
THIRD EDITION

**BIOLOGICAL
PRINCIPLES
WITH HUMAN
APPLICATIONS**

GIDEON E. NELSON

THIRD EDITION

**BIOLOGICAL
PRINCIPLES
WITH HUMAN
APPLICATIONS**

GIDEON E. NELSON

*Professor of Biology Emeritus
University of South Florida*



JOHN WILEY & SONS

NEW YORK ◇ CHICHESTER ◇ BRISBANE ◇ TORONTO ◇ SINGAPORE

TO THE STUDENT: A Study Guide for the textbook is available through your college bookstore under the title Study Guide to Accompany *Biological Principles with Human Applications*, Third Edition, by Gideon E. Nelson. The Study Guide can help you with course material by acting as a tutorial, review, and study aid. If the Study Guide is not in stock, ask the bookstore manager to order a copy for you.

Copyright © 1980, 1984, 1989, by John Wiley & Sons, Inc.

All rights reserved. Published simultaneously in Canada.

Reproduction or translation of any part of this work beyond that permitted by Sections 107 and 108 of the 1976 United States Copyright Act without the permission of the copyright owner is unlawful. Requests for permission or further information should be addressed to the Permissions Department, John Wiley & Sons.

Library of Congress Cataloging in Publication Data:

Nelson, Gideon E.

Biological principles with human applications / Gideon E.

Nelson. — 3rd ed.

p. cm.

Rev. ed. of: *Biological principles with human perspectives.*

2nd ed. c1984.

Bibliography: p.

Includes index.

ISBN 0-471-61775-X

I. Biology. 2. Human biology. I. Nelson, Gideon E.

Biological principles with human perspectives. II. Title.

QH308.2.N44 1989

599.9—dc19

88-7931

CIP

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

P R E F A C E

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.



C O N T E N T S

CHAPTER 1 BIOLOGY: AN INQUIRY INTO LIFE	1		
EARLY HUMANS AND NATURE	2		
Domestication of Plants and Animals	3		
NATURAL HISTORY AND MODERN BIOLOGY	6		
BIOLOGY TODAY	7		
Bioethics	8		
THE PHILOSOPHY OF SCIENCE	10		
How Scientists Use Inductive-Deductive Logic	11		
Science and Other Kinds of Knowledge	13		
KEY TERMS	14		
SELF-TEST QUESTIONS	14		
CHAPTER 2 THE HUMAN ORGANISM AS A BIOLOGICAL ENTITY	17		
UNITY WITH OTHER FORMS OF LIFE	18		
Elements and Compounds	19		
Cells and Organ Systems	22		
Basic Physiology	24		
UNITY WITH DIVERSITY	25		
Humans as a Primates	25		
Distinctive Features of Humans	27		
Unique Features of Humans	30		
KEY TERMS	32		
SELF-TEST QUESTIONS	32		
CHAPTER 3 CELLS AND THEIR FUNCTIONS	35		
HOW TO STUDY EXTREMELY SMALL OBJECTS	37		
THE ANATOMY OF A CELL	40		
Passage of Materials Through the Cell Membrane	42		
Organelles Made of Membranes	44		
Organelles Not Made of Membranes	47		
Cytoplasmic Structures in Summary	48		
The Nucleus and Its Structures	48		
THE LIFE CYCLE OF A CELL	49		
CELLS AND TISSUES	51		
CELLS AS BASIC BIOLOGICAL UNITS	54		
KEY TERMS	54		
SELF-TEST QUESTIONS	55		
CHAPTER 4 THE ROLE OF NUTRIENTS IN THE BODY	57		
NUTRIENTS AND THEIR FUNCTIONS	58		
PROTEINS	59		
Structural Proteins	61		
Blood Proteins	61		
Enzymes	61		
Protein Requirements	62		
Protein Deficiency	62		
VITAMINS	65		
MINERALS	68		
Calcium and Phosphorus	69		
Iron	69		
Iodine	69		
Nonessential Minerals	70		
WATER	70		
SOME DIETARY MISCONCEPTIONS ABOUT FOOD AND NUTRITION	71		
KEY TERMS	74		
SELF-TEST QUESTIONS	75		
CHAPTER 5 CALORIES, FOOD, AND YOU	77		
ENERGY AND LIFE	78		
ENERGY AND THE ORGANISM	79		
MEETING ENERGY NEEDS WITH FOOD SOURCES	81		
THE ENERGY NUTRIENTS	82		
Carbohydrates	82		
Fats	84		

THE ENERGY MACHINE 87		THE HUMAN RESPIRATORY SYSTEM 125	
ATP—The Energy Currency of Life 87		Functions of the Respiratory Tract 125	
Cellular Respiration 87		Getting Air into the	
Respiration in Muscle Tissue 90		Lungs—Ventilation 126	
SOME DIETARY MISCONCEPTIONS ABOUT		Gas Exchange and Transport 127	
FOOD AND ENERGY 91		KEY TERMS 128	
KEY TERMS 92		SELF-TEST QUESTIONS 128	
SELF-TEST QUESTIONS 92			
CHAPTER 6 FEEDING ADAPTATIONS		CHAPTER 8 HORMONES	131
AND DIGESTION	95	METHOD OF STUDYING HORMONES 132	
THE DIGESTIVE REACTION 96		Removal of Glands 132	
THE HUMAN DIGESTIVE SYSTEM		Clinical Studies 134	
The Mouth 97		Bioassay Tests 134	
The Stomach 97		WHERE HORMONES ARE PRODUCED 135	
The Small Intestine 99		Pituitary Gland 136	
The Large Intestine 101		Thyroid Gland 139	
FEEDING ADAPTATIONS IN OTHER		Adrenal Glands 140	
ANIMALS 102		HORMONES AND TARGET TISSUES 142	
Filter Feeders 102		Second Messenger Concept 142	
Herbivores 104		Calcium Ions and Calmodulin 143	
KEY TERMS 106		Steroid Hormones and DNA 143	
SELF-TEST QUESTIONS 106		HORMONAL FUNCTION: AND	
		OVERVIEW 144	
CHAPTER 7 CIRCULATION AND		KEY TERMS 144	
RESPIRATION	109	SELF-TEST QUESTIONS 145	
CIRCULATORY SYSTEMS 110		CHAPTER 9 THE NERVOUS SYSTEM	147
Simple Systems 110		FUNCTIONS OF THE NERVOUS SYSTEM 148	
Open-Type Systems 110		THE NEURON 148	
Closed-Type Systems 110		THE NERVE IMPULSE 151	
THE HUMAN CIRCULATORY SYSTEM 111		SYNAPTIC TRANSMISSION 153	
Blood 111		ORGANIZATION OF THE VERTEBRATE	
Capillaries 113		NERVOUS SYSTEM 155	
Lymph and the Lymphatic System 114		The Spinal Cord 155	
Veins 114		The Spinal Reflex 157	
Heart 117		The Peripheral Nerves 158	
Arteries 120		OTHER TYPES OF NERVOUS SYSTEMS 161	
RESPIRATORY SYSTEMS 120		KEY TERMS 162	
Gas Exchange 120		SELF-TEST QUESTIONS 162	
Requirements for Respiratory		CHAPTER 10 SENSE ORGANS	
Structures 120		AND THE BRAIN	165
Respiratory Structures 122		SENSORY PERCEPTION 166	

Light	166	
Sound	171	
Balance	173	
Chemical Sensing	174	
Heat, Cold, Touch, and Pain	175	
THE BRAIN	177	
Methods of Studying the Brain	178	
Parts of the Brain and Their Functions	179	
How the Brain Functions	182	
KEY TERMS	183	
SELF-TEST QUESTIONS	183	
CHAPTER 11 REGULATING THE INTERNAL ENVIRONMENT: HOMEOSTASIS		187
THE CONCEPT OF SELF-REGULATION: HOMEOSTASIS	188	
EXAMPLES OF HOMEOSTASIS: BLOOD GASES AND BODY TEMPERATURE	189	
Blood Gases	189	
Body Temperature	190	
THE KIDNEY AS A HOMEOSTATIC ORGAN	192	
How a Nephron Functions	192	
The Artificial Kidney Machine	194	
BIOLOGICAL RHYTHMS	195	
KEY TERMS	198	
SELF-TEST QUESTIONS	198	
CHAPTER 12 HOW TO MAINTAIN A LIVING MACHINE		201
PROTECTIVE MECHANISMS	202	
Skin	202	
Blood	205	
The Immune System	206	
WHEN PROTECTIVE MECHANISMS FAIL	209	
AIDS	209	
Cancer	210	
THE QUEST FOR HEALTH	212	
HOW TO MAINTAIN A HEALTHY BODY	213	
HEALTH CARE—SOME BIOETHICAL PROBLEMS	215	
KEY TERMS	216	
SELF-TEST QUESTIONS	216	
CHAPTER 13 ABOUT BEGETTING: SEX AND REPRODUCTION		219
SEXUAL AND ASEXUAL REPRODUCTION	221	
CELLULAR REPRODUCTION	222	
Mitosis	222	
Meiosis	225	
REPRODUCTION IN HUMANS	227	
THE FEMALE REPRODUCTIVE SYSTEM	227	
The Formation of Egg Cells	230	
Ovulation	231	
The Female Reproductive Cycle	232	
THE MALE REPRODUCTIVE SYSTEM	232	
The Formation of Sperm Cells	235	
The Male Reproductive Cycle	236	
FERTILIZATION	237	
BIRTH CONTROL	238	
Methods for Males	238	
Methods for Females	238	
Birth Control in the Future	241	
INDUCED ABORTION—A BIOETHICAL DILEMMA	241	
KEY TERMS	242	
SELF-TEST QUESTIONS	242	
CHAPTER 14 DEVELOPMENT AND GROWTH		245
FORMATION OF THE EMBRYO	247	
Fertilization	247	
Cleavage and Blastula Formation	247	
Gastrulation and the Germ Layers	247	
Differentiation	249	
FETAL MEMBRANES AND PLACENTA	249	
Amnion	249	
Yolk Sac and Primitive Gut	250	
Allantois	250	
Chorion and Placenta	251	
DEVELOPMENT OF ORGAN SYSTEMS IN THE EMBRYO	252	
Nervous System	252	
Circulatory System	253	
THE TRIMESTERS OF FETAL DEVELOPMENT	254	

Trimester One	254		
Trimester Two	255		
Trimester Three	256		
LABOR AND BIRTH	258		
Multiple Births	258		
THE NEWBORN INFANT	260		
Nutrition and Infant Development	260		
THE HUMAN LIFE CYCLE	261		
SOME RECENT ADVANCES	264		
<i>In Vitro</i> Fertilization	264		
Embryo Transfer	264		
Cloning	265		
KEY TERMS	266		
SELF-TEST QUESTIONS	266		
CHAPTER 15 GENETICS PART I: THE NATURE OF GENES		269	
THE GENETIC BLUEPRINT—DNA	270		
THE GENE CONCEPT	270		
Identifying the Gene	271		
Evidence That Genes Are Made of DNA	271		
THE STRUCTURE AND FUNCTION OF DNA	273		
DNA Replication: DNA→DNA	274		
Transcription: DNA→RNA	276		
Translation: mRNA→Protein	277		
DNA AND CHROMOSOMES	280		
Chromosome Numbers	281		
Diploidy and Haploidy	282		
GENETIC ENGINEERING—A BIOETHICAL PROBLEM?	283		
KEY TERMS	284		
SELF-TEST QUESTIONS	285		
CHAPTER 16 GENETICS PART II: GENES AND HUMAN HEREDITY		287	
SOME METHODS OF STUDY	289		
SOME PATTERNS OF INHERITANCE	291		
Monohybrid Inheritance	291		
Interacting (Codominant) Genes	293		
Sex Chromosomes	294		
Quantitative Inheritance	296		
TECHNIQUES FOR STUDYING HUMAN HEREDITY	298		
Pedigree Analysis and Inherited Diseases	298		
Locating Genes on Chromosomes	299		
THE ORIGIN OF NEW GENES: MUTATION	301		
Types of Mutation	302		
Causes of Mutation	303		
KEY TERMS	304		
SELF-TEST QUESTIONS	304		
CHAPTER 17 EVOLUTION PART I: EVIDENCE			307
BEGINNINGS	308		
Origin of the Earth	308		
Origin of Life	308		
EVIDENCE OF EVOLUTION	311		
Fossils	311		
Comparative Structure and Development	315		
Comparative Physiology	318		
Evolution Observed	319		
KEY TERMS	321		
SELF-TEST QUESTIONS	321		
CHAPTER 18 EVOLUTION PART II: THEORIES AND MECHANISMS			325
DARWIN'S ACHIEVEMENTS	328		
The Changing World	328		
Gradual Change	328		
Common Ancestry	328		
Evolution by Natural Selection	328		
THE DARWINIAN REVOLUTION	330		
MODERN NATURAL SELECTION	331		
Variation	331		
Survival of the Fit	331		
SOME MAJOR FEATURES OF EVOLUTION	332		
Adaptation	332		
Species Formation	337		

Adaptive Radiation	339		
Human Evolution	342		
KEY TERMS	347		
SELF-TEST QUESTIONS	348		
CHAPTER 19 MOTHER EARTH AND THE BIOSPHERE		351	
THE BIOSPHERE	352		
Solar Energy	352		
Available Water	354		
Chemicals and Exchange Mechanisms	355		
BIOGEOCHEMICAL CYCLES	356		
The Carbon Cycle	356		
The Nitrogen Cycle	357		
THE ECOSYSTEM CONCEPT	359		
The Abiotic Component	359		
The Producer Component	359		
The Consumer Component	359		
The Decomposer Component	360		
ENERGY FLOW IN ECOSYSTEMS	361		
Food Chains and Food Webs	361		
Ecological Pyramids	361		
The Energy Flow Model	363		
SOME INTERACTIONS BETWEEN ORGANISMS IN ECOSYSTEMS	364		
Predation	365		
Prey Defenses	367		
Competition	368		
Symbiosis	369		
INTERACTIONS WITHIN SPECIES IN ECOSYSTEMS	371		
Territoriality	371		
Social Dominance	372		
Altruism	372		
KEY TERMS	372		
SELF-TEST QUESTIONS	373		
CHAPTER 20 THE BIOSPHERE AND HUMAN LIFE			375
BIOMES AND HOW HUMANS USE THEM	376		
Tundra	376		
Taiga: Northern Coniferous Forest	376		
Temperate Deciduous Forests	379		
Grasslands	379		
Deserts	383		
Tropical Biomes	383		
Marine and Freshwater Biomes	385		
RACHEL CARSON AND THE ECOLOGICAL REVOLUTION	388		
SOME ENVIRONMENTAL PROBLEMS	388		
Air Pollution	389		
Water Pollution	392		
Pesticides	394		
HOW DID WE GET INTO THIS MESS?	396		
KEY TERMS	398		
SELF-TEST QUESTIONS	398		
GLOSSARY			401
INDEX			425

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.

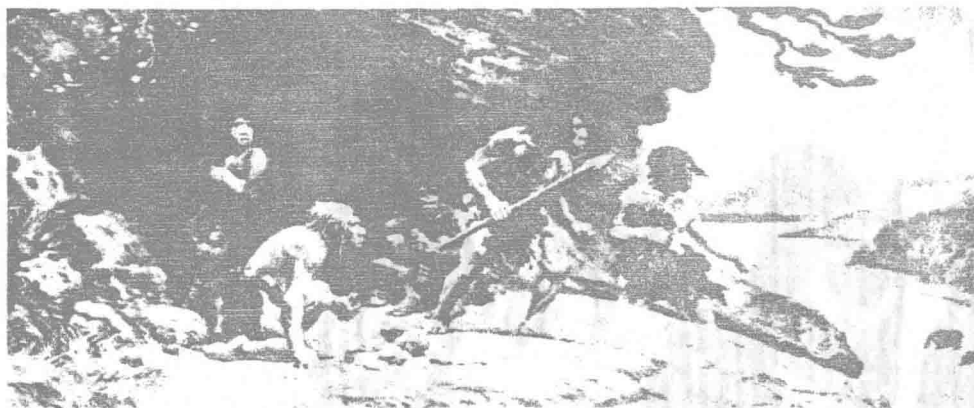


FIGURE 1-2 Members of a Neanderthal group as they may have lived thousands of years ago. Their facial features and body forms were probably similar to ours.

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-

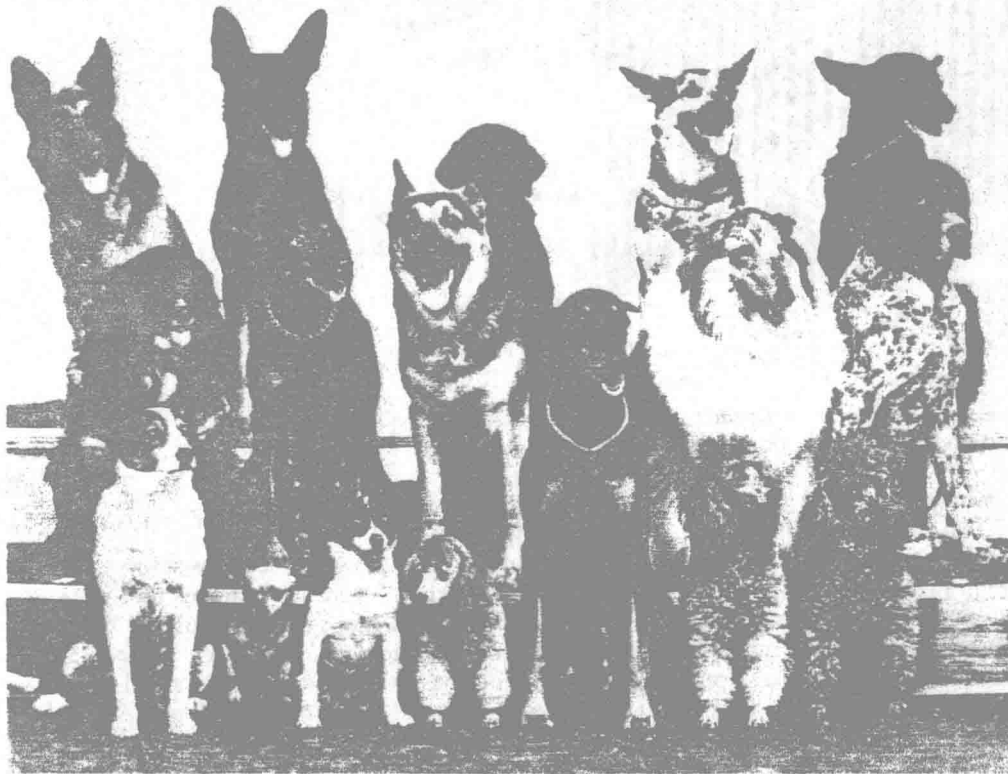


FIGURE 1-3 Human selection produced this wide array of domesticated dogs.

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.

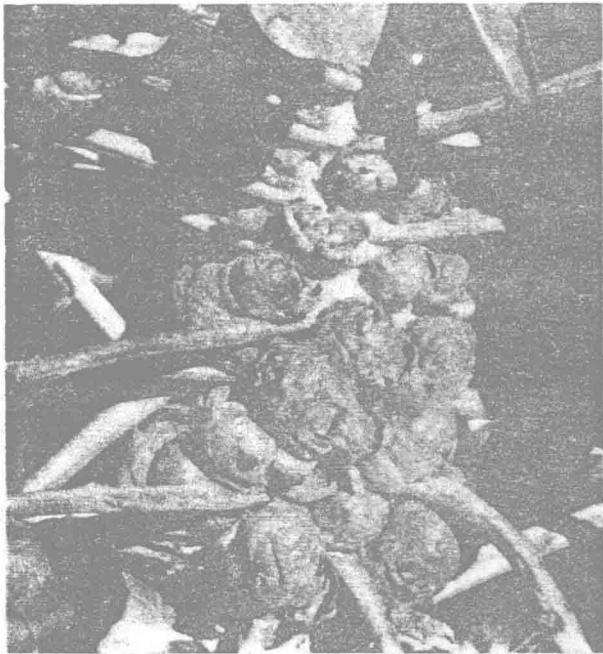
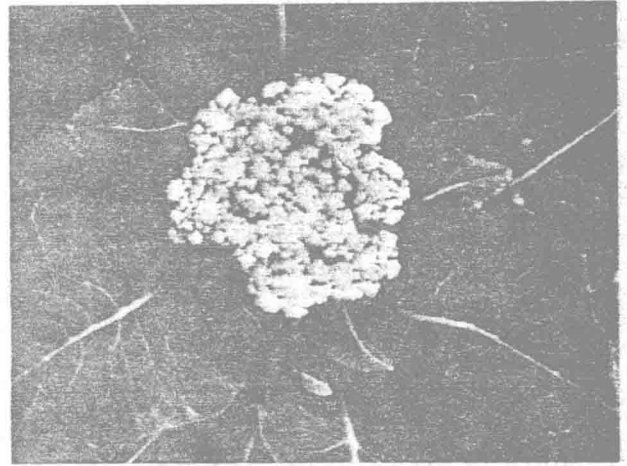
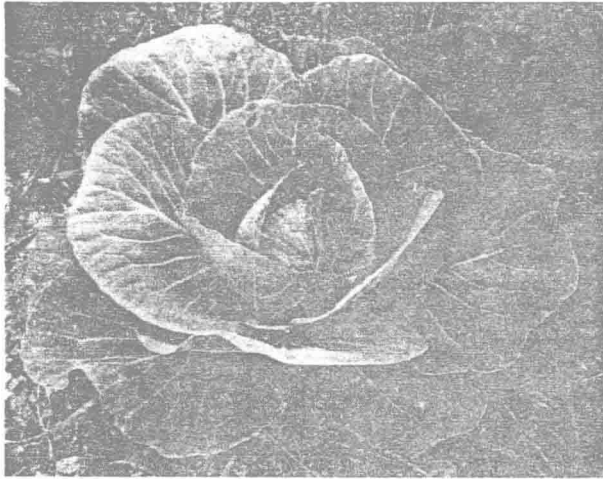


FIGURE 1-4 Artificial selection produced these four distinct kinds of vegetables from a single species of mustard plant. Each was selected to emphasize different parts of the plant: the terminal bud in cabbage (upper left), the flowers in cauliflower (top right), the lateral buds in brussels sprouts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