

Preface

We have designed this laboratory manual for an introductory biology course with a broad survey of basic laboratory techniques. The experiments and procedures are simple, safe, easy to perform, and especially appropriate for large classes. Few experiments require more than one class meeting to complete the procedure. Each exercise includes many photographs and illustrations, traditional topics, and experiments that help students learn about life. Procedures within each exercise are numerous and discrete so that an exercise can be tailored to the needs of the students, the style of the instructor, and the facilities available.

TO THE STUDENT

We hope this manual is an interesting guide to many areas of biology. As you read about these areas, you'll probably spend equal amounts of time observing and experimenting. Don't hesitate to go beyond the observations that we've outlined—your future success as a scientist and an informed citizen depends on your ability to seek and notice things that others may overlook. Now is the time to develop this ability with a mixture of hard work and relaxed observation. Have fun, and learning will come easily. Also, remember that this manual is designed with your instructors in mind as well. Go to them often with questions—their experience is a valuable tool that you should use as you work.

TO THE INSTRUCTOR

This manual's straightforward approach emphasizes experiments and activities that optimize students' investment of time and your investment of supplies, equipment, and preparation. Simple, safe, and straightforward experiments are most effective if you interpret the work in depth. Most experiments can be done easily by a student in 2 to 3 hours. Terminology, structures, photographs, and concepts are limited to those that the student can readily observe and understand. In each exercise we have included a few activities requiring a greater investment of effort if resources are available, but omitting them will not detract from the objectives.

This manual functions best with an instructor's guidance and is not an autotutorial system. We've tried to guide students from observations to conclusions, to help students make their own discoveries, and to make the transition from observation to understanding biological principles. But

discussions and interactions between student and instructor are major components of a successful laboratory experience. Be sure to examine the "Questions for Further Study and Inquiry" in each exercise. We hope they will help you expand students' perceptions that each exercise has broad application to their world.

DIGITAL INTEGRATION

As educators, we recognize that today's students are digital learners. Virtually every exercise of this manual is accompanied by tailor-made digital resources, including assignable questions and a variety of high-definition videos, PowerPoint images, and other resources that demonstrate basic techniques, emphasize biological principles, test for understanding, and engage students as they learn biology in the laboratory.

Digital resources are available to instructors at connect.mheducation.com. Instructors will want to assign these resources to help students know what they'll be doing, what principles they'll be investigating, and what concepts they'll need to understand before coming to lab.

WHAT'S NEW IN THIS EDITION

Throughout the manual, we have expanded and improved several of the most popular and effective features of previous editions, including

- **Learning Objectives** have been updated to provide an overview of what students will do and learn in the exercise.
- **Procedures and Doing Biology Yourself** require students to *do* biology as they apply skills they've learned to develop and study hypotheses about biology.
- **Questions** throughout each exercise encourage students to pause and think about their data and what they've learned in lab.
- **Questions for Further Study and Inquiry** at the end of each exercise help students apply what they've learned to broader topics and issues in biology.
- **Writing to Learn Biology** encourages students to develop their ideas about what they learned in lab.

- **Caution and Safety First** icons make students aware of safety issues associated with the procedures they'll use in lab.
- Boxed readings titled **Inquiry-Based Learning** encourage students to apply what they've learned to independently answer questions about intriguing biological topics.
- Updated health-related exercises help students better understand topics such as blood pressure, atherosclerosis, and their risk of cardiovascular disease.
- Several illustrations have been replaced with photographs to provide more realistic images to support the Exercise content.
- Approximately 60 illustrations and photos have been revised.
- Questions within procedures now include lines on which students can write their answers.
- An assignable, updated library of videos and Connect questions helps students prepare for lab and understand the instruments and techniques that will be important for their investigations. Instructors may assign these videos before class time to help ensure that students arrive prepared for lab.
- Exercise 13—Figure 13.2 caption is expanded
- Exercise 14—Explanation of the structure of chromatids is expanded
- Exercise 15—Labels for figure 15.2 have been added for paternal versus maternal chromosomes; description of the structure of replicated versus nonreplicated chromosomes has been clarified; figure 15.6 is new; figure 15.7 is revised to clarify the state and number of chromosomes in first polar bodies and second polar bodies, and corpus albicans has been labeled and added as a defined term in the text
- Exercise 16—Global prevalence of genetically transformed crops has been updated to 2017 statistics
- Exercise 17—Figure 17.4 has a panel of 3 new photos on sickle cell anemia; figure 17.6 contains improved photos of hairlines
- Exercise 18—Definition of evolution is revised to be more concise; questions about Hardy-Weinberg genetics are expanded for clarity; a new question about the effect of natural selection on sickle cell anemia has been added to Questions for Further Study and Inquiry

Exercise-Specific Changes

- Exercise 1—Additional explanation provided for both mean and standard deviation
- Exercise 2—Mass, volume, and median are further defined; new illustration in figure 2.3 on measuring the volume of liquid; figure 2.4b has explanatory labels added
- Exercise 3—Additional questions have been added to Procedure 3.6 Using a dissecting microscope
- Exercise 4—Several illustrations have better labels; a new photo is supplied for figure 4.6a *Elodea* cells; figure 4.13 has been redrawn to more directly correlate to the associated photo; a new question is added to Questions for Further Study and Inquiry to compare plant and animal cells
- Exercise 6—Qualitative tests are defined; a new photo has been added to figure 6.2 to explain Benedict's test
- Exercise 7—Clarifying edits made to introductory material
- Exercise 9—Explanations of hypotonic, hypertonic, and isotonic are expanded
- Exercise 10—Steps of Procedures 10.1 and 10.2 are clarified; a new question on experimental design has been added to Questions for Further Study and Inquiry
- Exercise 19—Figure 19.2 has been revised to better illustrate lineages of human evolution; the term "diastema" has been added and defined; figure 19.4 is relabeled for clarity
- Exercise 20—Procedure 20.4 is expanded to help students design and implement experimental controls.
- Exercise 22—Formula for population growth is revised; data for Figure 22.5 are updated to reflect 2018 predictions; question 6 is expanded to include 2018 population values and growth rates
- Exercise 23—Question 1 is revised to emphasize hypothesis testing; table 23.3 is reorganized to accept handwritten student data
- Exercise 24—Organization of domains and kingdoms is updated to current taxonomy; table 24.1, prokaryotic versus eukaryotic characteristics, is modified for precision; figure 24.2, structure of a bacterial cell, is revised and contains a new photo; explanation of binary fission is expanded to include protein FtsZ and its role in cell separation
- Exercise 25—Explanations of Archaeplastida and the term "protist" are clarified; in table 25.2 the list of chlorophylls diagnostic to each type of algae is updated; figure 25.4 is relabeled to clarify sexual versus asexual reproductive paths; figure 25.8 contains a new photo of Volvox colonies

- Exercise 26—Photomicrograph and illustration of African sleeping sickness blood cells and parasites are revised to clarify their relationship
- Exercise 27—Explanations of fungal sporangiophores and sporangia are expanded; figure 27.13 is modified to better show the diagnostic reproductive structure, ascus; Questions for Further Study and Inquiry has a new question to explain the benefit of fungi to other organisms
- Exercise 31—A learning objective is added on understanding flower structure and function; the explanation of sporogenesis is expanded; a Question for Further Study and Inquiry has been added to help students understand flower parts
- Exercise 32—A new question is added to Questions for Further Study and Inquiry on common leaf morphologies
- Exercise 35—The definition of bioassay is revised
- Exercise 36—Introductions to terms animals, multicellular, ancient, and primitive have been clarified; description of intracellular versus extracellular digestion in poriferans has been clarified
- Exercise 37—Taxonomic hierarchy of the classes and subphyla of flatworms is updated; the groups Neodermata and Turbellaria have been redefined and updated; taxonomy of tapeworms is updated
- Exercise 39—Taxonomy of major arthropod classes has been updated and reorganized to include Chelicerata, Crustacea, Myriapoda, and Hexapoda; table 39.3 has been relabeled to reflect updated arthropod taxonomy
- Exercise 40—The taxonomy of pre-vertebrate groups has been updated; class Actinopterygii has replaced Osteichthyes; figure 40.21 of amphibian transitional stages is revised
- Exercise 41—Figure 41.2 has revised labeling; figure 41.3 is relabeled to distinguish flat cuboidal and columnar cells more clearly; figure 41.4 is relabeled to show Bowman's capsule more clearly; figure 41.5 is relabeled to more clearly distinguish columnar cells; figure 41.7 has been replaced to better show stratified squamous epithelium; types of connective tissue have been separated into connective tissue proper and special connective tissue
- Exercise 42—Descriptions of the appendicular skeleton and the axial skeleton are added; the number of skull, spine, and rib cage bones has been updated to conventional values; figure 42.2 is new; Figure 42.4 has been replaced with improved images of normal and osteoporotic bone; revisions to Questions for Further Study and Inquiry
- Exercise 43—A new learning objective is added to distinguish between isotonic and isometric contractions; explanations of muscle load, muscle tone, and muscle tension are expanded; figure 43.2 is relabeled to clearly distinguish between flexion and extension; Procedure 43.1 concerning flexion and extension of the forearm has been modified for clarity
- Exercise 44—Descriptions of negative pressure and its role in breathing have been expanded; procedures to distinguish the role of intercostal muscles and breathing are expanded and clarified; Procedure 44.1 has been modified for more consistent chest expansion measurements; typical values for tidal, expiratory, inspiratory, and residual volumes have been provided; directions for measuring breathing rate in Procedure 44.7 are clarified
- Exercise 46—Figure 46.1 has been modified to illustrate fovea centralis; Procedure 46.3 has been modified to accommodate lab partners
- Exercise 47—A new Question 2 has been added; Question 3 has been expanded to provide more examples and practice with terms such as cranial, caudal, lateral, distal, etc.; directions for the skinning and abdominal incision during rat dissection are expanded
- Exercise 48—Descriptions of the thyroid gland and diaphragm are expanded; explanatory questions about the lung structure and heart musculature are expanded
- Exercise 49—Figure 49.4 has been revised and enlarged to better show the structure and cross section of a kidney
- Exercise 50—Distinction has been enhanced between the animal and vegetal poles
- Exercise 51—Directions are enhanced for Procedure 51.1 to examine kinesis in pill bugs; directions are enhanced for Procedure 51.2 to study agonistic behavior in fighting fish, to encourage better creativity by the students in experimental design; a new question has been added to Questions for Further Study and Inquiry
- Appendix II has been updated to include upcoming changes to how a basic unit of the metric system is defined

Figure 1 Relationship of students' grades in an introductory biology course to their point of class attendance