister and L. Ornstein those used in Fig. A3-1. Mrs. Scott Agar gave her permission for me to use a drawing from W. B. Scott's *A History of the Land Mammals in the Western Hemisphere* (Macmillan) as Fig. D1-1a. The United States Geological Survey gave me permission to use their 'Classification of the Major Divisions of Geological Time.' The quotation from Aristotle that forms part of the front matter is from Edith Hamilton's *The Greek Way* (Norton).

The original line drawings were prepared from my rough sketches by Russell Peterson.

John A. Moore

New York
October 1956

Introduction for the Student

SINCE YOU HAVE REACHED that rung in the educational ladder where this book is used as a required text or reference, the terms biology, zoology, and botany are undoubtedly familiar. As a reminder, biology is the science of living things. It has two subdivisions: zoology, the animal science, and botany, the plant science. The field of biology is a wide one. The description of a new species of wasp, a study of the factors controlling heart beat, the investigation of the manner in which characteristics are inherited, the synthesis of a compound that will destroy the organism responsible for malaria, studies of the effects of different light waves on the human eye, the working out of the minimum diet that will support growth in man and other animals, and investigations of the influence of atomic radiations on living creatures are examples of some of the things that biologists do.

Biology today is very different from what it was fifty or a hundred years ago, and we should humbly admit that it probably will be very different fifty or a hundred years from now. During the eighteenth century and the first half of the nineteenth century, the major effort of biologists was the cataloguing of the seemingly unending variety of animals and plants. This inventory is by no means complete even today, but this activity is no longer the central task of biologists.

The middle of the nineteenth century saw a marked change of emphasis. Biologists, or at least an increasing number of them, became interested in the *problems* associated with the phenomena of life. No longer were they content merely to classify organisms and to study their anatomy. 'Hows' and 'whys' were replacing 'whats.' Increasingly successful efforts were made to relate biological phenomena to various conceptual schemes, the most noteworthy being Darwin's theory of evolution. These trends have continued down to the present, and the first half of the twentieth century might be thought of as the period of the rise of theoretical biology.

In the survey of zoology that will be made in this book, emphasis will be placed on biological principles, problems, and experimental

tion, for it is in these areas that biology makes its greatest contribution to human welfare and intellectual satisfaction.

It is neither possible, nor desirable, to treat the entire subject matter of zoology in a single course or book. Any attempt to do so would result in much unorganized superficiality and little insight. Our plan will be to select certain topics for detailed consideration while indicating the framework of the entire field. This approach will allow a beginning student to gain a real appreciation of the philosophy and data of modern biological research.

At the end of each chapter there will be found references to books and articles giving additional information about the subjects mentioned. Many of these are written for advanced students but even the beginner should profit from them. For one thing he will be transferred from the level of the textbook, where things may appear simple and established, to the current status of biological problems, where things are complex and confused.

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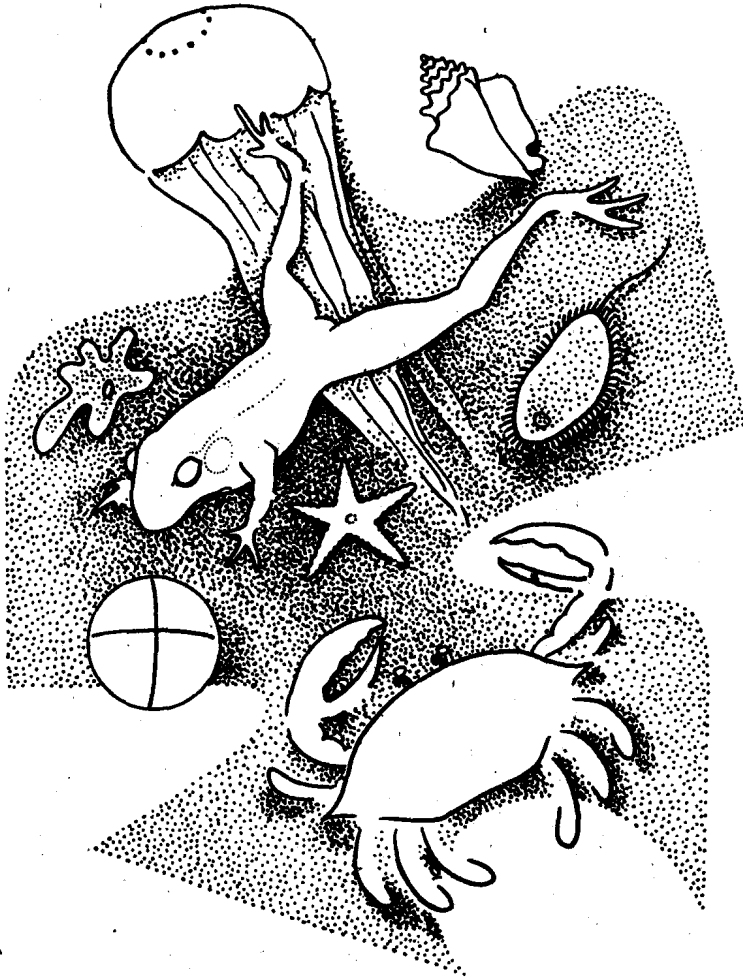
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PART A

GENERAL FEATURES OF A BIOLOGICAL SYSTEM

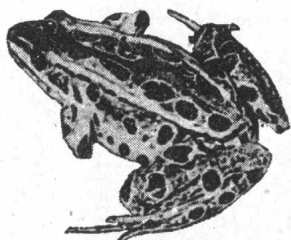


PROSPECTUS

The first section of our treatment of zoology will be a study of the nature of life and the main problems associated with being alive. It will be a preview of the entire field of biology, the life science. In this way we shall establish the necessary basis for the later study in meaningful detail of the separate parts of biology. We shall examine the woods before beginning a study of the trees.

Biology is the body of knowledge that is concerned with organisms, both living and dead. It consists of facts and theories relating to the structure, physiological activity, development, evolution, heredity, habits, distribution, and importance to man of the members of the plant and animal kingdoms. In fundamental characteristics organisms are much the same, sharing as they do the common property of being alive. This last statement will be our keynote. Much of our discussion will be about the frog, but the approach will be general—the frog as an animal and not the frog as a frog. Nearly any animal would serve our purpose, but for convenience, availability, and adaptability for laboratory work, the frog is excellent.

THE MEADOW FROG
RANA PZIENS



THE BULLFROG
RANA CATESBEIANA



Adult



Distribution



Habitat

AI-1

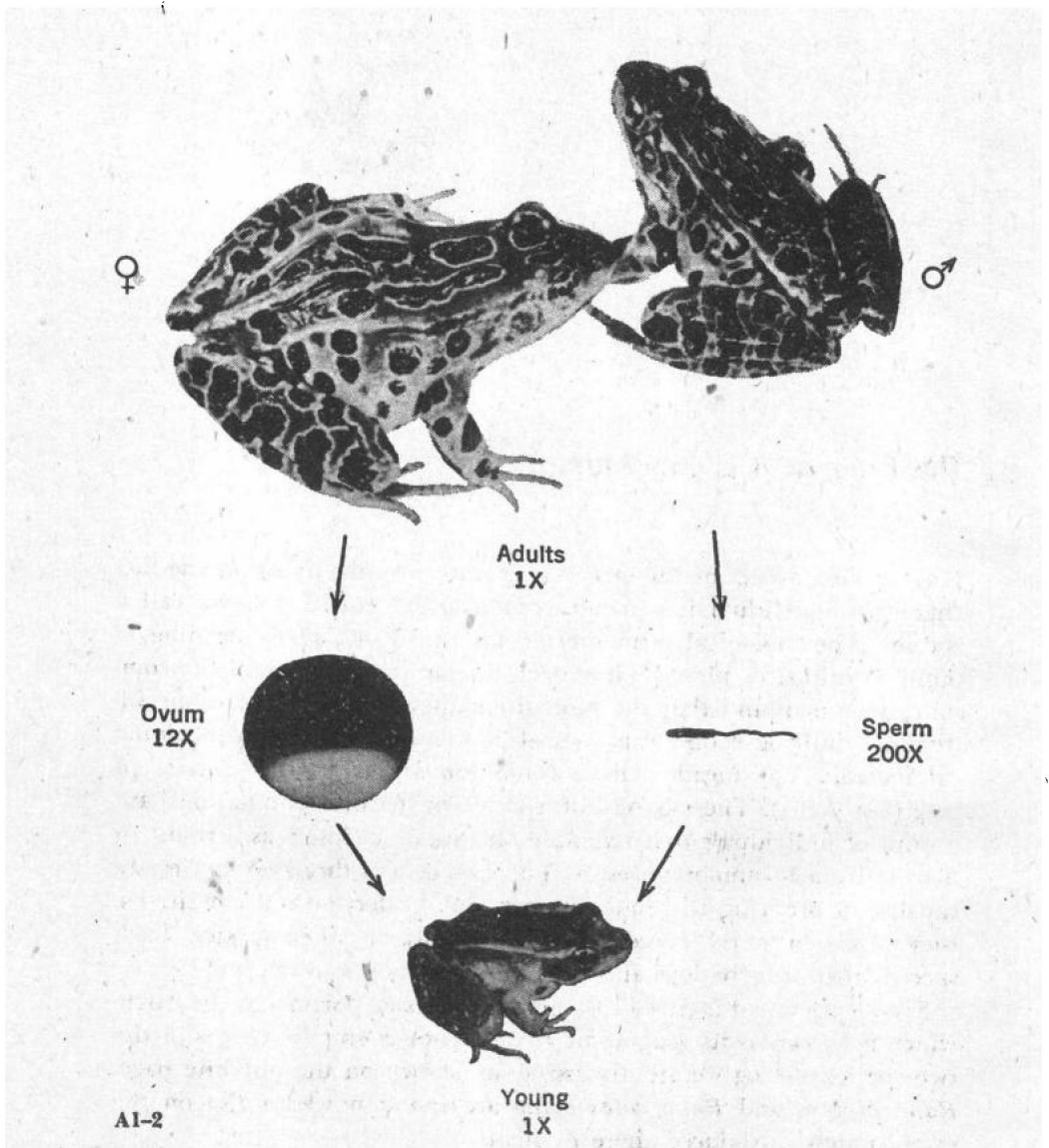
The Frog as a Living Animal

One striking aspect of this perplexing state we call 'living' is the fact that each individual is a member of a larger entity that we call a species. The biological term *species* has nearly the same meaning as 'kind of animal or plant.' Thus, each human being is one of the community of mankind that the biologist names *Homo sapiens*. The individual bullfrog is one of a natural population with the name *Rana catesbeiana*. The meadow frog, *Rana pipiens*, is another species of frog (Fig. A1-1). These 'kinds' or 'species' or 'natural populations' are groups of individuals that resemble one another closely as a result of descent from a common ancestor. The members of the same species are capable of breeding with one another and, under natural conditions, they rarely or never breed with individuals of other species. Each species, then, is a biological unit of reproduction and descent.

Every species is restricted to a greater or lesser portion of the earth, which is known as its *geographic range*. The geographic ranges of the two species of frog we are discussing are shown on the opposite page. *Rana pipiens* and *Rana catesbeiana* are found nowhere else on the earth, unless introduced there by man.

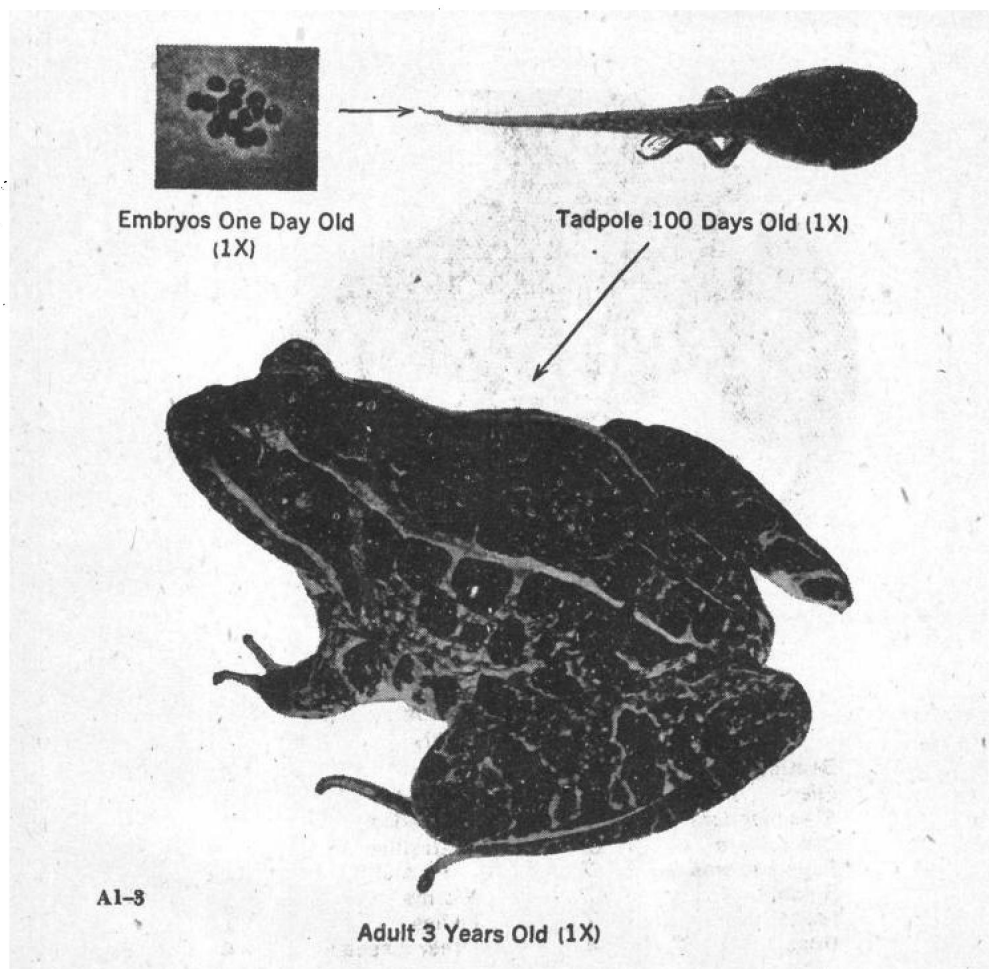
Within its geographic range, each species has its own *habitat*, or place where it lives. The habitat of the bullfrog is large bodies of water such as ponds, lakes, and rivers. The meadow frog has a somewhat different habitat. It prefers marshy areas. Typical habitats of the two species are shown on the opposite page.

A frog is able to do certain things and has characteristics that distinguish it, and other living creatures, from non-living objects. The principal characteristics of the living state will be explained briefly in the next few pages and the rest of the book will consist of an elaboration.



REPRODUCTION

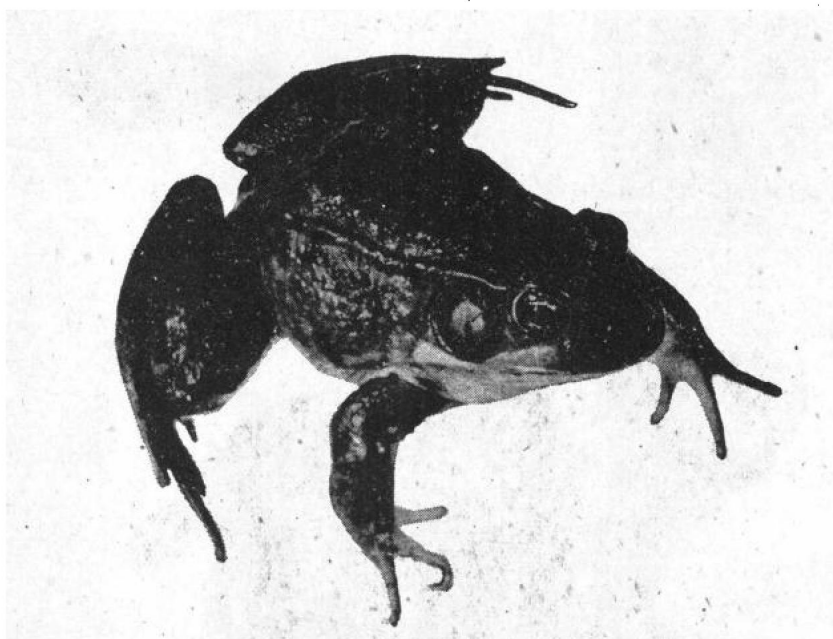
The essential feature of living organisms is *reproduction*, or the ability to produce other organisms of the same kind as the parents. In the frog and most familiar animals two sexes are present, male and female. The males produce *sperm* and the females produce *ova*. The union of one sperm and one ovum, a process known as *fertilization*, is the beginning of a new individual of the same type as the parents. This is an example of one sort of *sexual reproduction*. There are other types of reproduction and these will be discussed later.



GROWTH

Growth, or the increase in size, is characteristic of all organisms. The fertilized ovum of *Rana pipiens* weighs about 0.004 grams and the full-grown frog about 50 grams. (A gram is a unit of weight in the metric system corresponding to $\frac{1}{28}$ of an ounce; a five-cent piece weighs about 5 grams.) When a frog embryo begins its development it contains a supply of food material, called yolk. With this and the water it takes in from the surrounding pond it produces a tiny tadpole. From this time on the organism uses an external source of food. During the tadpole stage food consists largely of plant material. After the tadpole has changed into a frog, insects and other animals serve as food.

Each species has a characteristic adult size, subject to some variations. A frog never reaches the size of man, nor man that of an elephant. Size is an inherited characteristic.



Food of the green frog
(data of Hamilton)

Beetles	22%	Snails	3
Flies	14	Crayfish	2
Grasshoppers	13	Millipedes	2
Caterpillars	12	Butterflies	
Bees and wasps	7	and moths	1
Spiders	7	Worms	1
Frogs	7	Fishes	1
Bugs	4	Other insects	4

A1-4

METABOLISM

Living organisms differ from non-living things in their ability to convert raw materials ('food') into more of their own substance. This is accomplished by an exceedingly complex series of chemical reactions that is known as *metabolism*. It is this ability to make more of living substance that is the basis of growth and, indirectly, of reproduction.

Metabolism is the basis not only of growth but of maintenance as well. Most organisms grow for only a portion of their entire life but food is required at all times.