THIRD EDITION

BIOLOGICAL PRINCIPLES WITH HUMAN APPLICATIONS

GIDEON E. NELSON

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PREFACE

Biological Principles with Human Applications is designed for a one-term, introductory biology course for general college students. In an effort to make the text as "user friendly" as possible, considerable effort has been devoted to presenting the material in a readable, informative, and interesting style.

In today's complex world, a knowledge of biological concepts is important and useful in the life of every person. News media stories about cancer cures, dietary fads, brain neurotransmitters, genetic engineering, and acid rain make exciting news, but individuals need a background of basic biological knowledge to assess the accuracy and significance of such information. To support and enhance this philosophy, I planned the text around several goals.

One of these is to present major topics that are of importance in the field of biology, as well as having an impact on our everyday lives. In this endeavor the text emphasizes concepts underlying these topics rather than technical terminology and an extensive factual background. In each chapter the important basic concepts are summarized in a box following the sections that relate to them. In this way the reader can clearly identify the concepts and connect them immediately to the appropriate text material.

A second goal is to provide a background of subject matter that will help the reader interpret and evaluate the kinds of biological information that appear frequently in the news media and in popular periodicals. A basic knowledge of the immune system, for example, helps an individual understand why the AIDS virus is such a threat to human health. A knowledge of some basic genetic concepts aids a person's understanding of human heredity and gene splicing.

A third goal is to use human examples extensively to demonstrate basic biological concepts. After all, human beings are among the most important biological creatures on earth and exemplify nearly all biological principles as well as any other forms of life. Students are usually more interested, and thus more motivated, to learn concepts that apply to themselves as well as to other organisms.

The last, but not least, goal is to make the text as usable as possible for the reader. Each chapter begins with an abbreviated chapter outline and a list of objectives. Within each chapter, careful attention has been given to readability, clear explanations of complex concepts, and minimal use of technical terminology. A glossary at the back of the book defines each major term used in the text material. Every chapter concludes with a list of key terms and a set of self-test questions to help the reader review the chapter. A separate study guide with additional types of questions is available from the publisher.

Previous users of the text may wish to know how this edition differs from the former one. First, all material retained from the previous edition has been closely examined and brought up to date with new information as necessary. The sequence and number of chapters remain as before.

Second, a series of new topics were added to various chapters. These topics include the use of inductive–deductive reasoning in scientific methodology, the role of calcium ions and calmodulin in the hormonal system, how the AIDS virus attacks the immune system, genetic engineering as a bioethical problem, sequencing the human genome, the role of heredity in human behavior (sociobiology), new theories for the origin of present-day *Homo sapiens*, and global warming and the greenhouse effect. Finally, many of the recommendations made by reviewers and former users of the text were incorporated in this edition.

The following individuals reviewed the manuscript and contributed valuable improvements: James Heisinger, State University of South Dakota; Hadar Isseroff, State University College at Buffalo; Klaus Kalthoff, University of Texas at Austin; Charles L. Ralf, Colorado State University; and Martin Roeder, Florida State University.

I greatly appreciate the skill and efforts of the many people at John Wiley who produced this textbook. My special thanks go to Linda Larrabee, Biology Editor; John Spettell, Editorial Assistant; Linda Muriello, Production Supervisor; Jean Moorhead, Marketing Coordinator; Priscilla Todd, College Editing Department; David Levy for the design of the book; and Stella Kupferberg and Ann Manning in the Photo Research Department.

I wish to dedicate this edition to my wife, Nancy, for her enthusiastic help, support, and love.

GIDEON E. NELSON

Tallahassee, Florida
November 1988

CHAPTER 1

Edward Hicks, 1780–1849, *Peaceable Kingdom*, c. 1834. Detail. National Gallery of Art, Washington, D.C. Gift of Edgar William and Bernice Chrysler Garbisch.

CONTENTS

CHAPTER 1

Biology: An Inquiry into Life

MAJOR TOPICS

EARLY HUMANS AND NATURE
- Domestication of Plants and Animals

NATURAL HISTORY AND MODERN BIOLOGY

BIOLOGY TODAY
- Bioethics

THE PHILOSOPHY OF SCIENCE
- How Scientists Use Inductive–Deductive Logic
- Science and Other Kinds of Knowledge

CHAPTER OBJECTIVES

To define the science of biology and examine the properties of living matter.

To examine the close kinship between prehistoric humans and nature.

To consider how modern biology has expanded and interacted with the social sciences.

To describe how science has advanced by using inductive–deductive logic.

Equipped with his five senses, man explores the universe around him and calls the adventure science.

Edwin Powell Hubble

The opening quotation is an especially appropriate one because *science*—the systematic gathering of knowledge obtained by observation and experimentation—is truly an astonishing adventure. Our five senses, vision, smell, equilibrium, hearing, and touch, are the basic "tools" for exploring nature. We extend the functions of these tools by using sophisticated devices such as optical instruments, ultracentrifuges, gas chromatographs, cameras, spectrophotometers, and personal computers. With these tools investigators have made profound discoveries about our planet and the universe. So far as anyone can tell, we will never exhaust the exciting potential for gaining new knowledge about the natural world.

The science of biology is concerned with gaining knowledge about the phenomenon called life. To accomplish this, biologists assume that all living forms have basic properties that may be investigated by observation and experimentation. These properties include a structure based on cells that obtain and use nutrients for energy and growth, employ self-regulatory control systems, have the ability to reproduce, utilize hereditary mechanisms, adapt to the environment, and have an evolutionary history. A vast range of activities also relate to the life processes from the movement of molecules in cells to the functioning of huge ecosystems. By organizing and unifying the diverse information from these many sources, biologists believe that we can better comprehend the intricate complex of events that make up life.

EARLY HUMANS AND NATURE

All the evidence that we have about the cultures of prehistoric human beings indicates that they had a sense of close kinship with nature and were greatly interested in other living creatures. This is supported by the remarkable paintings and engravings made by our prehistoric ancestors on the walls of more than 100 caves in France and Spain (Figure 1-1). These depict a variety of wild animals, including bison, wild ox, horses, bears, mammoths, stags, and lions. Biological themes are also expressed in the thousands of carved ornamental objects recovered from caves and burial sites. Anthropologists would say that this interest is not at all unusual considering how closely primitive peoples were involved with their environment.

FIGURE 1-1 Paintings made by prehistoric humans on the wall of a cave in France.

FIGURE 1-2 Members of a Neanderthal group as they may have lived thousands of years ago. Their facial features and body forms were probably similar to ours.

Picture yourself, for a moment, as a member of a small tribe living about 10,000 years ago. Your home, possibly a cave entrance, is provided by nature. Even if your tribe lives in human-made shelters of some sort, the shelters are made of plant materials, or perhaps of animal hides. To protect themselves from the weather, your clanspeople would have to make clothing from animal skins (Figure 1-2). Many of the tribe's waking hours are spent hunting and gathering food, mostly plant materials such as seeds, fruits, leaves, and edible roots. Firewood for cooking and warmth also has to be collected and transported.

Because the human body is so defenseless (lacking even a decent coat of fur), you are almost helpless against most perils of the environment. Only two features probably enable you to survive from day to day: a relatively large body size, which makes you one of the larger predators, and cunning in avoiding danger. As a hunter–gatherer, life is rigorous and life spans are short. Imagine the problems associated with even simple illnesses!

Unusual events in your environment such as catastrophic weather, eclipses, and changing seasons probably awe and mystify your fellow tribespeople. This awe of natural events, as well as the mysteries of birth and death, frequently becomes the basis for various tribal rituals and religions. In such a manner early humankind evolved in an intimate association with nature, a bond that persisted for many thousands of years.

Domestication of Plants and Animals

We tend to forget that all our pets, livestock, and food plants were derived from native forms that were domesticated in prehistoric times. Most of this happened, according to fossil evidence, over the past 10,000 years and involved a relatively small variety of plants and animals. We can only speculate how this actually came about; perhaps by first taming the young of wild animals for pets or food, and by planting the seeds of wild plants near a campsite. The actual process of domestication—breeding animals to bring out certain traits, or selecting and growing plants with desired features—is a more sophisticated and long-term process.

The domestication of many animals and plants evidently took place repeatedly, at different times, and in widely separated areas. The dog was domesticated in Iraq about 12,000 years B.C., probably as a pet, and in the New World about 11,000 B.C., possibly as a meat source. The domestication of pigs and cattle appeared independently in Europe and China. Different species of sweet potatoes (yams) were domesticated in West Africa, in Southeast Asia, and in tropical America.

Another striking feature of domestication is the number of different forms that humans have been able to derive from the same species. The dog, thought to be the first domesticated animal, exists today in an amazing range of sizes and varieties (Fig-

FIGURE 1-3 Human selection produced this wide array of domesticated dogs.

ure 1-3). All were produced by human selection and all are interfertile with one another. From a leafy plant in the mustard family, *Brassica oleracea*, artificial selection has produced cabbage, cauliflower, kohlrabi, brussels sprouts, broccoli, and kale (Figure 1-4). Table 1-1 lists some of the other common animals and approximately how long they have been domesticated.

The most profound consequence of domestication was the development of *agriculture* which began about 10,000 years ago. It allowed many more people to live on smaller plots of ground and led eventually to an immense population expansion all over the earth. Perhaps, as has been suggested, humans were domesticated by plants and animals, rather than vice versa! It seems certain that the almost total interdependence now existing between humans and their

TABLE 1-1 The Domestication Time for a Variety of Animals

Species	*Domestication*	*Number of Varieties*
Pigeon	Prehistoric	140
Donkey	Prehistoric	15
Guinea pig	Prehistoric	25
Dog	12,000–8000 B.C.	200
Cow	6000–2000 B.C.	60
Pig	5000–2000 B.C.	35
Chicken	3000 B.C.	125
Horse	3,000–2000 B.C.	60
Cat	2000 B.C.	25
Duck	1000 B.C.	30
Canary	A.D. 1500	20

Source: Table modified from paper by K. F. Dyer, Evolution Observed—Some Examples of Evolution Occurring in Historical Times. *Journal of Biological Education*, Volume 2, pp. 317–338, 1968.

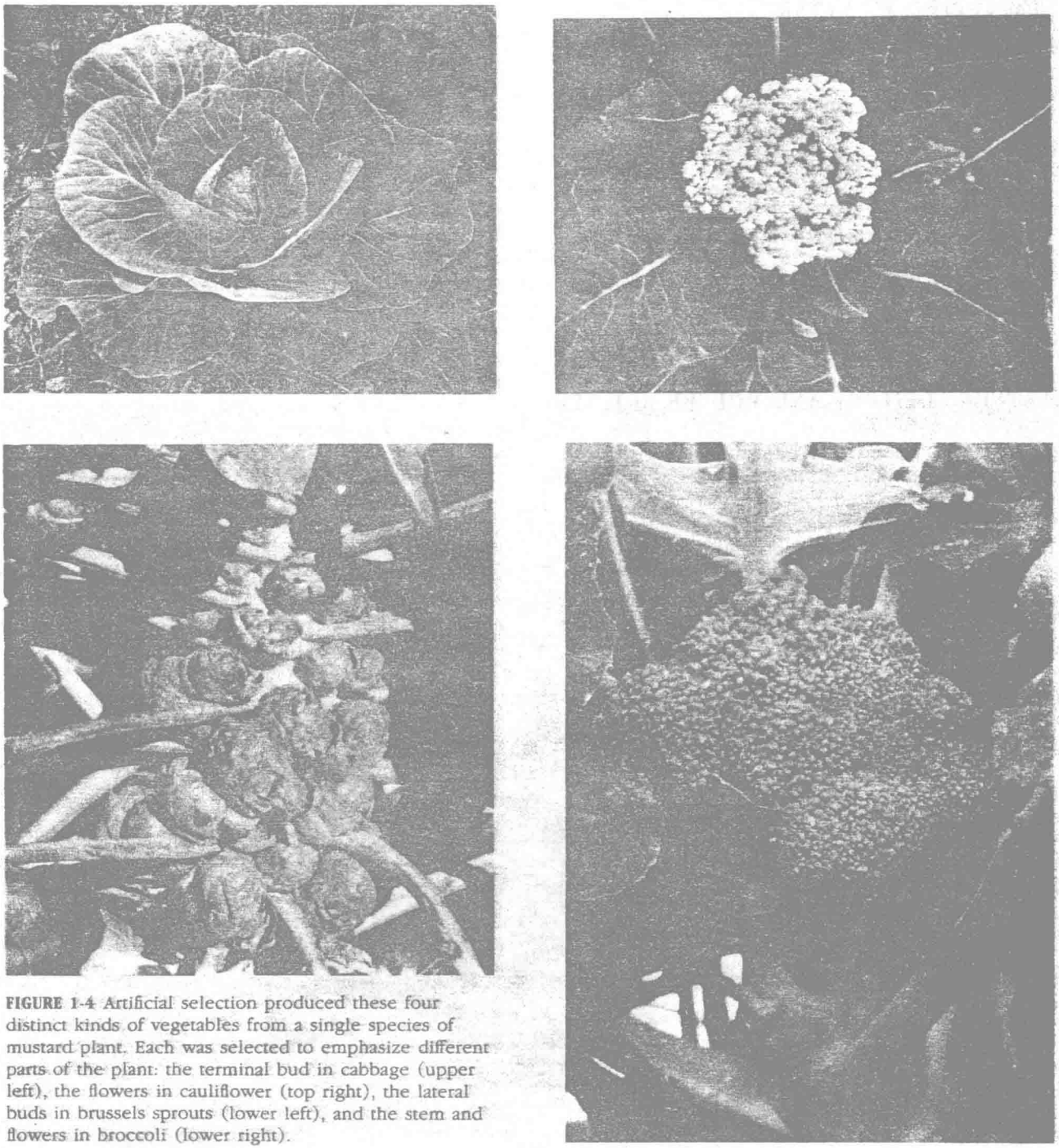

FIGURE 1-4 Artificial selection produced these four distinct kinds of vegetables from a single species of mustard plant. Each was selected to emphasize different parts of the plant: the terminal bud in cabbage (upper left), the flowers in cauliflower (top right), the lateral buds in brussels sprouts (lower left), and the stem and flowers in broccoli (lower right).

domesticates grew from the coevolution that occurred between them over an extensive period of time.

Basic Concepts

Biology is a branch of science that studies life and its processes by means of observation and experimentation.

Human cultures evolved in an intimate association with nature.

Domestication played a key role in the expansion of human populations.

NATURAL HISTORY AND MODERN BIOLOGY

As centuries passed and human cultures evolved, people began to organize their knowledge about nature into the broad field of natural history. One aspect of early natural history studies concerned the search for plants with medicinal properties. From this search eventually came a long list of useful drugs: scopolamine from the mandrake plant, narcotics from the opium poppy, digitalis from foxglove, and reserpine from the shrub *Rauwolfia* are a few. Even at present, nearly half of prescribed drugs are plant products. Somewhat offsetting the numerous beneficial drug discoveries were those of dubious value to humankind, including cocaine from the coca plant, marijuana from the cannabis plant, the opiates such as heroin and opium, and, of course, tobacco and alcohol.

From these early inquiries into natural history eventually grew the branch of science we now call biology. Although we have systematized the study of life into a formal science, nearly everyone still feels some kind of personal kinship with nature. Urban dwellers try to capture a little of it by growing plants and keeping pets; many of us get closer to nature by going camping or hiking, and some adventuresome souls even go backpacking in wilderness areas (Figure 1-5). Backpacking is so popular, in fact, that over three *million* individuals now hike on the beautiful and rugged Appalachian trail each year.

Even with our love of nature we seem to retain considerable awe and fear of nature. Thus the camper, hiker, and backpacker all need special clothing and other gear as protection against the rigors of the environment. And, in the fashion of our ancient ancestors, modern campers like to build campfires at night and huddle around them. The fire not only provides warmth, but more importantly it also creates

FIGURE 1-5 A backpacker hiking in the Grand Teton National Park, Wyoming.