How-To-Do-It

Daphnia—A Handy Guide for the Classroom Teacher

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The study of arthropods in junior and high school science classes usually focuses on the dissection of crayfish and grasshoppers. While both of these are good organisms for study, working with living organisms adds a spark of student interest not found with preserved specimens.

I have successfully used *Daphnia*, a common water flea, to bring out student enthusiasm in the laboratory. I can collect them in a local seasonal pond, and they are also available from biological supply houses (such as Carolina Biological Supply). A gallon jar of water holds an ample supply of specimens for about a week's study. They are large enough to see when collecting, yet small enough to allow viewing in detail under the low and medium power of a microscope.

During lab work observing *Daphnia* my students often asked questions that were as thought provoking as they were difficult to answer. My wife, Betty, and I began seeking the answers to some of these questions, and this article is the result of our research. We offer it as a reference to other biology teachers.

Daphnia are probably the most well known group of the order Cladocera and are members of the family Daphniidae. Most of this genus live in slow moving, shallow, fresh water, such as ponds or river margins. These bodies of water may be permanent or seasonal, drying out at some point during the year (Willmoth 1967).

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Antennae are the chief organs of locomotion. In *Daphnia*, these antennae are large and their propelling movements are interspersed with pauses during which it sinks with its antennae opened out to slow its downward progress (Kaestner 1970).

Daphnia respond to the chemical nature of their environment. They move toward areas of higher oxygen concentration which are more suited for their metabolism and where the food supply is more abundant (Kaestner 1970). The color of *Daphnia* is an indicator of the oxygen content of water. *Daphnia* are colorless in well-aerated water and pink due to hemoglobin build-up in stagnant water (Barnes 1980). They respond to temperature changes by swimming up as the temperature lowers and down as the temperature increases (Kaestner 1970).

Daphnia respond to their physical environment through the use of sensory abdominal setae and sensory hairs on the basal segment of the antennae (Hickman 1973). The movable, fused compound eye of this Cladoceran allows the animal to swim freely while orienting in any plane (Kaestner 1970).

Daphnia feed on bacteria, protozoa, nonfilamentous algae, and organic detritus, with the latter being used only when other food sources are depleted (Horton, Rowan, Webster and Peters 1979). The Cladocera are filter feeders, using some of the four to six pairs of trunk appendages which also serve as gills taking in oxygen (Hickman 1973). The water current passes from front to back and the collected material is moved to a food groove by special setae at the basal part of the appendage (Barnes 1980). These particles are pushed forward along the midventral gully between

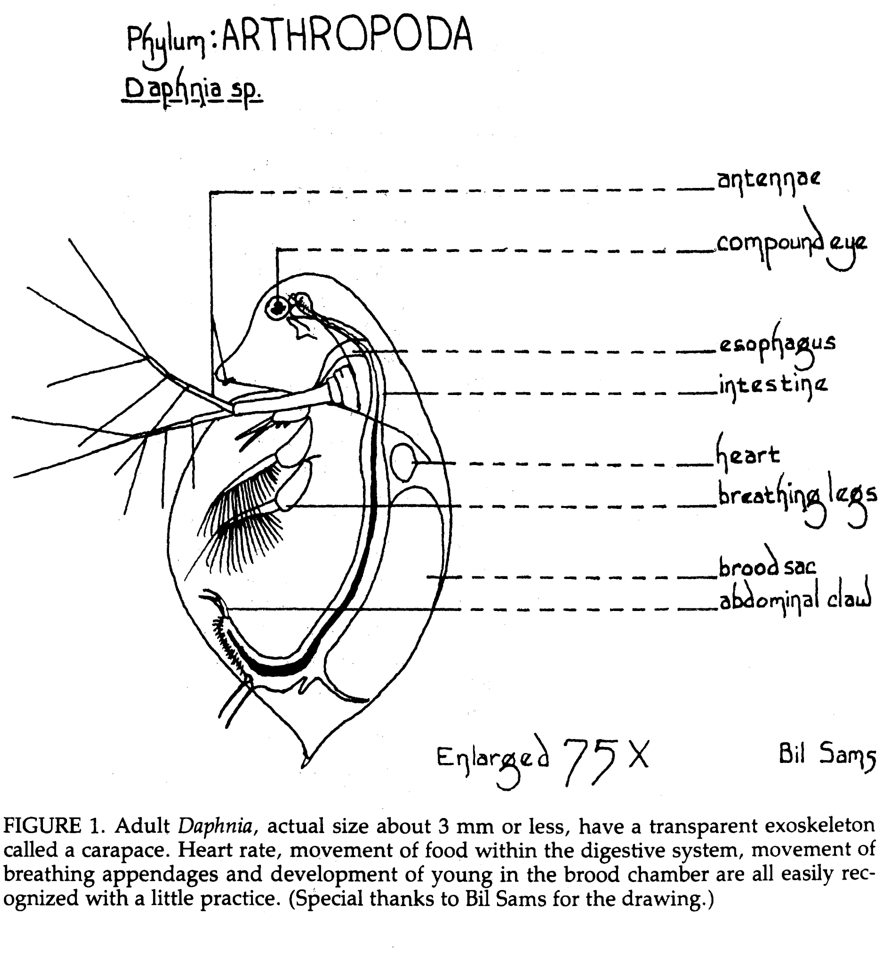

FIGURE 1. Adult *Daphnia*, actual size about 3 mm or less, have a transparent exoskeleton called a carapace. Heart rate, movement of food within the digestive system, movement of breathing appendages and development of young in the brood chamber are all easily recognized with a little practice. (Special thanks to Bil Sams for the drawing.)

TABLE 1. Summary of Factors Influencing *Daphnia*

	Affected By:								
Characteristic	O_2 *Level*	*Temperature*	*Time of Day*	*Condition of Individual*	*Scarcity of Food*	*Congestion*	*Waste Accumulation*	*Light*	*Salinity*
Color of *Daphnia*	X								
Heart Rate		X	X	X					
Appearance of Males in pop.		X			X	X	X		
Breaking Dormancy	X	X						X	X
Cyclomorphosis		X							

the bases of the appendages to the mouth (Willmouth 1967). The mouth opens into an esophagus with leads to the stomach and intestine. The digestive ceca may open to the front of the intestine (Hickman 1973). Once digestion is completed, nitrogenous and other metabolic wastes are removed through the maxillary glands (Barnes 1980). Indigestable wastes are removed through the anus.

Reproduction in *Daphnia* occurs mainly through parthenogenesis. This is a process in which eggs formed in the ovary of an unfertilized female develop and form within the brood chamber. Up to forty eggs called summer eggs may be formed at a time. During development these eggs go through a kind of meiosis within the nuclear membrane which gives the young a gene combination on their chromosomes different from the mother (Kaestner 1970). At birth these fully formed young are released from the brood chamber by an inward flexing of the postabdomen (Willmoth 1967).

In a stable environment, populations of *Daphnia* will be solely female and reproduce only by parthenogenesis. The life span of *Daphnia* is variable, generally lasting 30 to 60 days (Hickman 1973). An adult *Daphnia* is capable of producing a brood of eggs every two to three days (Orlans 1977).

However, in response to environmental variations (see Table 1), changes in the ovaries of the females take place which give rise to the production of eggs that will form male *Daphnia* (Kaestner 1980). Mature males mate with females forming winter eggs. These eggs are surrounded by ample amounts of yolk to maintain the egg during dormancy. Usually two winter eggs are encased in a protective structure called an ephippium. This structure is resistant to drying, freezing and passage through the digestive systems of some fish, birds, and mammals making dispersal possible. The ephippium is formed in the brood chamber and released when the female molts (Barnes 1980; Kaestner 1970). The period of dormancy within an ephippium is variable lasting until environmental conditions are favorable to survival (see Table 1).

Seasonal changes in body form (cyclomorphosis) occur in *Daphnia*. The most notable change is the shape of the head, but the size of the compound eye and spine on the posterior end of the carapace are also affected. As temperature increases, the normally rounded head of *Daphnia* begins to elongate and become pointed and helmet-shaped (Willmoth 1967). To culture *Daphnia* for observation of cyclomorphosis, a temperature of 24.5°C. produces long helmets and 7.5°C. produces rounded heads (Kaestner 1970).

Cyclomorphosis appears to be an environmental adaptation, but the function for the adaptation is not presently understood. One possibility is animals with helmets fare better against predation by fish. A study cited in Kaestner (1970) indicates large helmets affect swimming patterns in such a way that they were less likely to be preyed upon by guppies.

Because of their small size *Daphnia* are ideal for classroom exploration. In my junior high science classes we've investigated the effects of substances such as coffee and tobacco tea made by soaking a cigarette in water for approximately two hours, as well as the effects of a rocket ride on the breathing rate and pulse of *Daphnia* using Estes model rockets with parachute recovery. Older students might be able to explore factors affecting the sudden introduction of males in a culture or the conditions when initiate cyclomorphic changes. One thing is guaranteed however, if your zoology labs have been lacking excitement lately, the use of *Daphnia* will bring the enthusiasm back.

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