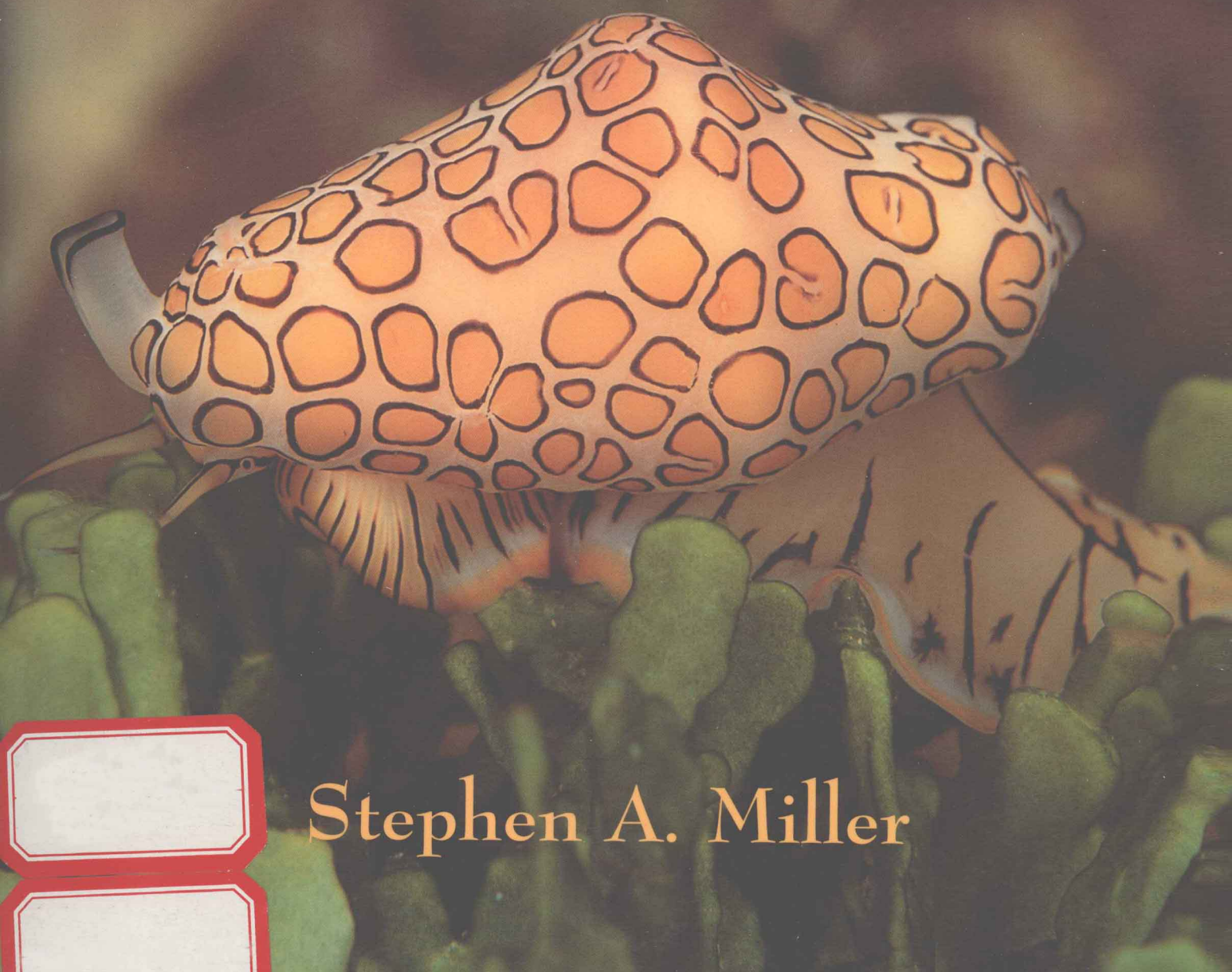
General Zoology
Laboratory Manual

Fourth Edition



Stephen A. Miller

General Zoology

Laboratory Manual

Fourth Edition

Stephen A. Miller
College of the Ozarks

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Preface

This *General Zoology Laboratory Manual* is intended for students taking their first course in zoology. Provided are exercises and experiences that will help students: (1) understand the general principles that unite animal biology, (2) appreciate the diversity found in the animal kingdom and understand the evolutionary relationships that explain this diversity, (3) become familiar with the structure and function of vertebrate organ systems and appreciate some of the evolutionary changes that took place in the development of those organ systems, and (4) develop problem-solving skills.

The fourth edition of *General Zoology Laboratory Manual* has been carefully edited for clarity and conciseness, and important additions to the manual have been made. Numerous older photographs and drawings have been replaced. The glossary has been expanded. The fourth edition has been made more interactive than the third by expanding the Student Worksheets at the end of each exercise and adding a prelaboratory quiz at the beginning of each exercise. This quiz helps students evaluate their readiness for the laboratory exercise and can be used by instructors to assess student preparation. Nineteen black-and-white plates of dissected specimens have been added to aid students during their dissections. The coverage of scientific method in exercise 1 has been expanded. In recent years, cladistic analysis of evolutionary relationships among animals has become increasingly important in zoology. Exercise 7 is a new exercise that introduces students to principles of animal taxonomy and cladistics using animal models. Other exercises in unit II apply these principles by having students use class characteristics studied in an exercise to construct a cladogram for the animal phylum studied.

Pedagogy in the fourth edition has retained popular features from the third edition. Review questions are in the form of "Stop and Ask Yourself" boxes and worksheets, which appear at the end of each exercise and are in a tear-out format so they can be used as graded homework assignments. Boldfaced type is used in the manual to emphasize important terms for each exercise. These include names of structures and concepts students will encounter on exams. A list of key terms is located at the end of each exercise and highlights important new terms and concepts introduced in each exercise. Activities to be carried out by students are highlighted by icons at the beginning (▼) and end (▲) of a set of instructions.

The plan for this manual is as follows:

Unit I contains exercises that focus on general biological principles. Exercise 1 includes an introduction to microscopes and scientific method. Problem-solving activities have been incorporated into exercises 1, 3, 4, and 6.

Unit II is a survey of the animal phyla. Exercise 7 is an introduction to taxonomy and cladistics. A brief "evolutionary perspective" begins other exercises in this section and describes the position of the phylum in question within the animal kingdom. Each exercise includes coverage of class representatives, and some have activities that illustrate processes unique to the particular animal group. Most of these exercises conclude with a discussion of evolutionary relationships within the phylum studied and an activity involving cladistic analysis of these relationships.

Unit III is a systematic approach to the study of vertebrate structure, function, and evolution. The evolutionary orientation of unit III helps the student understand the changes that occurred in the evolution of vertebrate organ systems. Many activities ask the student to think critically about the adaptive significance of what is being observed. The shark is used in demonstration dissections, and the rat is the primary specimen for student dissection. Specimens illustrating intermediate stages of evolution of the particular organ system are used as demonstrations when materials are readily available to the instructor.

This manual includes more than can be covered in a one-semester course, which allows some flexibility in course planning based on the preferences of individual instructors. For example, some instructors have a very brief survey of the animal phyla in their labs and focus on units I and III. These instructors can select a few activities in each of the exercises of unit 2 to survey the animal phyla in a few laboratory periods. Other instructors may omit most of unit I if the students have had general biological principles in another course.

An Instructor's Resource Guide is available for all adopters of the fourth edition of *General Zoology Laboratory*

Manual. This guide lists all materials required for preparing each laboratory exercise. It also gives formulas for solutions and media and includes suggestions for incorporating living material into the laboratory. Answers to the "Prelaboratory Quiz," "Stop and Ask Yourself" questions, and the worksheet questions are also included in the resource guide.

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I would like to thank those individuals who helped to make this laboratory manual possible. Many comments from users of the third edition were most helpful in preparation of the fourth edition. The comments and suggestions of the reviewers were most helpful. Reviewers of the fourth edition were

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They will recognize that many of their suggestions are incorporated into the manual. The writing of this laboratory manual would have been impossible without the help of the WCB editors and their staff. The advice of Marge Kemp and Adora Pozolinski has proven extremely valuable. The project manager for the fourth edition was Gloria G. Schiesl. Her ability to keep the manuscript moving through all phases of production is greatly appreciated. I am also grateful for the support of Carol, Trey, Jeremy, Eric, and Bryan during this revision and for their understanding when this project encroached upon family time.

Stephen A. Miller, Ph.D.

Getting Started

The following section contains terms and concepts that will be used throughout this laboratory manual. Although most of these terms will be redefined within the exercises that follow, it is helpful to have some knowledge of them before beginning. The metric system is used throughout this laboratory manual. You must be familiar with metric units and know how to carry out conversions between larger and smaller units of measurement. The Terms of Direction and Body Planes and Sections are used frequently in units II and III for locating the parts of an animal and indicating how an animal or a structure is to be cut in a dissection. This information is located at the beginning of the laboratory manual for convenient, later reference.

The Metric System

Scientific measurements are usually carried out using the metric system. Metric units are used exclusively in this laboratory manual. The main advantage of the metric system is the convenience that results from its decimal nature. With the exception of units of time, units for measuring a given quantity are derived from a basic unit by multiplying or dividing by multiples of ten. The fundamental units of the metric system are

liter, a unit of capacity;
meter, a unit of length;
gram, a unit of mass;
second, a unit of time.

Units larger or smaller than these are formed by adding prefixes such as kilo (1,000), centi (1/100), and milli (1/1,000). Thus, kilometer = 1,000 meters, centimeter = 1/100 of a meter, and millimeter = 1/1,000 of a meter.

Other units used in measuring microscopic distances are the following:

The micrometer (μm) = 1/1,000,000 of a meter or 1×10^{-6} m.
The nanometer (nm) = 1/1,000,000,000 of a meter or 1×10^{-9} m.
The angstrom (Å) = 1/10,000,000,000 of a meter or 1×10^{-10} m.

Some commonly used units of conversion between metric and the English systems are given below.

English	*Metric*
1 mile	1.6 kilometers
1 inch	2.54 centimeters
0.39 inch	1 centimeter
1 ounce	28 grams
0.035 ounce	1 gram
1 fluid ounce	30 milliliters
0.033 fluid ounce	1 milliliter
1 pound	0.45 kilogram
2.2 pounds	1 kilogram

Microscope and Seat Assignment

Seat number _____
Microscope number _____

Microscope calibrations using an ocular micrometer (from exercise 1):

Low power (10 × objective). 1 ocular unit = _____ μm.
High power (40 × objective). 1 ocular unit = _____ μm.

Estimation of the diameter of the field of view (from exercise 1):

Low power (10 × objective). Diameter = approximately _____ μm.
High power (40 × objective). Diameter = approximately _____ μm.

Terms of Direction, Symmetry, and Body Planes and Sections

Terms of Direction

Terms of direction are used for locating body parts relative to a point of reference.

Aboral The end opposite the mouth. Opposite—oral.
Anterior The head end. Usually the end of a bilateral animal that meets its environment. Opposite—posterior.

Caudal Toward the tail. Opposite—cephalic.
Cephalic Toward the head. Opposite—caudal.
Distal Away from the point of attachment of a structure on the body (e.g., The toes are distal to the knee.). Opposite—proximal.
Dorsal The back of an animal. Usually the upper surface. For animals that walk upright, dorsal and posterior are synonymous. Opposite—ventral.
Inferior Below a point of reference. Opposite—superior.
Lateral Away from the midsagittal plane of the body. Opposite—medial.
Medial (median) On or near the plane of the body that divides a bilaterally symmetrical animal into mirror images. Opposite—lateral.
Oral The end containing the mouth. Opposite—aboral.
Posterior The tail end. Opposite—anterior.
Proximal Toward the point of attachment of a structure on the body. (e.g., The hip is proximal to the knee.). Opposite—distal.
Superior Above a point of reference. Opposite—inferior.
Ventral The belly of an animal, usually the lower surface. For animals that walk upright, ventral and anterior are synonymous. Opposite—dorsal.

Symmetry

Symmetry describes how the parts of an organism are arranged around an axis or a point (fig. .001). The three categories listed below are most common.

Asymmetry The arrangement of body parts without a central axis or point (e.g., the sponges).
Bilateral symmetry The arrangement of body parts such that a single plane passing dorsoventrally through the longitudinal axis divides the animal into right and left mirror images (e.g., vertebrates).
Radial symmetry The arrangement of body parts such that any plane passing through the oral—aboral axis divides the animal into mirror images (e.g., the cnidarians). Radial symmetry can be modified by the arrangement of some structures in pairs, or in other combinations, around the central axis (e.g., biradial symmetry in the ctenophorans and pentaradial symmetry in the echinoderms).

Body Planes and Sections

References to body planes are used to indicate the position of some structure relative to an imaginary plane passing through the body. References to body, organ, and tissue sections indicate how something is cut to observe internal structures.

Cross section A section cut perpendicular to the longitudinal axis of a structure.
Frontal A plane or section perpendicular to both sagittal and transverse planes. Divides an animal into dorsal and ventral regions.
Longitudinal section A section cut parallel to the longitudinal axis of a structure.
Median A plane or section passing through the longitudinal axis of a bilateral animal. Divides the animal into halves that are mirror images of each other.
Sagittal A plane or section passing dorsoventrally through the body of a bilateral animal parallel to the longitudinal axis.
Transverse A plane or section perpendicular to both sagittal and frontal planes. Divides an animal into anterior and posterior regions.

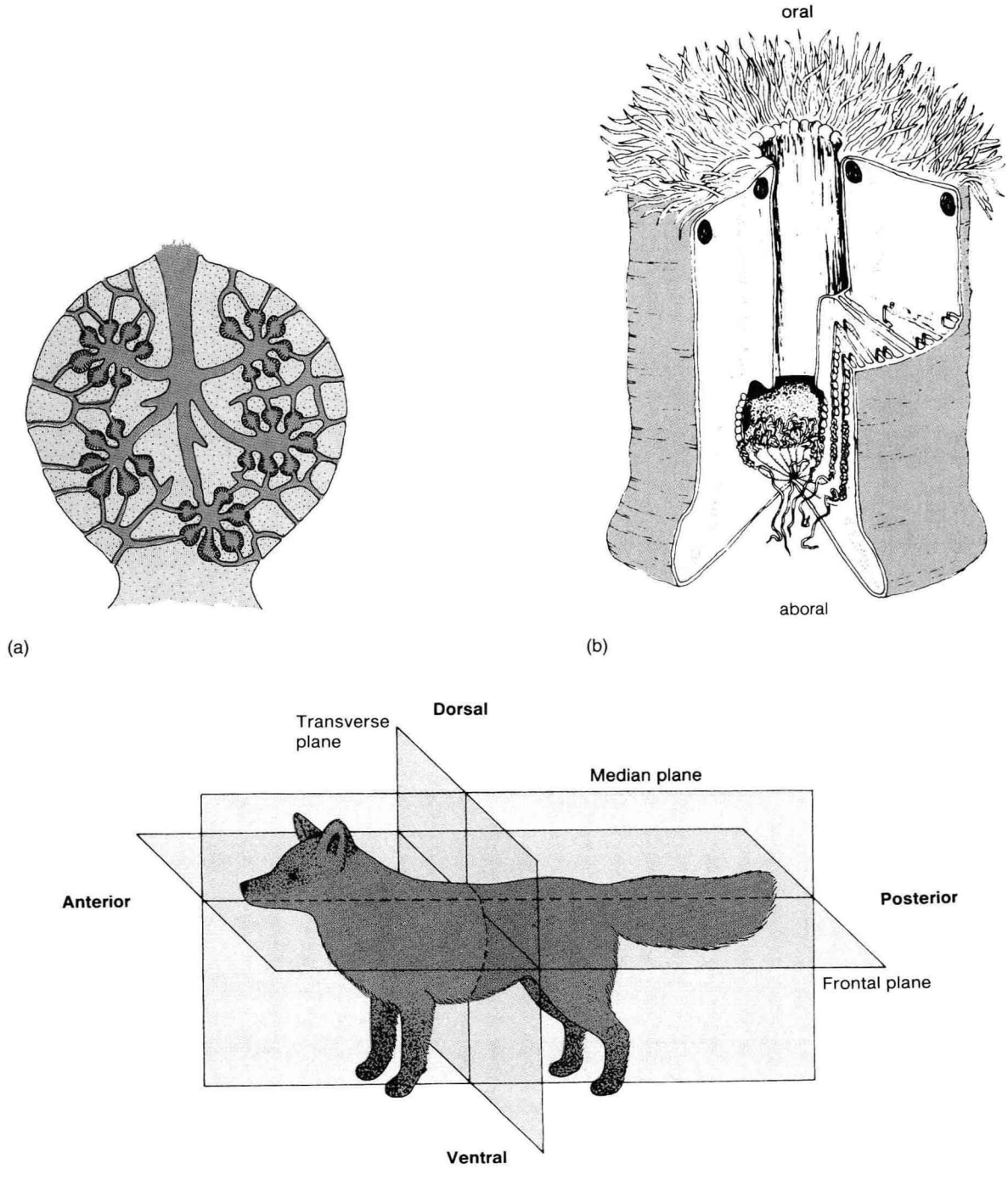

Figure .001 Symmetry, body planes, and terms of direction: *(a)* asymmetry, leucon sponge; *(b)* radial symmetry, a sea anemone; *(c)* bilateral symmetry, a vertebrate.

Correlation Chart

Exercises in This Manual Correlated with the Leading Zoology Textbooks

Exercises in Miller *General Zoology Laboratory Manual*, 4th edition, 1999	**Miller and Harley** *Zoology*, 4th edition, 1999	**Hickman et al.** *Integrated Principles of Zoology*, 10th edition, 1997	**Harris** *Concepts in Zoology*, 2nd edition, 1996
1. The Microscope and Scientific Method	1, 3	1	1
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3. Aspects of Cell Function	3, 4, 5, 6	5	3
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5. Embryology	10	7	6
6. Adaptations of Stream Invertebrates	11–15	40, 41	17–19
7. The Classification of Organisms	16	12	21
8. Animal-like Protists	17	13	22
9. Porifera	18	14	23
10. Cnidaria	18	15	24
11. Platyhelminthes	19	16	25
12. Pseudocoelomates	20	17	26
13. Mollusca	21	18	28
14. Annelida	22	19	29
15. Arthropoda	23, 24	20–22	30–32
16. Echinodermata	25	25	33
17. Chordata	26	27	34
18. Vertebrate Musculoskeletal Systems	27–31, 32	28–32, 33	35–39, 10
19. Vertebrate Nervous Regulation	27–31, 33, 34	28–32, 37	35–39, 8, 9
20. Vertebrate Circulation	27–31, 36	28–32, 35	35–39, 11
21. Vertebrate Respiration	27–31, 36	28–32, 35	35–39, 12
22. Vertebrate Digestion	27–31, 37	28–32, 36	35–39, 13
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24. Vertebrate Reproduction	27–31, 39	28–32, 6	35–39, 16

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- The Compound Microscope (1 1/2 hours)
- The Dissecting Microscope (1/2 hour)
- An Introduction to Scientific Method (1 hour)

Exercise 2: Cells and Tissues

A. Cell Structure
- Animal Cells—Light Microscope (1 1/2 hours)
- Animal Cells—Electron Microscope (1 hour)

B. Histology: Epithelial and Connective Tissues (2 hours)

Exercise 3: Aspects of Cell Function

A. Transport in and out of Cells (1 1/2 hours)
B. Aerobic Cellular Respiration (2–3 hours)
C. Cell Division (1 1/2 hours)

Exercise 4: Genetics (3 hours)

Exercise 5: Embryology (3 hours)

Exercise 6: Adaptations of Stream Invertebrates—A Scavenger Hunt (3 hours)

Unit II: An Evolutionary Approach to the Animal Phyla

Exercise 7: The Classification of Organisms (2 hours)

Exercise 8: Animallike Protists (2 hours)

Exercise 9: Porifera (2 hours)

Exercise 10: Cnidaria and Ctenophora (2 hours)

Exercise 11: Platyhelminthes (2 hours)

Exercise 12: The Pseudocoelomates (2 hours)

Exercise 13: Mollusca (2 hours)

Exercise 14: Annelida (2 hours)

Exercise 15: Arthropoda (3 hours)

Exercise 16: Echinodermata (1 1/2 hours)

Exercise 17: Chordata (1 1/2 hours)

Unit III: An Evolutionary Approach to Vertebrate Structure and Function

Exercise 18: Vertebrate Musculoskeletal Systems
- Bone Structure (1/2 hour)
- The Skeleton (1 1/2 hours)
- The Muscular System (1 hour)

Exercise 19: Vertebrate Nervous Regulation (3 hours)

Exercise 20: Vertebrate Circulation
- Formed Elements (1/2 hour)
- Microcirculation (1/2 hour)
- Systemic Circulation—The Shark (1 hour)
- The Mammalian Heart (1/2 hour)
- Systemic Circulation—The Rat (2 hours)
- Comparative Heart Structure (1/2 hour)
- Circulatory Physiology—The Electrocardiogram (1/2 hour)
- Circulatory Physiology—Antibody Action (1/2 hour)

Exercise 21: Vertebrate Respiration (1 1/2 hours)

Exercise 22: Vertebrate Digestion (3 hours)

Exercise 23: Vertebrate Excretion (2 hours)

Exercise 24: Vertebrate Reproduction (2 hours)

UNIT

I

Introductory Concepts and Skills

Certain basic concepts unite the diverse subdisciplines within biology. All biologists must have a working knowledge of these important concepts. For example, outside of evolution, modern biology loses much of its meaning and excitement. For this reason, units 2 and 3 emphasize evolutionary relationships. Similarly, the modern biologist cannot function without some background in cell and tissue structure and function, genetics, embryology, and ecology. Unit 1 stresses these unifying concepts. All of these topics set the stage for material that is to come in units 2 and 3. As you proceed through this course, you will find that what you learned in unit 1 is built upon and emphasized in different ways.