HOW-TO-DO-IT

Teaching the Major Invertebrate Phyla in One Laboratory Session

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Abstract

This one-session laboratory exercise teaches all the major invertebrate phyla in about 2 hours.

Key Words: *Invertebrate; evolution; biodiversity; laboratory.*

In many survey classes, such as general biology, marine biology, or life sciences, covering the major invertebrate phyla can become a time sink. I have developed a laboratory exercise in which students examine the Porifera (sponges), Cnidaria (jellyfish, etc.), Annelida (worms), Mollusca (snails, clams, etc.), Arthropoda (insects, crabs, etc.), Brachiopoda (lamp shells), Echinodermata (brittle stars, urchins, etc.), and Chordata (tunicates) in one session. This multistation laboratory uses a combination of preserved and live specimens, slides, and images to present samples of each phylum. The exercise is designed to take advantage of an aquarium in the classroom but does not require one. Students answer questions and sketch what they observe at one or two stations per phylum. The lab takes approximately 2 hours with a 20-minute setup, and students are able to see the vast diversity among these phyla and understand the similarities and differences across the groups. I have found this laboratory to be effective in teaching the invertebrate phyla in a course when time is a limiting factor.

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○ Course Context

This laboratory exercise was created for my marine biology course but can be applied to any class that includes biodiversity. This is an introductory, nonmajors class and can be taken at any point during the student's degree program. The course takes place over a 15-week semester, each week consisting of a 3-hour combination lecture and laboratory block. Typically, there are 80 students enrolled in the course in four sections of 20 students each. Students' majors are all from arts and communication fields such as film, journalism, fiction writing, art, and music.

○ Rationale: Incorporating Evolution When Teaching Biodiversity

The majority (~95%) of animals on the planet are invertebrates (Anderson, 2001). If only the vertebrates are covered, students will not have an understanding of the evolutionary spectrum of animal diversity. Invertebrates have many different body plans and ways to complete the basic needs of life, including feeding, reproduction, and dispersal. In addition, many students have never learned about the subphylum Urochordata (sea squirts/tunicates) and are under the mistaken impression that all chordates have a back bone. This laboratory exercise helps to put the diversity of animals in perspective for the students.

The *National Science Education Standards* for K–12 students (National Research Council [NRC], 1996) ask that students understand that "the great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms." In addition, students need to understand that "biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships" (NRC, 1996). These standards continue at the college level in the Bio2010 plan for biology undergraduates (NRC, 2003).

It is imperative to teach evolutionary relationships when teaching biodiversity. This reinforces evolutionary concepts preceding the laboratory. Without an understanding of the basic evolutionary framework, students will simply memorize facts and be unable to understand how organisms are connected. There are a variety of resources available for teachers of evolution, including Tree of Life (http://www.tolweb.org), Understanding Evolution (http://evolution.berkeley.edu), National Center for Science Education (http://www.ncse.com), and the PBS Evolution site (http://www.pbs.org/wgbh/evolution/index.html).

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○ Objectives

The objectives of this laboratory are to (1) be able to recognize to which phylum an animal belongs, (2) learn the evolutionary relationships of the invertebrate phyla, and (3) understand the process of evolution at the phylum level (i.e., sponges have evolved even if they appear to be morphologically similar to fossil sponges).

○ Teacher Procedures

When teaching this laboratory, I always present recent phylogenies of the animal kingdom. Textbooks are often behind in incorporating the latest phylogenic hypotheses, and this can be used to further discussion on the nature of science. I frequently consult the Tree of Life website to learn more about recent research. This past semester, I used the recent paper by Schierwater et al. (2009) to show my students contemporary thinking about animal relationships. Schierwater et al. (2009) found that the Placozoa are at the base of the metazoa, rather than the Porifera or sponges (Figure 1). I used this to stimulate an in-class discussion prior to this laboratory to talk about the differences between the new phylogeny and the one presented in the text (Figure 1; Castro & Huber, 2008). This discussion focused specifically on how these differences reflected different evolutionary relationships among these organisms.

In this exercise, 10 stations are set up in order on the tables in the classroom (Table 1). Each station is labeled with the station number, phylum name, a short description of the phylum, and diagrams (copied, labeled, and cited) from various invertebrate textbooks (e.g., Anderson, 2001) to assist with answering questions. If specimens are not available, I typically will get photographs or other images to augment the preserved and live material. I also provide video of animals such as sponges if living organisms are not available. I use one or two microscopes per station for my 20 students, but that can be varied easily, depending on class size or facilities.

In the classroom, we have a 60-gallon marine tank that is stocked with invertebrates and some fishes from the Gulf of Mexico. I have the students observe the tank during the laboratory (Figure 2). Additional specimens include living organisms, dried sponges, coral skeletons, and organisms in jars. Preserved specimens were purchased from Carolina Biological Supply (http://www.carolina.com) or Ward's Natural Science (http://www.wardsci.com), and living organisms were obtained from Gulf Specimen Biological Supply (http://www.gulfspecimen.org) or Ward's.

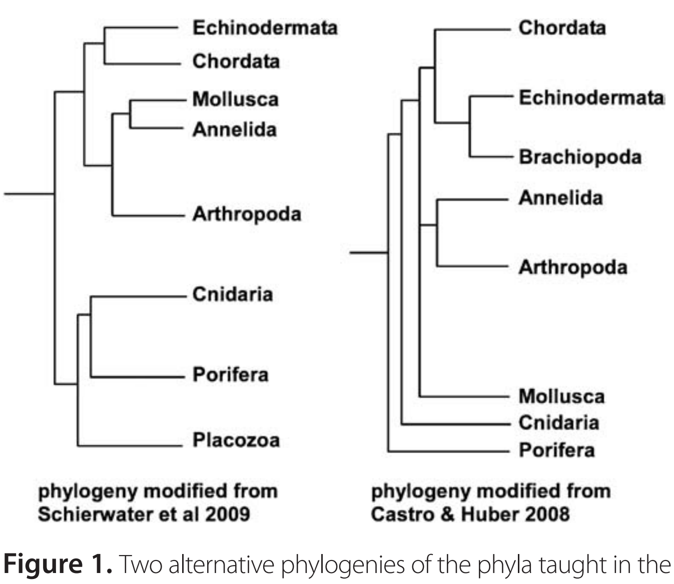

Figure 1. Two alternative phylogenies of the phyla taught in the invertebrate phyla laboratory. I use recent papers to further explain the process of science and how we construct phylogenies.

Figure 2. Students from Fall 2009 answering questions at the marine tank.

○ Student Procedures

In this laboratory, you will rotate from station to station (untimed), observing several specimens from each of eight phyla. As you move around the room, think about what taxonomists value in placing certain organisms together: why are the organisms at each station more similar to each other than to those at other stations? Try to imagine how you would classify a brand new, heretofore undiscovered organism – what physical or behavioral traits would you look at first when trying to classify it? With these questions in mind, let's move on to the phyla.

○ Assessment & Discussion

This lab exercise is a great way to present the invertebrate phyla in a few hours. Students get to explore the material and work independently or in groups as they learn. The students complete most of the laboratory in class and then turn it in with completed questions the following week. The questions and material presented can be modified for any classroom setup and budget. Setup can take around 20 minutes, so I prepare the stations ahead of time and then move them into the classroom just before lab. It is helpful to have all the microscopes focused and ready to go.

Assessment on the material from this laboratory will appear on the final exam in the class. I ask my students for feedback on all laboratory exercises at the end of the course and always get positive reviews. This exercise will take 2 hours to complete, and students do not like for it to be split across multiple weeks. The adjunct faculty enjoy teaching this exercise and find that students leave with a better understanding of the invertebrate phyla.

I use select questions (in italics in Table 1) to focus on the evolutionary principles covered in the lab. After the labs are graded and returned, as a class we have a discussion about those questions, focusing on commonly missed items for that section. We also will look again at the phylogenies during this discussion and go over remaining questions about the material. The in-class discussion is very important in helping students understand the big picture of the animal kingdom.

Table 1. Station setup and questions (those in italics focus on evolutionary principles).

Station	Setup at Station	Questions for Students
Station 1: Porifera	Mixed spicule slide	1. Sketch the slide, remembering to label the spicules: 2. What do you think the spicules are made of? Why? *3. How would you test the hypothesis that spicules deter predators? How might a sponge that lacks spicules (like a bath sponge) protect itself?*
Station 2: Porifera	Commercial sponge slide Preserved sponges in jars Living sponges (in tank)	1. Look at the slide of the commercial sponge. Label the ostia (holes). 2. There are two samples of commercial sponges: living (in the tank) and preserved. Sketch the two, paying close attention to the differences between them. 3. What changes do you think take place between living and deceased versions of the same species? 4. *Questions for later: Sponges seem very different from other animals. Why are they still classified as metazoans? Is it true that they haven't evolved in millions of years?*
Station 3: Cnidaria	Medusae jars (cnidaria set) Obelia Medusae slide Deerhorn coral skeleton Brain coral skeleton	1. Sketch the *Obelia* medusa (pelagic form) and label the bell, mouth, and tentacles. 2. What are contained within the tentacles? What is their function? 3. Look at the skeleton of the deerhorn coral and the live sea whip in the tank. 4. *What do both of these (soft and hard coral) have in common? Why do you think they are shaped the way they are?*
Station 4: Cnidaria	Obelia whole mount slide Portuguese man of war slide	1. Sketch the Portuguese man of war tentacle, labeling the nematocysts. 2. Do you see a pattern of how the nematocysts are distributed? 3. Why is the man of war dangerous to humans? 4. Look at the *Obelia* whole-mount slide and draw it – label the feeding tentacles and reproductive structures. 5. Would you recognize this as the same animal you saw in the *Obelia* medusa slide (**Station 3**)? Why or why not?
Station 5: Annelida	Annelida jar collection Worm x-s slide	1. Looking at the collection of preserved and living worms – what features do they all have in common? 2. Sketch the slide of the worm in cross-section, remembering to label the blood vessels, intestine, and muscles. 3. Worms have a closed circulatory system – what advantages do you think it provides for the worms? 4. What do the polychaetes use to move? *5. Many polychaetes that live in tubes decorate them with debris that they find around them. Why do you think they do this? What do you think the costs are to the organism? What are the benefits?*
Station 6: Mollusca	Mollusks jar collection Mussel gill slide	1. Looking at the collection of mollusks, what do you see as common features across the group? 2. Sketch the slide of the gill and label blood vessels and the gill. 3. *Why does the gill have so many layers?* 4. What is the function of the gill? 5. Look in the tank – we have snails, slugs, oysters, and chitons. Pick one and draw it. 6. What behavior do you see the snails doing while you are watching the tank? What do you think they eat? Why?
Station 7: Arthropoda	Arthropoda jar collection (marine only) Hermit crab (in tank) Barnacles (in tank)	1. Look at the collection of preserved and living crustaceans – what features do they all have in common? 2. Sketch a hermit crab, taking care to label eyes, mouth, legs, claws, and shell. 3. What do you observe the crabs doing? 4. Where do they get their shells? 5. *The barnacles in the tank are arthropods; how would you recognize that? Do you see any common features?* 6. *Question for later: Compared to mollusks, arthropods are much more diverse on land than in the water. Insects (bugs) are very abundant. What do you think helped the arthropods become so successful on land?*

(Continued)

Table 1. (Cont'd)

Station	Setup at Station	Questions for Students
Station 8: Mollusca vs. Brachiopoda	Preserved mussel in jar Preserved brachiopod in jar	1. Draw the brachiopod and the mussel: 2. What external differences do you see? 3. Look at the diagrams at the station – what other differences are there? 4. Why am I making you draw all these animals? Am I just being cruel or is there something I am hoping that you will learn by drawing instead of looking at pictures? (Hint: while cruelty may indeed play a role, there just might be other factors to consider.)
Station 9: Echinodermata	Preserved echinoderms in jars Living echinoderms in tank	1. After looking at the echinoderms, please list the common features that you see. 2. In the tank, look at the brittle stars and the sea stars – what differences do you see between them? Brittle stars tend to eat detritus, whereas sea stars are predators. They are also in separate classes within the phylum. 3. Sketch and label brittle stars and sea stars, paying close attention to their differences. 4. *The sea urchins and sea cucumbers look different from the sea stars and brittle stars. What features do each of them have that identify them as echinoderms?*
Station 10: Chordata	Preserved tunicates in jars	1. Look at the preserved tunicates – how do you think this organism feeds? 2. Draw a tunicate. *3. Question for later: Which features make this group part of the chordates? Can you see them in the adult?* 4. *Question for later: What modifications do you think the predator tunicate that we saw in class a few weeks ago has for eating prey instead of filter feeding?* 5. Question for later: List one thing you liked about this lab, one thing you didn't, and give me a suggestion on how to change it for next year.

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References

Anderson, D.T., Ed. (2001). *Invertebrate Zoology*. Oxford, UK: Oxford University Press.

Castro, P. & Huber, M. (2008). *Marine Biology, 7th Ed*. New York, NY: McGraw Hill.

National Research Council. (1996). *National Science Education Standards*. Washington, D.C.: National Academy Press.

National Research Council. (2003). *Bio2010: Transforming Undergraduate Education for Future Research Biologists*. Washington, D.C.: National Academics Press.

Schierwater, B., Eitel, M., Jakob, W., Osigus, H.-J., Hadrys, H., Dellaporta, S.L. & others. (2009). Concatenated analysis sheds light on early metazoan evolution and fuels a modern "Urmetazoon" hypothesis. *PLoS Biology*, 7(1), e1000020.

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