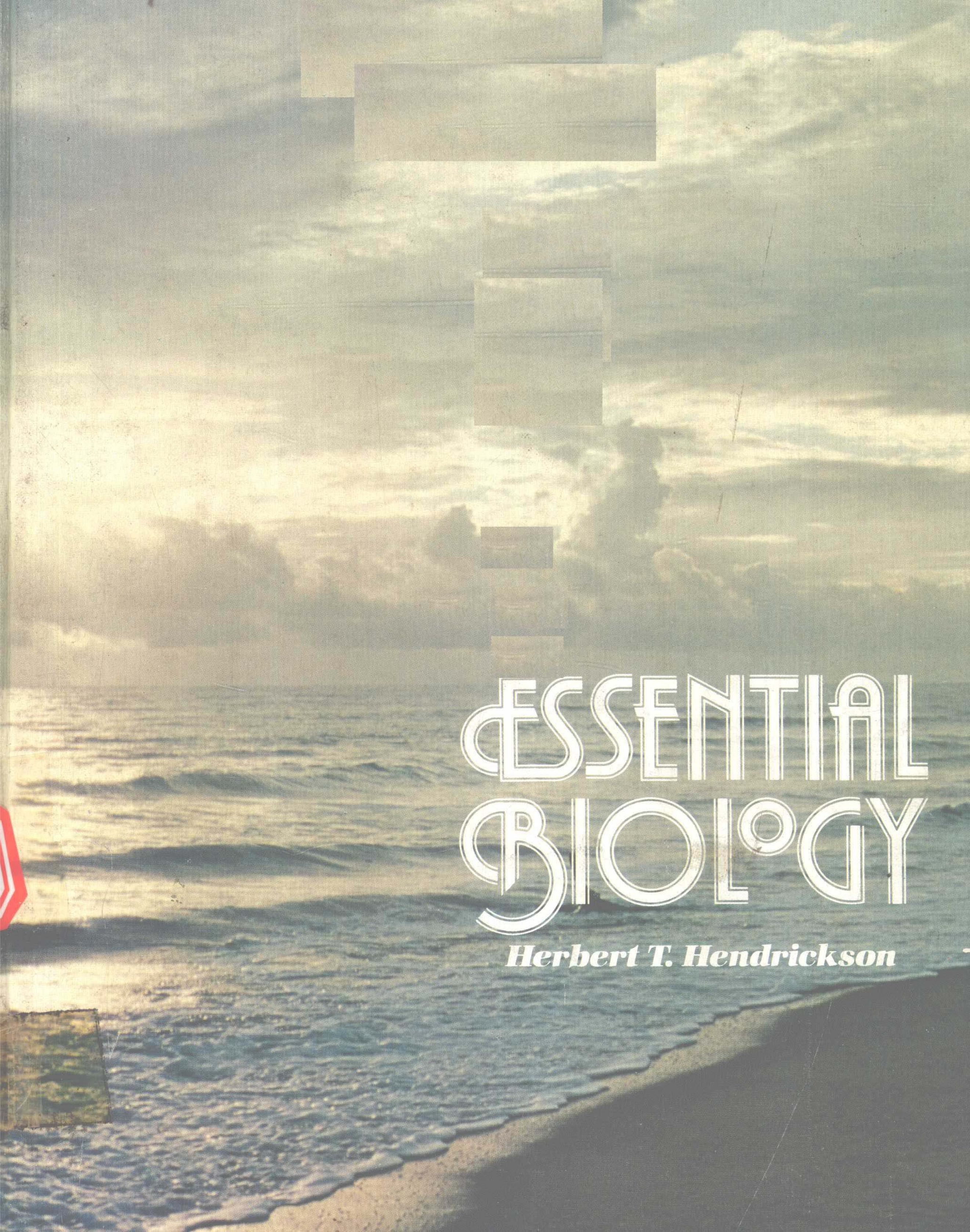

ESSENTIAL BIOLOGY

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Preface

Every professional biologist that I have ever met is convinced that the most fascinating, profound, and relevant subject in the world is biology. As a confirmed member of this select group, I accept its major belief with no qualms. Our ability to earn a living while studying a subject that is both intellectually challenging and emotionally satisfying comes close to being idyllic. We relish the exquisite details of description and the precise vocabulary that allows us to communicate the almost infinite array of diversity that is found in the living world.

Biology is a very broad and diversified area of knowledge complete with a multitude of specific facts. Our contemporary understanding of the living world is based on, and relies heavily upon, insights gained from the areas of chemistry, physics, and mathematics. New information is being added to the subject at a stupefying rate. Most introductory courses in biology attempt to survey all of this knowledge within the span of one school year. Any way you look at it, that is a great deal of information to cover in a relatively short time.

For people who plan to major in biology or one of the allied areas, the standard introductory course is probably necessary. However, the majority of students taking an introductory course do not intend to become biologists. These people have great difficulty perceiving the significance and relevance of all the details that are usually presented.

One proposed solution to the problem of different needs of different students is to offer a second, shorter introductory course for the nonmajor. While many competent biologists may differ with this opinion, I feel that there are only two major functions that such a shortened introductory course must fulfill.

First, I think that this kind of course should portray clearly what science is and what constitutes good, scientific practice, how the practitioners of science work, and what they can and cannot do and why. An introductory course for nonmajors must spend more time dealing with the philosophy of science because these students may not be exposed to it again. I also think that it is a mistake to make vague, abstract generalizations about the way science or scientists work, without having a solid understanding of the factual material involved. Therefore, it is necessary to cite real examples of scientific work in enough detail to show how science differs from other areas of human knowledge.

Second, I think that this course should convey some knowledge from the body of information that is biology. Many students have come to the conclusion that biology, and probably the other sciences, involves nothing more than the memorization of a prodigious number of facts couched in a foreign vocabulary. It is easy to get that impression because it is, at least partially, correct. But biology is also a thinker's game. Biologists want to know the implications of those multitudes of facts and the relationships among them. That cannot be done without knowledge of the facts, but mastery of those individual facts does not constitute an understanding of biology. There is a tendency on the part of all of us involved in introductory courses to forget that.

These two basic ideas have led me to conclude that most introductory courses in biology for the nonmajor attempt to cover entirely too much information to do proper justice to any of it. Trying to survey the entire realm of biology results in frustration for everyone involved. Instead, I think the course should try restricting itself to a small number of general ideas or concepts, explaining them thoroughly enough so that the student can achieve real understanding of both the working of science and the principles of life.

This book is intended to be the text for such a course. It is designed specifically for a course offered at the University of North Carolina at Greensboro for nonscience majors. It differs from most biology texts in that it is smaller and less comprehensive. It attempts to promote ideas and discovery, rather than rote memorization.

While the use of specialized vocabulary has been reduced, it has not been eliminated, nor has it been simplified to the extent that it could be used by a fourth grader. This is supposed to be a college-level text. Similarly, it is not possible to discuss biology on a mature, intelligent level without some reference to chemistry, physics, and mathematics. These areas are only mentioned when they are pertinent to an increased understanding of biology.

This book will probably be considered easy when compared to many competitive texts on the market, but that does not necessarily mean that the reader will not be challenged to do some thinking. Some of the ideas that characterize thinking in the area of biology are not always intuitively obvious.

If you want to give an introduction to biology that will be manageable within the time span of a typical semester, it is obvious to me that something has got to be omitted. Because the principal orientation of this book is conceptual, the most notable exclusion is the traditional coverage of anatomy and physiology, or structures and functions. There is no discussion of muscular contraction, nervous impulse transmission, how blood flows through the heart, how food is digested, or other similar topics usually found in introductory biology texts.

The omissions do not imply unimportance. They are simply practical necessities. Studies of structure and function have generated a monstrous collection of names and details (all of which are very satisfying to professional biologists) but have resulted in very few conceptual breakthroughs. The major concepts that have resulted from such studies, such as negative feedback and the relationship between form and function, are explored in an appropriate context.

What I have tried to do in this text is to focus on those areas in which the most widely meaningful ideas have emerged. I hope that most students and their professors will agree with my choice of areas.

Herbert T. Hendrickson

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The Scientific Study of Life

Objectives

The student should be able to:

1 / *explain and differentiate the characteristics of science from other areas of human knowledge.*

2 / *use the metric system of measurement.*

3 / *discriminate among* hypothesis, theory, *and* law.

4 / *design simple experiments using a control.*

5 / *characterize those traits shared by all living things that are absent in nonliving things.*

Science as a Discipline

Biology is the scientific study of life. One of the implications of that statement is that it is possible to study life in more than one way. However, within the covers of this book the multiple modes of investigation will be restricted to that which is scientific. There is an assumption that the contributions to human knowledge made by this scientific approach are in some way different from those made by other disciplines, such as history, fine arts, humanities, and mathematics. There is no claim made that these other approaches are better or worse, or more or less valid. However, they are different, and the insights and understandings of the world that we can achieve by using these different approaches will vary.

CHARACTERISTICS OF SCIENCE

The words *science* and *scientific* are familiar parts of the modern American vocabulary whose general meanings are vaguely understood but seldom defined precisely. This situation is partly due to the use of the term *science* in two different ways. First, science is a body of information about the material world; second, it is a process by which that information is obtained. Some people have described the process of science as nothing more than the rigorous application of common sense, and thus the content of science is that body of information obtained by using this rigorous, commonsense method. While there is a certain amount of circular reasoning in that description, there are few real conflicts in practice with respect to what is or is not science.

Science, as a body of information about the material world, deals only with those things we can observe either directly with our unaided senses or indirectly through some artificial aid to our senses. Furthermore, the observations must be repeatable and verifiable. A person does not have to be a believer or a practitioner of long standing to confirm the basic, factual observations of science content. It may sometimes require long training to operate some of the indirect aids used to make some observations, but the observations themselves are repeatable by anyone. This quality of consistency and repeatability in the making of observations is a characteristic feature of science. Unique events, or one-of-a-kind phenomena, are not the subject of science. Such subjects usually comprise the basis of history.

In addition, in science the observations are described in such a way as to minimize their ambiguity. Efforts are made to present observations as precisely and quantitatively as possible. For example, sizes of objects are usually measured by some mutually acceptable standard such as the metric system rather than subjectively described as large or small. Weights, volumes, velocities, temperatures, and many other physical properties are referred to by such standard-reference units.

The standard units of measurement used in scientific work are known as the metric system and often cause beginning students much difficulty. The difficulty is due to the fact that most of us have grown up with the English system of measurement, using inches, feet, pints, quarts, pounds, ounces, and several more obscure units. We are not used to working with any other system. This situation will probably change completely within one generation as the United States converts to the metric system. Legislation, enacted in 1975, encourages the country to adopt this alternative system of measurements within ten years.

Throughout most of the world the metric system is the standard means of measurement, because the metric system is simpler than our familiar English system. As an example, there are at least four commonly used units of length in the English system: the inch, the foot, the yard, and the mile, as well as several more or less obscure units such as the furlong, the rod, the chain, the fathom, and so on. The metric system has only one unit of length, the meter. The English system of volumes uses so many different units that you can easily be driven to distraction. For example, what are the relationships among teaspoon, tablespoon, cup, ounce, pint, quart, gallon, peck, bushel, barrel, and cubic yard? In contrast, the metric system has one unit of volume, the liter. The metric system has one unit of weight, the gram.

You would probably expect that one unit of length cannot be very useful for measuring something much smaller than the standard or something much larger. For example, we don't express the distance between New York and Los Angeles in inches, nor do we try to express the dimensions of a sheet of paper in miles. For this reason the metric system is set up in decimals. The standard units can be divided into tenths, hundredths, thousandths, and so on, or they can be expressed as multiples of ten. By multiplying or dividing the basic unit by tens, we obtain a continuous system of measurement from the exceedingly small to the immensely large. Each factor of ten that is used in conjunction with the standard unit can be represented by a standard prefix.

deci-	tenth	$\frac{1}{10}$	$\times 10^{-1}$
centi-	hundredth	$\frac{1}{100}$	$\times 10^{-2}$
milli-	thousandth	$\frac{1}{1,000}$	$\times 10^{-3}$