

Exercise 1, Exercise 1A: Compound Light Microscope

References

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- Culling, C. F. A. 1974. Modern microscopy: elementary theory and practice. London, Butterworths. *Clear and concise; especially useful for specialized techniques such as dark-field, polarizing, phase-contrast, and Nomarski microscopy.*
- Ford, B. J. 1985. Single lens: the story of the simple microscope. New York, Harper and Row, Publishers. *An illustrated history. If you should wish to know (for example) what kind of microscope Darwin used on the Beagle, you'll find it here!*
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- Gray, P. (ed.). 1973. The encyclopedia of microscopy and microtechnique. New York, Van Nostrand Reinhold Co. *From "Acanthocephala" to "Zoom microscopes," this encyclopedia embraces microscopy theory and practice, disciplines, techniques for microscopy with different animal groups, reagents, etc.*
- Möllring, F. K. 1978. Microscopy from the very beginning. Oberkochen, West Germany, Carl Zeiss. *Designed for getting the beginner started right. Clear illustrations, lots of practical hints.*
- Slayter, E. M. 1992. Light and electron microscopy. New York, Cambridge University Press. *Describes the principles of operation of all types of microscopes. Advanced.*
- Spencer, M. 1982. Fundamentals of light microscopy. New York, Cambridge University Press. *Most useful for more advanced microscopy.*
- Taylor, D. L., M. Nederlof, F. Lanni, and A. S. Waggoner. 1992. The new vision of light microscopy. *Amer. Sci.* **80**:322–335 (July–Aug.). *Explains the many new ways the light microscope is being used in biological research. The authors point out that a renaissance and revolution in light microscopy are now underway that is not widely known outside the biological community.*
- Wilson, M. B. 1976. The science and art of basic microscopy. Bellaire, TX, American Society for Medical Technology. *Designed as a text for a minicourse*

in microscopy for the clinical laboratory, the five modules present nature of light, basic optics, the compound microscope, microscopy in the clinical laboratory, and other microscopy techniques. This concise booklet is loaded with practical information. See especially Module Four.

Exercise 2, Exercise 2A: The Cell—Unit of Protoplasmic Organization

References

Descriptions of the tissues and cellular inclusions studied in the exercise may be found in any histology text.

Exercise 2B: Cell Division: Mitosis and Cytokinesis

References

A series of articles on the cell cycle and mitosis appeared in the November 3, 1989 issue of *Science* that provide all you could possibly want to know (and a lot more) about these events. Much abbreviated treatments are found in genetics and molecular genetics texts.

Cell Function

Exercise A: Movement of Materials across Cell Membranes

Part 1: Brownian Movement

Materials

Compound microscopes
Worm or insect, to be ground up as described in the manual
Toothpicks, slides, coverslips
Carmen solution or India ink

Part 2: Diffusion and Osmosis

Materials for Diffusion Experiments

500 ml beakers
Ice
Thermometers
Potassium permanganate
Agar plates. These may be purchased from biological supply houses or prepared by pouring agar, mixed according to directions on the package, into disposable petri dishes to a depth of 5–6 mm. Cover and allow to solidify.

1 M solutions of AgNO_3 , $\text{K}_3\text{Fe}(\text{CN})_6$, KBr , and NaCl .
Place in dropper bottles.
No. 5 cork borer

Materials for Osmosis Experiment

Osmometer as pictured in Figure 3-1 of Manual.
Assemble as follows:

Glass tube, length 4 feet
Dialysis tubing, flat width 1 inch, length 5 inches
Rubber stopper, single hole, no. 1 size
Dialysis tubing closure (Carolina Biological Supply Co., no. BA-68-4239)
Quart size mason jar or 1-liter beaker
35% white Karo syrup solution
Ring stand with clamp
Wax pencil
Meter stick
Thread
Pasteur pipette

Soak the dialysis tubing in water for a few minutes to make it pliable. Roll the end of the tubing between the fingers. Carefully open the end and stretch gently so as not to tear it. Insert the rubber stopper, wrap thread securely around the tubing, and tie. Fold the opposite end back about a half inch and clamp with closure (Fig. 1). Add syrup solution through the hole in the stopper using a Pasteur pipette or syringe and 16- or 18-gauge needle. Fill to capacity. Insert the glass tubing carefully. Lower it into the mason jar filled with water and wait until the liquid comes above the stopper before beginning the experiment.

Compound microscope
Glass slides and coverslips

Fresh mammalian whole blood. This often can be obtained from a local hospital. Or collect whole blood in a heparinized syringe from a laboratory animal such as a rat.

0.9% physiological saline (0.9 g NaCl /100 ml water)
5% salt solution (5 g NaCl /100 ml water)

Part 3: Carrier-Mediated Transport

Materials and Solutions

Goldfish
Depression slides
Compound microscopes
Hypodermic needles, used as teasing needles
Basic saline medium prepared as follows (amounts in g/liter):

NaCl	5.8
KCl	0.19
$\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$	0.22
$\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$	0.20
NaHCO_3	1.26
$\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$	0.07

Test medium. This is the basic saline medium plus 2.5 mg chlorphenol red per 100 ml.

Notes

1. This exercise illustrates all the principal ways that substances cross living membranes, except endocytosis. Most classes will witness phagocytosis by ameba while performing Exercise A; if not, this demonstration could be easily introduced here to round out this exercise.
2. **Time allocation.** All of the exercises are easily completed during a single three-hour laboratory period. For a two-hour period, you may substitute the alternative demonstration of diffusion described below. Have the students begin with the osmometer since, after getting it under way, they need only check the rise of the fluid every 15 minutes (or less frequently if you prefer) while proceeding with the other exercises more or less in order.
3. **Preparation.** Of the various procedures, setting up the osmometers (usually one osmometer per student pair) and preparing the basic saline medium for the active transport experiment will require the most preparation time.
4. **An alternative demonstration of diffusion.** Diffusion can be demonstrated quite effectively by placing a gelatin capsule containing potassium permanganate crystals into a tall cylinder (a 1-liter graduated cylinder is suitable) of water. The capsule must be perforated with a few pinholes to allow the permanganate to escape. To prevent the capsule from floating to the top, place it in a glass vial, cover the end with a bit of netting held in place with string, and drop the vial into the cylinder. The permanganate molecules will begin diffusing through the water as evidenced by the upward spread of purple color. The cylinder may be observed during the period and in subsequent laboratories since it requires several days for the color to reach the water surface.
5. **Kidney tubule transport.** For the active transport experiment with goldfish, tadpole kidneys may be substituted. Goldfish tubules often exhibit better transport if the fish have not been fed two to three days before the experiment. If very small goldfish are used, expect to use one fish per student. If your class is large and many goldfish will be required, it is usually economical to purchase them from the same sources that supply local pet dealers.

Only the proximal portion of the goldfish kidney transports chlorphenol red, so students usually need to search among several tubules to find transporting sections. The ends of the broken tubules pinch off, isolating the fluid in the tubular lumina from the test medium. After 30 minutes or more, the tubules are usually visibly swelled with pinkish fluid, since water osmotically accompanies the actively secreted chlorphenol red.

References

For osmosis and diffusion, most any cell physiology text may be consulted. Consult the following references for additional information on carrier-mediated transport by goldfish tubules.

- Forster, R. P. 1948. Use of thin kidney slices and isolated renal tubules for direct study of cellular transport kinetics. *Science* **108**:65–67.
- Hoar, W. S. 1968. Active transport through cell membranes. In G. A. Kerkut (ed.). *Exp. Physiol. Biochem.* **1**:148–153. *Details an experimental procedure similar to this exercise.*
- Jaffee, O. C. 1954. Phenol red transport in the pronephros and mesonephros of the developing frog (*Rana pipiens*). *Jour. Cell. Comp. Physiol.* **44**:347–361.

Exercise B: Action of Enzymes

Materials and Solutions

Two white spot plates per student pair
 Test tubes and test tube rack
 10 ml graduated cylinders
 Ice
 Warm water bath (such as a beaker of warm water)
 Boiling water bath

0.25% starch solution: Make a paste by stirring 2.5 g of soluble potato starch in 50 ml of distilled water. Add this paste slowly to 500 ml of boiling salt solution containing 0.35 g NaCl. Allow to boil for 5 minutes with constant stirring. Cool and dilute to 1 liter.

0.25% alpha-amylase from *Bacillus subtilis* (0.125 g/50 ml): Prepare just before needed. Fifty ml should suffice for a laboratory of 12 student pairs. Alpha-amylase is available from Sigma Chemical Company. Keep the preparation on ice during the laboratory period to avoid loss of enzyme activity.

McIlvaine's buffer: Buffer solutions of pH 3.4, 7.0, and 8.0 are prepared by mixing specified proportions of two stock solutions.

Stock solution A: 0.1 M citric acid. 19.212 g anhydrous citric acid made to 1000 ml with distilled water.

Stock solution B: 0.2 M sodium phosphate, dibasic. 28.396 g anhydrous dibasic sodium phosphate made up to 1000 ml with distilled water. (If using 7 hydrate dibasic sodium phosphate, make up 53.628 g to 1000 with distilled water.)

Prepare working buffers as follows (check pH with a pH meter):

pH 3.4: 14.3 parts of solution A and 5.7 parts of solution B.

pH 7.0: 3.53 parts of solution A and 16.47 parts of solution B.

pH 8.0: 0.55 parts of solution A and 19.45 parts of solution B.

I-KI solution: Dissolve 15 g potassium iodide in 500 ml water, add 5 g iodine slowly, stirring to dissolve. Make up to 1 liter with water. Store in a brown bottle.

Benedict's solution: Dissolve 173 g sodium citrate and 100 g anhydrous sodium carbonate in 600 ml of hot distilled water.

Dissolve 17.3 g cupric sulfate in 150 ml distilled water.

Slowly, with constant stirring, add the cupric sulfate solution to the sodium citrate–sodium carbonate solution. Dilute with distilled water to make 1 liter.

Notes

1. **This exercise requires about two hours** of laboratory time.
2. **It is important to test the amylase preparation before the laboratory** to determine its activity. It should completely hydrolyze starch to sugars in 3 to 4 minutes at room temperature and at pH 7.0, as determined by the I-KI spot-plate test. The exercise calls for diluting the amylase solution 1 to 12; this dilution is usually about right, but we have found that adjustments to the dilution are often necessary. If the preparation is too weak (has been diluted too much) the starch will never be broken down (i.e., it will continue to change color of the I-KI solution indefinitely). If too strong, the reaction will proceed too fast for the students to time it with any precision.
3. **The test for maltose (Benedict's test)** yields an orange-red precipitate of cuprous oxide when a reducing sugar—maltose in this case—is present. But if maltose is present in small quantity, as it is following the hydrolysis of starch, students must be advised to look carefully for the precipitate, which will settle to the bottom of the tube; it will not be a conspicuous color change. We find that sometimes the tubes must be heated for at least 10 minutes to yield visible precipitate.

Exercise 3, Exercise 3A: Meiosis—Maturation Division of Germ Cells

References

- Foor, W. E. 1967. Ultrastructural aspects of oocyte development and shell formation in *Ascaris lumbricoides*. *Jour. Parasitology* **53**:1245–1261.
- Huettner, A. F. 1941. *Fundamentals of comparative embryology of the vertebrates*. New York, Macmillan

Publishing Company, Inc. *Exercise and excellent drawings of grasshopper spermatogenesis.*

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- Wilson, E. B. 1937. The cell in development and heredity. New York, Macmillan Publishing Company, Inc.

Exercise 3B: Cleavage Patterns: Spiral and Radial Cleavage

References

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- Brookbank, J. W. 1978. Developmental biology: embryos, plants, and regeneration. New York, Harper & Row, Publishers. *Chapter 3 deals exclusively with spiral cleavage.*
- Coe, W. R. 1899. The maturation and fertilization of the egg of *Cerebratulus*. Zoologische Jahrbucher **12**:425–476 and 3 plates. *Classical study of early development up to the point of the first cleavage.*
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- Korschelt, E., and K. Heider. 1895. Textbook of the embryology of invertebrates. London, Swan Sonnenschein & Company. *Description of echinoderm larvae and their metamorphosis.*
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Washington, D.C., National Library of Medicine. *Especially good description of Cerebratulus development.*

- Morgan, T. H. 1927. Experimental embryology. New York, Columbia University Press. *Clear descriptions of development of Cerebratulus larvae from egg fragments and isolated blastomeres.*
- Richards, A. 1931. Outline of comparative embryology. New York, John Wiley & Sons, Inc. *Excellent discussion of cleavage types.*

Exercise 3C: Frog Development

References

- de Beer, G. R. 1951. Vertebrate zoology. London, Sidgwick and Jackson Limited. *Thorough treatment of Rana development.*
- Rugh, R. 1934. Induced ovulation and artificial fertilization on the frog. Biol. Bull. **66**:22–27.
- Shaver, J. R. 1953. Studies on the initiation of cleavage in the frog egg. Jour. Exp. Zool. **122**:169–192.
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Exercise 4: Tissue Structure and Function

References

- Freeman, W. H., and B. Bracegirdle. 1982. An atlas of histology, ed. 2. London, Heinemann Educational Books. *Atlas of light micrographs with interpretive drawings.*
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Exercise 5: Introduction to Animal Classification

References

- References that explain the construction and use of taxonomic keys:

- Blackwelder, R. E. 1967. Taxonomy: a text and reference book. New York, John Wiley & Sons, Inc. *This superb book, which the publisher has shamefully allowed to go out of print, details the use of dichotomous keys on pp. 69 and 297.*
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Exercise 6, Exercise 6A: Subphylum Sarcodina: *Amoeba* and Others

References

- Anderson, O. R. 1988. Comparative protozoology: ecology, physiology, life history. New York, Springer-Verlag. *Original and rather advanced treatment, packed with information, although its topical rather than phylogenetic organization splits up the treatment of each taxonomic group. Some excellent diagrams, SEMs, and other micrographs.*
- Brown, F. A., Jr. (ed.). 1950. Selected invertebrate types. New York, John Wiley & Sons, Inc. *Contains brief but authoritative descriptive accounts of Amoeba proteus, Entamoeba histolytica, Arcella vulgaris, and Diffugia oblonga, as well as two heliozoan actinopods, Actinophrys and Actinosphaerium. The accounts include suggestions for approaching the study of each species.*
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ing on history, taxonomy, culture maintenance, morphology, locomotion, and various biochemical and physiological studies.

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- Lee, J. J., S. H. Hutner, and E. C. Bovee. 1985. An illustrated guide to the protozoa. Lawrence, Kansas, Society of Protozoologists. *This comes close to being the protozoologist's vade mecum. It is a richly illustrated key to families and genera, but also contains group descriptions, and is introduced with a concise section of useful techniques.*
- Needham, J. (ed.). 1959. Culture methods for invertebrate animals. New York, Dover Publications, Inc. *The Dover edition is a facsimile reproduction of the classic 1937 edition. It is a gold mine of information and should be on every invertebrate zoologist's bookshelf.*
- Patterson, D. J. 1992. Free-living freshwater protozoa: a color guide. Boca Raton, Florida, CRC Press, Inc. *Explains collection, classification, and identification of the common free-living protozoa; good bibliography.*
- Pierce, S. K., and T. K. Mangel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *Includes a fine series of SEMs of naked and shelled amebas, forams, and radiolarians.*
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- Stossel, T. P. 1990. How cells crawl. *Amer. Sci.* **78**(5):408–423. *Molecular details of how the muscle protein actin is involved in cell motility.*

Exercise 6B: Subphylum Mastigophora—*Euglena*, *Volvox*, and *Trypanosoma*

References

- Brown, F. A., Jr. (ed.). 1950. Selected invertebrate types. New York, John Wiley & Sons, Inc. *Descriptions of Euglena, Volvox, Trypanosoma, and several other flagellates.*
- Buetow, D. E. (ed.). 1989. The biology of *Euglena*. San Diego, California, Academic Press. *Four volumes of this advanced multiauthored treatise have now appeared. While of particular interest to specialists in phycology, plant biochemistry, and molecular biology, the regular appearance of new volumes*

attests to the popularity of *Euglena* as an experimental organism, especially for studies of chloroplast development, cell structure, diurnal rhythm, vitamin B₁₂, locomotion, and trace-metal nutrients.

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Exercise 6C: Phylum Apicomplexa, Class Sporozoea—*Gregarina* and *Plasmodium*

References

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- Sheridan, P. 1986. Monocystis: earthworm parasite. *Amer. Biol. Teacher* **48**:20–23 (Jan.). *Explains how to collect specimens for study, and make temporary or permanent smears.*

Exercise 6D: Phylum Ciliophora—*Paramecium* and Other Ciliates

References

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- Goldstein, P., and J. Metzner. 1971. Experiments with microscopic animals. Garden City, NY, Doubleday & Company, Inc. *Provides instructions on how to culture the ciliates Stentor and Dileptus and how to implement simple experiments to answer biological questions.*
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- Pierce, S. K., and T. K. Maugel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *See page 22 for a fine phase-contrast photograph of Paramecium together with an interpretive drawing. This is followed by several SEMs of paramecium, Didinium, Euplotes, Stentor, and Vorticella.*
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Experimenting in Zoology: Effect of Temperature on the Locomotor Activity of *Stentor*

References

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ground information on the organism's behavior under different conditions.

Experimenting in Zoology: Genetic Polymorphism in *Tetrabymena* Demonstrated by Randomly Amplified Polymorphic DNA Markers (RAPDs)

References

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Exercise 7, Exercise 7A: Class Calcarea—*Sycon*

References

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- Burbank, W. D. 1950. Porifera. In Selected Invertebrate Types, Frank A. Brown, Jr. (ed.). New York, John Wiley & Sons, Inc. *Brief but practical descriptions of Sycon and several other genera, including Leucosolenia, Euplectella, Hylonema, Hippospongia, and others. Good illustrations.*
- Pennak, R. W. 1989. Freshwater invertebrates of the United States, ed. 3. New York, The Ronald Press Company. *A wealth of practical information on freshwater sponges, including a key to species. But identification is exacting, requiring study of spicules and gemmule anatomy.*
- Pierce, S. K., and T. K. Mangel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *This manual presents a fine series of light and scanning electron micrographs of spicules, choanocytes, and sections of Sycon (designated Scypha) together with interpretive drawings.*

Exercise 8, Exercise 8A: Class Hydrozoa—*Hydra*, *Obelia*, *Gonionemus*

References

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- Committee on Marine Invertebrates (eds.). 1981. Laboratory animal management: marine invertebrates. Washington, D.C., National Academy Press. *See pp. 114–116 and p. 124 for notes on maintaining hydroid polyps in the laboratory, and leads into the literature.*
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- Hyman, L. H. 1940. The invertebrates: Protozoa through Ctenophora. New York, McGraw-Hill Book Company, Inc.
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- Needham, J. G. (ed.). 1937. Culture methods for invertebrate animals. Ithaca. Comstock Publishing Company. *See p. 140 for a contribution by Libbie Hyman on collecting and rearing hydra. See p. 205 for a method for rearing Artemia salina.*
- Pennak, R. W. 1989. Fresh-water invertebrates of the United States: Protozoa to Mollusca, ed. 2. New York, John Wiley & Sons, Inc. *See Chapter 4 for descriptions of hydra and Craspedacusta and a key to the species of the freshwater Hydrozoa.*
- Pierce, S. K., and T. K. Mangel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *Includes light and scanning electron micrographs of Obelia, Tubularia and other hydroids; hydromedusae; hydra; a series on Aurelia life cycle; anthozoans including Metridium (full page interpretive drawing of a longitudinal section), and others. Several of the SEMs we have seen nowhere else. Highly recommended.*
- Waterman, T. H. 1950. *Tubularia crocea*. In Brown, F. A., Jr. (ed.) Selected invertebrate types. New York, John Wiley & Sons, Inc. *Detailed laboratory study directions given for this species as well as*

several other hydroids, including *Obelia* and *Gonionemus*. This is a valuable reference.

Exercise 8B: Class Scyphozoa—*Aurelia*, A “True” Jellyfish

References

- Headstrom, R. 1984. The weird and the beautiful. New York, Cornwall Books. *Aurelia and other scyphozoans are described briefly and illustrated in Chapter 14.*
- Waterman, T. H. 1950. *Aurelia aurita*. In Brown, F. A., Jr. (ed.), Selected invertebrate types. New York, John Wiley & Sons, Inc. *Aurelia is described in some detail. There are also excellent sectional illustrations of Aurelia, strobila, planula larva, and ephyra.*

Exercise 8C: Class Anthozoa—*Metridium*, a Sea Anemone, and *Astrangia*, a Stony Coral

References

- Brown, F. A. (ed.). 1950. Selected invertebrate types. New York, John Wiley & Sons. *Excellent descriptions of Metridium and Astrangia with notes on physiology and reproduction.*
- Goreau, T. F., N. I. Goreau, and T. J. Goreau. 1979. Corals and coral reefs. *Sci. Amer.* **241**:124–135 (Aug.). *Good summary of coral biology, including the physiology of coral symbiosis and calcification.*
- Hessinger, D. A., and J. A. Hessinger. 1981. Methods for rearing sea anemones in the laboratory pp. 153–179. In Committee on marine invertebrates (eds.), *Laboratory animal management: marine invertebrates*. Washington, D.C., National Academy Press.

Exercise 9, Exercise 9A: Class Turbellaria—The Planarians

References

- Brøndsted, H. V. 1969. Planarian regeneration. Pergamon Press.

- Brown, F. A., Jr. (ed.). 1950. Selected invertebrate types. New York, John Wiley & Sons, Inc. *Contains excellent descriptions of Dugesia and Bdelloura, by Libbie Hyman.*
- Buchsbaum, R., M. Buchsbaum, J. Pearse, and V. Pearse. 1987. *Animals without backbones*, ed. 3. Chicago, The University of Chicago Press. *See Chapters 9 and 10 for treatment of planarians.*
- Chandebois, R. 1976. Histogenesis and morphogenesis in planarian regeneration. *Monographs in Developmental Biology*, vol. 11. Basel, S. Karger.
- Hay, E. D. 1966. *Regeneration*. New York, Holt, Rinehart and Winston.
- Lender, T. 1962. Factors in morphogenesis of regenerating freshwater planaria. *Advances in Morphogenesis* **2**:305–331. *Description of regenerative neoblasts and induction mechanisms in tissue and organ regeneration.*
- Pearse, V., J. Pearse, M. Buchsbaum, and R. Buchsbaum. 1987. *Living invertebrates*. Palo Alto, California, Blackwell Scientific Publications. *See Chapters 8 and 9.*
- Pennak, R. W. 1989. *Fresh-water invertebrates of the United States*, ed. 3. New York, John Wiley & Sons. *Chapter 5 contains a thorough description of the freshwater turbellarians, methods of culturing and preserving, and a key to genera and species of Turbellaria.*
- Pierce, S. K., and T. K. Mangel. 1987. *Illustrated invertebrate anatomy: a laboratory guide*. New York, Oxford University Press. *Light and scanning electron micrographs of planaria and other turbellarians.*
- Taliaferro, W. H. 1920. Reactions to light in *Planaria maculata* with special reference to the function and structure of the eyes. *Jour. Exp. Zool.* **31**:59–116. *Orientation to light and function of the eyes.*
- Ward, H. B., and G. C. Whipple, edited by W. T. Edmondson. 1959. *Freshwater Biology*, ed. 2. New York, John Wiley & Sons, Inc. *Keys to species, and introductions by Libbie Hyman.*

Exercise 9B: Class Trematoda—The Digenetic Flukes

References

- Brown, F. A., Jr. (ed.). 1950. Selected invertebrate types. New York, John Wiley & Sons, Inc. *Description of the morphology of Clonorchis (= Opisthorchis) with passable drawing. Larval stages also described. Also described are*

Gorgodera (*from frog urinary bladder*), Fasciola hepatica, and Schistosoma haematobium.

Conquest of the parasites, 60 minutes color video from NOVA, available from Coronet Films, Coronet Building, 65 E. Water Street, Chicago, Illinois 60601. *This is an excellent presentation of the devastating effects of schistosomiasis (among other human parasitic diseases treated), and explains how the parasite artfully dodges the immune system. Efforts to develop effective controls are discussed. Sections of this film would serve as good background material for the class.*

Desowitz, R. S. 1981. New Guinea tapeworms and Jewish grandmothers. New York, W. W. Norton & Co. *It would be difficult to find a more readable, information laden account of the multiple ramifications of the schistosome problem than is found in Chapter 8 of this delightful book—and wholly authoritative (Desowitz spent nine years in Africa and picked up a schistosomiasis infection himself).*

Hyman, L. H. 1951. The invertebrates, vol. 2, Platyhelminthes and Rhynchocoela. The acoelomate Bilateria. New York, McGraw-Hill Book Co. *This classic remains an important source of information on the morphology of the Digenea.*

Komiya, Y. 1966. Clonorchis and clonorchiasis. In Dawes, B. (ed.), *Advances in parasitology*, vol. 4. New York, Academic Press, Inc., pp. 53–106.

Komiya, Y., and N. Suzuki. 1964. Biology of *Clonorchis sinensis*. In Morishita, K., et al. (eds.), *Progress of medical parasitology in Japan*, vol. 1, Tokyo, Meguro Parasitological Museum, pp. 349–354.

Exercise 9C: Class Cestoda— The Tapeworms

References

Brown, F. A., Jr. (ed.). 1950. Selected invertebrate types. New York, John Wiley & Sons, Inc. *C. G. Goodchild describes the morphology of Taenia pisiformis on pp. 199–204. Other cestodes also are described in this book.*

Desowitz, R. S. 1981. New Guinea tapeworms and Jewish grandmothers. New York, W. W. Norton & Co. *Desowitz confesses to “a coolness of heart toward tapeworms.” So will most students. But the curious tale of how Scandinavian fishermen imported the fish tapeworm to the Great Lakes and thence to Jewish grandmothers in New York City, surely destined to become a classic story, makes a great opener for this laboratory.*

Exercise 10, Exercise 10A: Phylum Nematoda—*Ascaris* and Others

References

Brown, F. A., Jr. 1950. Selected invertebrate types. New York, John Wiley & Sons, Inc. *Includes brief but authoritative descriptions of Ascaris, Turbatrix, Enterobius, Trichinella spiralis, Necator americanus, and Wuchereria bancrofti.*

Crofton, H. D. 1966. Nematodes. London, Hutchinson and Company.

Croll, N. A., and B. E. Matthews. 1977. Biology of nematodes. New York, John Wiley & Sons. *Excellent and concise treatment covering morphology, behavior, nutrition, development, and life cycles of free-living and parasitic nematodes.*

Fretter, V., and A. Graham. 1976. A functional anatomy of invertebrates. New York, Academic Press. *Chapter 8 describes the nematodes, much of it devoted to Ascaris. Very useful, succinct background information for this laboratory.*

Goldstein P., and J. Metzner. 1971. Experiments with microscopic animals. Garden City, New York, Doubleday & Company, Inc. *Suggestions for simple experiments with soil nematodes, vinegar eels, and parasitic nematodes.*

Hyman, L. H. 1951. The invertebrates, vol 3: Acanthocephala, Aschelminthes, and Entoprocta. The pseudocoelomate bilateria. New York, McGraw-Hill Book Company. *Extensive treatment of nematodes.*

Pennak, R. W. 1989. Fresh-water invertebrates of the United States: Protozoa to Mollusca, ed. 3. New York, John Wiley & Sons. *Chapter 9 is devoted to the nematodes.*

Pierce, S. K., and T. K. Mangel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *See page 129 for helpful high magnification light micrographs of Turbatrix aceti.*

Poinar, G. O., Jr. 1983. The natural history of nematodes. Englewood Cliffs, New Jersey, Prentice-Hall, Inc. *Most of this very readable book concerns nematode life cycles, vector associations, and control methods. An interesting historical background and nematode morphology are treated briefly in the opening sections. Poinar states that over 15,000 nematodes have been described, and that it is estimated that there are at least 500,000 species of nematodes in the world.*

Roberts, L. S., and J. Janovy, Jr. 1996. Foundations of parasitology, ed. 5. Dubuque. Iowa, Wm. C. Brown Publishers.

- Rowett, H. G. Q. 1985. Dissection guides. Part V. Invertebrates. London, John Murray. (Available through Ward's Natural Science Establishment.) *Series of drawings and dissection procedure.*
- Wharton, D. A. 1986. A functional biology of nematodes. Baltimore, The Johns Hopkins University Press. *An excellent general biology of nematodes.*

Exercise 10B: A Brief Look at Some Pseudocoelomates

References

- Brown, F. A., Jr. 1950. Selected invertebrate types. New York, John Wiley & Sons, Inc. *Descriptions of Hydatina, a rotifer similar to Philodina; the acanthocephalan Neoechinorhynchus; and the gastrotrich Chaetonotus.*
- Brunson, R. B. 1949. The life history and ecology of the two North American gastrotrichs. *Trans. Micr. Soc.* **68**:1–20.
- Hyman, L. H. 1951. The invertebrates, vol. 3: Acanthocephala, Aschelminthes, and Entoprocta. The pseudocoelomate bilateria. New York, McGraw-Hill Book Company. *Still one of the best sources of authoritative information on these groups.*
- Pierce, S. K., and T. K. Maugel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *See page 131 for a helpful light micrograph and interpretive drawing of a rotifer.*
- Freeman, W. H., and B. Bracegirdle. 1982. An atlas of invertebrate structure. London, Heinemann Educational Books. *Photographs and helpful interpretive drawings of Anodonta, gills, and glochidium.*
- Hoar, W. S., and C. P. Hickman, Jr. 1983. A laboratory companion for general and comparative physiology, ed. 3. Englewood Cliffs, New Jersey, Prentice-Hall, Inc. *Exercise 16 includes a study of the effects of acetylcholine, adrenalin, and 5-hydroxytryptamine on the bivalve heart.*
- Morton, B. 1983. Feeding and digestion in bivalvia, pp. 65–147. *In* Wilber, K. M. (ed.), *The Mollusca*, vol. 5: Physiology, part 2. New York, Academic Press. *Thorough illustrated review of feeding and digestion.*
- Pennak, R. W. 1989. Fresh-water invertebrates of the United States, ed. 3. New York, John Wiley & Sons. *Chapter 25 is one of the best sources of information on gross anatomy, physiology, reproduction, and ecology of freshwater bivalves. It includes a key to bivalve families and genera (but requires gravid females for satisfactory keying beyond family level).*
- Pierce, M. E. 1950. *Venus mercenaria*. *In* F. A. Brown, Jr. (ed.), *Selected Invertebrate Types*, pp. 324–334. New York, John Wiley & Sons, Ltd. *Excellent description of bivalve anatomy with suggestions for simple experimental observations.*
- Pierce, S. K., and T. K. Maugel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *Includes photographs accompanied by interpretive drawings of several clams: surf clam Spisula, Yoldia, the mussel Mytilus edulis, the scallop Aequipectin, and the oyster Crassostrea. Also includes an extensive collection of SEMs of several bivalve gills with interpretive drawings. A valuable reference for the laboratory.*
- Purchon, R. D. 1977. The biology of the Mollusca, ed. 2. New York, Pergamon Press. *Includes chapters on feeding and digestion in bivalves.*
- Rowett, H. G. Q. 1985. Dissection guides. Part V. Invertebrates. London, John Murray. (Available through Ward's Natural Science Establishment.) *Series of nine drawings showing the progressive dissection of Anodonta.*
- Trueman, E. R. 1983. Locomotion in molluscs, pp. 155–198. *In* Wilber, K. M. (ed.), *The Mollusca*, vol. 4: Physiology, part 1. New York, Academic Press. *Analysis of burrowing in bivalves.*
- Video: Freshwater clam. 1990. Human Relations Media (175 Tompkins Ave., Pleasantville, New York 10570); VHS, 12 min.; purchase \$95.00, rental \$40.00. *Systematic though slow-paced dissection of clam, probably best suited for pre-college level.*

Exercise 11, Exercise 11A: Class Bivalva (Pelecypoda)—The Freshwater Clam

References

- Aiello, E. L. 1960. Factors affecting ciliar activity on the gill of the mussel *Mytilus edulis*. *Physiol. Zool.* **33**:120–135. *Detailed study of gill physiology. Includes an assay of 5-hydroxytryptamine on the mussel heart (a 10^{-6} gm/ml application of 5-HT caused increases in both amplitude and rate of the heartbeat).*
- Bullough, W. S. 1950. Practical invertebrate anatomy. London, Macmillan & Company, Ltd. *Describes the anatomy of Anodonta.*
- Burky, A. J. 1983. Physiological ecology of freshwater bivalves, pp. 281–327. *In* Wilber, K. M. (ed.), *The Mollusca*, vol. 6: Ecology. New York, Academic Press. *Includes feeding and life-cycle patterns.*

Exercise 11B: Class Gastropoda—The Pulmonate Land Snail

References

- Alexander, J. E., Jr., T. E. Audesirk, and G. J. Audesirk. 1985. Classical conditioning in the pond snail *Lymnaea stagnalis*. *Amer. Biol. Teacher* **47**(5):295–298 (May). *How to raise, condition, and test pond snails*.
- Bullough, W. S. 1950. Practical invertebrate anatomy. London, Macmillan & Company, Ltd. *Dissection directions for Helix and Limax (slug)*.
- Freeman, W. H., and B. Bracegirdle. 1982. An atlas of invertebrate structure. London, Heinemann Educational Books. *Photographs and interpretive drawings of general dissection and longitudinal section of pulmonate snails*.
- Hughes, R. N. 1986. A functional biology of marine gastropods. Baltimore, Johns Hopkins University Press.
- Hyman, L. H. 1967. The invertebrates, vol 6: Mollusca I. New York, McGraw-Hill Book Company. *This volume includes the gastropods*.
- Knudsen, J. W. 1966. Biological techniques: collecting, preserving, and illustrating plants and animals. New York, Harper & Row. *Details techniques for collection, shell and radula preparation, narcotizing and preserving pulmonates*.
- McCredie, S. 1989. They're still slimy, but naked snails are finding new friends. *Smithsonian*, **19**(11):135–141 (Feb.). *Life and times of the banana slug (and others) and the research of physiologist I. Deyrup-Olsen on slug mucus*.
- Pennak, R. W. 1989. Fresh-water invertebrates of the United States: Protozoa to Mollusca, ed. 3. New York, John Wiley & Sons, Inc. *Extended key of freshwater gastropods together with a wealth of general information on snails*.
- Pierce, S. K., and T. K. Mangel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *Photograph and interpretive drawing of the dissection of the pulmonate slug Limax*.
- Purchon, R. D. 1977. The biology of the Mollusca, ed. 2. New York, Pergamon Press. *Includes chapters on feeding and digestion in gastropods*.
- Rowett, H. G. Q. 1985. Dissection guides. Part V. Invertebrates. London, John Murray. (Available through Ward's Natural Science Establishment). *Series of 11 drawings showing the progressive dissection of Helix. This is perhaps the most useful illustrated guide available for snail dissection*.
- Trueman, E. R. 1983. Locomotion in molluscs, pp. 155–198. In Wilbur, K. M. (ed.), *The Mollusca*,

vol. 4: Physiology, part 1. New York, Academic Press. *Analysis of crawling in gastropods*.

Exercise 11C: Class Cephalopoda—*Loligo*, The Squid

References

- Bullough, W. S. 1950. Practical invertebrate anatomy. London, Macmillan & Company, Ltd. *Guide to the dissection of Loligo*.
- Freeman, W. H., and B. Bracegirdle. 1982. An atlas of invertebrate structure. London, Heinemann Educational Books. *Several photographs and interpretive drawings of Sepia dissection*.
- Hanlon, R. T., W. H. Hulet, R. F. Hixon, et al. 1979. Rearing experiments on the California market squid *Loligo opalescens* Berry, 1911. *Veliger* **21**:428–431.
- Hurley, A. C. 1976. Feeding behavior, food consumption, growth, and respiration of the squid *Loligo opalescens* raised in the laboratory. *Fish. Bull.* **74**:176–182.
- Pierce, M. E. 1950. *Loligo pealeii*, pp. 347–357. In Brown, F. A., Jr. (ed.), *Selected invertebrate types*. New York, John Wiley & Sons, Inc. *Dissection guide for Loligo*.
- Pierce, S. K., and T. K. Mangel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *Photographs and interpretive drawings of the dissection of Loligo*.
- Williams, L. W. 1909. The anatomy of the common squid *Loligo pealeii* Lesueur. Leiden, American Museum of Natural History.

Exercise 12, Exercise 12A: Class Polychaeta— The Clamworm

References

- Brown, F. A., Jr. 1950. *Neanthes virens*, pp. 271–279. In F. A. Brown, Jr. (ed.), *Selected invertebrate types*. New York, John Wiley & Sons, Inc. *Dissection guide for the clamworm*.
- Bullough, W. S. 1950. Practical invertebrate anatomy. London, Macmillan & Company. *Brief account of external and internal anatomy of the clamworm*.
- Pierce, S. K., and T. K. Mangel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *Helpful selection of light micrographs, scanning electron micrographs, and dissections of several errant and tube-dwelling polychaetes, including Nerilla, Nereis, Glycera*,

Diopatra, Lepidonotus, Amphitrite, Chaetopterus, and others.

- Reish, D. J. 1981. Culture methods for rearing polychaetous annelids through sexual maturity. *In* Laboratory animal management: marine invertebrates. Committee on Marine Invertebrates. Washington, D.C., National Academy Press. *Directions for handling and rearing clamworms.*
- Reish, D. J., and T. L. Richards. 1966. A culture method for maintaining large populations of polychaetous annelids in the laboratory. *Turtox News* **44**:16–17.
- Schroeder, P. S., and C. O. Hermans. 1975. Annelida: Polychaeta, pp. 1–213. *In* A. G. Giese and J. S. Pearse (ed.), *Reproduction of Marine Invertebrates*, vol 3: Annelida and Echiurans. New York, Academic Press.
- Video: Earthworm. 1990. Human Relations Media (175 Tompkins Ave., Pleasantville, New York 10570), VHS, 10 min.; purchase \$95.00, rental \$40.00. *A preserved earthworm is dissected; major organs are exposed though not all are identified. Designed for high-school level.*
- Video: Earthworm dissection explained. 1988. Bergwall Productions, Inc. (106 Charles Lindbergh Blvd., Uniondale, New York 11553-3695), 2 videos, 11 and 12 min.; purchase \$149.00. *College-level videos using preserved and (briefly) living specimens to show external and internal features. An anesthetized specimen is used to show the pumping aortic arches; good explanations of hermaphroditism and closed circulatory systems.*

Exercise 12B: Class Oligochaeta—The Earthworms

References

- Brown, F. A., Jr. 1950. *Lumbricus terrestris*. pp. 295–303. *In* F. A. Brown, Jr. (ed.), *Selected invertebrate types*. New York, John Wiley & Sons, Inc. *Directions for dissection and making simple observations on behavior, body fluid composition, and circulation.*
- Drewes, C., and K. Cain. 1999. As the worm turns: locomotion in a freshwater oligochaete worm. *Amer. Biol. Teach.* **61**(6):438–442. *Experiments to investigate swimming and crawling in an oligochaete.*
- Edwards, C. A., and J. R. Lofty. 1977. *Biology of earthworms*, ed. 2. London, Chapman and Hall. *Excellent review, including a helpful section on earthworm behavior. Chapter 1 deals with earthworm morphology.*
- Gray, J., and H. W. Lissmann. 1938. Studies in animal locomotion. VII. Locomotory reflexes in the earthworm. *Jour. Exp. Biol.* **15**:506–517.

- Lee, K. E. 1985. *Earthworms: their ecology and relationships with soils and land use*. Orlando, Florida, Academic Press.
- Lesiuk, N. M., and C. D. Drewes. 1999. Blackworms, blood vessels, pulsations and drug effects. *Amer. Biol. Teach.* **61**(1):48–53. *Physiology experiments using oligochaetes, Lumbriculus.*
- Mill, P. J. (ed.). 1978. *Physiology of annelids*. New York, Academic Press. *Contributed chapters on physiological subjects. Especially useful for this exercise are sections on locomotion, and on anatomy and physiology of the oligochaete digestive tract.*
- Prosser, C. L. 1934. The nervous system of the earthworm. *Quart. Rev. Biol.* **9**:181–200.
- Rowett, H. G. Q. 1985. *Dissection guides. Part V. Invertebrates*. London, John Murray. (Available through Ward's Natural Science Establishment.) *Series of drawings showing the progressive dissection of the earthworm, including a smear of the contents of the seminal vesicles showing stages of the parasite Monocystis, and diagram of the nephridium. Very useful.*
- Swartz, R. D. 1929. Modification of behavior in earthworms. *Jour. Comp. Psychol.* **9**:17–33.
- Wu, K. S. 1939. On the physiology and pharmacology of the earthworm gut. *Jour. Exp. Biol.* **16**:184–197.

Exercise 12C: Class Hirudinea—The Leech

References

- Brown, F. A., Jr. 1950. *Selected invertebrate types*. New York, John Wiley & Sons, Inc. *Contains an excellent description and dissection guide for the medicinal leech.*
- Conniff, R. 1987. The little suckers have made a comeback. *Discover*, August: 84–94. *Describes the uses of leeches in microsurgery, and many interesting biological facts. Well illustrated and an ideal semi-popularized account to make available to students.*
- Debski, E. A., and W. O. Friesen. 1985. Habituation of swimming activity in the medicinal leech. *Jour. Exp. Biol.* **116**:169–188.
- Klemm, D. J. (ed.). 1985. *A guide to the freshwater annelida (Polychaeta, Naidid and tubificid Oligochaeta, and Hirudinea) of North America*. Dubuque, Iowa, Kendall/Hunt Publishing Company. *Complete key to the identification of some 63 species of North American leeches. Extensive bibliography and a chapter on collecting and processing methods.*
- Lent, C. M. 1985. Serotonergic modulation of the feeding behavior of the medicinal leech. *Brain Res. Bull.* **14**:643–655. *Describes feeding behavior; good illustrations of wound and serated jaws.*

- Lent, C. M., and M. H. Dickinson. 1988. The neurobiology of feeding in leeches. *Sci. Amer.* **258**:98–103 (June). *Describes how a single neurotransmitter, serotonin, orchestrates the animal's search for a target, the movements of its jaws, the filling of its crop, and the distension of its body.*
- Mann, K. H. 1953. Segmentation of leeches. *Biol. Rev.* **28**:1–15.
- Mann, K. H. 1962. Leeches (Hirudinea): their structure, physiology, ecology, and embryology. New York, The Macmillan Company.
- Pennak, R. W. 1989. Freshwater invertebrates of the United States: Protozoa to Mollusca, ed. 3. New York, John Wiley & Sons. *Excellent overview of leech anatomy, physiology, reproduction, ecology, and culturing, with a key to North American species.*
- Rao, P., F. B. Bailie, and B. N. Bailey. 1985. Leechmania in microsurgery. *The Practitioner* **229**:901–905 (Oct.).
- Sawyer, R. T. 1986. Leech biology and behaviour, 3 volumes. Vol 1: Anatomy, physiology, and behaviour. Vol 2: Feeding biology, ecology, and systematics. Vol. 3: Bibliography. Oxford Clarendon Press. *This is the definitive monograph on leeches.*
- Sawyer, R. T. 1986. Leeches: new roles for an old medicine. *Ward's Bulletin*, Spring, 1986 (Ward's Natural Science Establishment, Inc.). *Succinct summary of the history of leeching, and present uses in medicine.*
- Whitlock, M. R., P. M. O'Hare, R. Sanders, and N. C. Morrow. 1983. The medicinal leech and its use in plastic surgery: a possible cause for infection. *Brit. Jour. Plast. Surg.* **36**:240–244.
- Zinn, D. J., and I. R. Kneeland. 1964. Narcotization and fixation of leeches (Hirudinea). *Trans. Am. Microsc. Soc.* **83**:275–276.

Exercise 13, Exercise 13A: The Chelicerate Arthropods—The Horseshoe Crab and Garden Spider

References

- Brown, F. A., Jr. (ed.). 1950. Selected invertebrate types. New York, John Wiley & Sons, Inc. *Detailed descriptions of behavior and external and internal anatomy of Argiope aurantia (pp. 382–394) and Limulus polyphemus (pp. 360–381).*
- Bullough, W. S. 1950. Practical invertebrate anatomy. London, Macmillan & Co. *External anatomy of Limulus with drawings (pp. 295–298).*
- Foelix, R. F. 1982. Biology of spiders. Cambridge, Massachusetts, Harvard University Press. *Comprehensive, attractively produced.*

- Logan, G. R., and C. A. Pickover. 1977. Sticky traps and spider prey. *Carolina Tips* **40**:25–26.
- Needham, J. G. (ed.). 1937. Culture methods for invertebrate animals. Ithaca, Comstock Publishing Company, Inc. (Dover Publications reprint, 1959.) *Methods detailed for feeding spiders, laboratory care of tarantulas, and (caution!) laboratory culturing of black widow spiders.*
- Wolff, R. J. 1994. Terrific tarantulas. *Carolina Tips* **57**(2):5–7. *Helpful suggestions for keeping tarantulas for classroom study.*

Exercise 14, Exercise 14A: Subphylum Crustacea—The Crayfish (or Lobster) and Other Crustaceans

References

- Brown, F. A., Jr. (ed.). 1950. Selected invertebrate types. New York, John Wiley & Sons, Inc. *Several anatomical descriptions of crustaceans, authored by J. H. Lochhead, including Artemia, Daphnia, Cyclops, and the crayfish. The latter is given an especially detailed treatment.*
- Collins, K., and B. Collins. 1985. *Daphnia*—a handy guide for the classroom teacher. *Amer. Biol. Teacher* **47**(5):299–300 (May). *Facts about Daphnia.*
- Lochhead, J. H. 1941. *Artemia*, the “brine shrimp.” *Turtox News* **19**:41–45.
- Lodge, D. M., M. W. Kershner, J. E. Aloï, and A. P. Covich. 1994. Effects of an omnivorous crayfish (*Orconectes rusticus*) on a freshwater littoral food web. *Ecology* **75**:1265–1281. *Demonstrates the important role that crayfish can play in biological communities.*
- Penn, G. H., Jr. 1943. A study of the life history of the Louisiana red-crawfish, *Cambarus clarkii* Girard. *Ecology* **24**:1–18.
- Pennak, R. W. 1989. Fresh-water invertebrates of the United States: Protozoa to Mollusca, ed. 3. New York, John Wiley & Sons. *Chapter 22 contains a wealth of information on crayfish characteristics, feeding habits, reproduction, and ecology, and a key to crayfish genera and some species.*
- Persoone, G., P. Sorgeloos, O. Roels, and E. Jaspers (eds.). 1980. The brine shrimp *Artemia*, vol. 3. Ecology, culturing, use in aquaculture. Wetteren, Belgium, Universa Press.
- Pierce, S. K., and T. K. Mangel. 1987. Illustrated invertebrate anatomy: a laboratory guide. New York, Oxford University Press. *See pages 244–249 for a photographic series of a crayfish dissection.*
- Rowett, H. G. Q. 1985. Dissection guides. Part V. Invertebrates. London, John Murray. (Available through Ward's Natural Science Establishment.)

Series of very helpful drawings showing the progressive dissection of the crayfish, including enlarged views of all the appendages.

Sorgeloos, P., and G. Persoone. 1973. A culture system for *Artemia*, *Daphnia*, and other invertebrates, with continuous separation of the larvae. *Arch. Hydrobiol.* **72**:133–138.

Exercise 15, Exercise 15A: The Myriapods—Centipedes and Millipedes

References

- Brown, F. A., Jr. (ed.). Selected invertebrate types. New York, John Wiley & Sons, Inc. *Detailed description of external and internal anatomy of Spirobolus.*
- Bullough, W. S. 1950. Practical invertebrate anatomy. London, Macmillan & Co., Ltd. *Anatomy of Lithobius and Julus (= Iulus) described.*
- Freeman, W. H., and B. Bracegirdle. 1982. An atlas of invertebrate structure. London, Heinemann Educational Books. *Includes a photograph and interpretive drawing of Lithobius.*
- Vitt, L. J. 1992. Lizard mimics millipede. *National Geographic Research and Exploration* **8**:76–95. *Suggests that lizards and snakes may evolve to mimic toxic millipedes.*

Exercise 15B: The Insects— The Grasshopper and the Honeybee

References

- Bullough, W. S. 1950. Practical invertebrate anatomy. London, Macmillan & Co., Ltd. *External anatomy of Apis is described on pp. 279–284.*
- Freeman, W. H., and B. Bracegirdle. 1982. An atlas of invertebrate structure. London, Heinemann Educational Books. *Detailed drawings and photographs of locust anatomy.*
- Jones, J. C. 1981. The anatomy of the grasshopper (*Romalea microptera*). Springfield, IL, Charles C. Thomas Publisher. *A meticulously detailed description of grasshopper anatomy with illustrations. Includes a detailed index and bibliography.*

Exercise 15C: The Insects— The House Cricket

References

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Exercise 16B: Class Ophiuroidea— The Brittle Stars

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Exercise 18C: Class Osteichthyes— The Bony Fishes

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Exercise 19C: The Skeletal Muscles

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