INVERTEBRATES

Status: Common Native

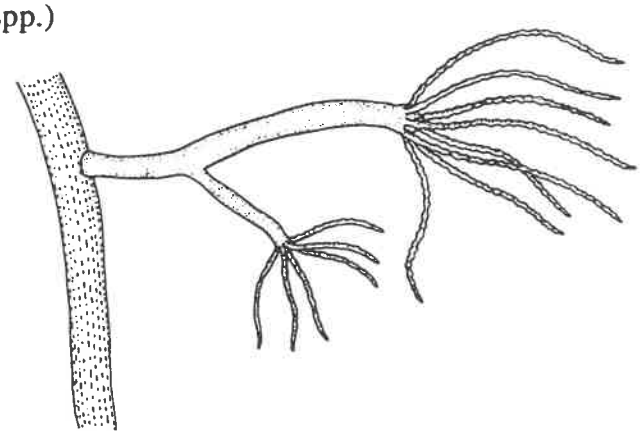
HYDRA

(Hydra spp.)

Description

Hydra are named after the nine-headed sea snake of Greek mythology and are freshwater relatives of corals, sea anemones and jellyfish. All are members of a primitive phylum, the *Cnidaria*, and share in common stinging tentacles and a *radially symmetrical* body plan. The gut of cnidarians has only one opening and is termed the gastrovascular cavity. Unlike more complex animals, cnidarians are designed around 2 sheets of tissue: the ectoderm, lining the exterior; and the endoderm, lining the gastrovascular cavity. The two are separated by a gelatinous partition named the mesoglea. This layer is greatly expanded in jellyfish, but is much reduced in hydra.

Hydra live attached to vegetation by the base of the tubular body or column, with their tentacles suspended free in the water. At the base of the tentacles is the mouth. Smaller animals which blunder into the tentacles are stung and paralyzed and drawn into the mouth. Most species of hydra are less than 0.6 inches (15 mm) in length, not including the tentacles, and are inconspicuous. Both column and tentacles are highly contractile and, by expelling gastrovascular fluid from the mouth, a hydra can shrink to a fraction of its previous volume. Hydra will only rarely be spotted in their natural habitats, but if samples of aquatic vegetation are transferred to a clear glass



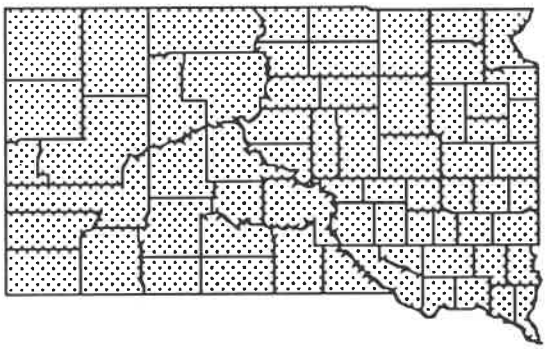
or plastic container, they will often be found in considerable numbers. Both the column and tentacles gradually extend in still water.

Several species of hydra have been recorded in the Great Plains, but most are difficult to identify without detailed microscopy. Two species, however, are distinctive. *Hydra (Chlorohydra) viridissima* (green hydra) is a bright green species, owing to the presence of numerous *algae* called zoochlorellae, which live as *symbionts* within the endodermal cells. The zoochlorellae carry out *photosynthesis* and produce sugars that are used by the hydra. In return, the *carnivorous* diet of the hydra provides a source of nitrogen for the *algae.* Green hydra are small, seldom more than 0.4 inches (10 mm) long, with tentacles about half the length of the column.

Hydra oligactis is easily distinguished from other hydra by its very long tentacles, which may extend to 2 inches (5 cm) or more when relaxed. The column is a pale translucent brown, 0.6 to 1 inch (15 to 25 mm) in length, with the base distinctly narrowed to form a "stem" or "foot."

Hydra vulgaris and *H. braueri* have been grouped as a "species clusters" by Campbell (1987), and each probably contains several true species. Classification depends on the structure of the eggs and stinging cells (see below). All of these species have tentacles that are similar in length to the column or somewhat shorter. The color is pale translucent brown or gray. None possesses the basal narrowing of the column seen in *H. oligactis*. This group includes animals that are 0.2 to 0.6 inches (5 to 15 mm) in length.

Distribution



True jellyfish, corals and sea anemones are restricted to ocean habitats, but a few cnidarians of the Class Hydrozoa occur in freshwater. Hydra are the most common of these and are widespread in clean waters throughout North America.

Hydra oligactis and *Chlorohydra viridissima* are both widespread and common in South Dakota in still and slow-flowing freshwater habitats. Members of the *H. vulgaris* and *H. braueri* complexes may also be encountered. Unlike many freshwater animals, hydra tolerate considerable *eutrophication*, which is a problem in many state waterways owing to intensive agriculture. They are also tolerant of wide temperature fluctuations, although most of our species probably over-winter as dormant eggs. I have found hydra in saline lakes with salinities up to 40 milliosmoles (approximately 1%) but they probably do not occur in salinities much higher than this. These broad ecological tolerances make hydra widespread and common, although they are sensitive to heavy metal toxicity.

Natural History

Hydra are *sessile* and live attached to aquatic vegetation, submerged twigs or rocks. They are frequently found on the floating leaves and suspended roots of duckweed, *Lemna* spp. Attachment is accomplished by mucous secretions from the basal disc. Although hydra remain stationary for long periods, they may move considerable distances by bending the column, attaching with the tentacles, releasing the basal disc, then flipping the column over and re-attaching. This behavior is termed somersaulting.

Prey are paralyzed by *neurotoxins* released from tiny stinging *organelles*, called cnidae or nematocysts. The cnidae are formed within the ectodermal cells of the column, and especially the tentacles, where they are packed in high densities. Each cnida is a capsule containing a long, invaginated hollow thread (see Figure 1). When stimulated by chemical or mechanical cues, the *permeability* of the cnida increases and water enters, increasing the pressure and blowing the thread inside out. Cnidae are usually released from the ectodermal cells when discharged. The largest cnidae (penetrants) contain the *neurotoxins* that are injected into prey via the hollow thread. Smaller cnidae include the *volvents*, which coil spontaneously on contact, and *glutinants*, which are adhesive.

Once a prey item is captured and paralyzed by the tentacles, body fluids leaking from puncture wounds stimulate a simple feeding response in the hydra. This involves a shortening of the tentacles, expansion and opening of the mouth, and

the engulfing of the victim. The major stimulant for this response is the common tri-peptide (a chain of 3 amino acids), glutathione. Digestion of the prey item in the gastrovascular cavity proceeds over several hours. Large molecules are taken up by the gastrovascular cells, where digestion is completed. Cuticles and other undigested remains are subsequently expelled through the mouth. Almost any small invertebrates, up to the size of the hydra, may be consumed, including annelid worms, rotifers, insect larvae, and (especially) small crustaceans, such as *Daphnia*, *Chydorus* and *Cyclops* spp.

Hydra reproduce in the summer months. Most reproduction is asexual involving a process termed budding, in which a new hydra develops as a bud from the parent column (see species illustration). Buds later break free, but are genetically identical to the parents (clones). Under favorable conditions, hydra may possess several buds at various stages of development. Sexual reproduction is usually confined to late summer. Ovaries develop as oval swellings near the column base, while testes form as conical projections higher up. *Hydra oligactis* is *dioecious*, with males and females occurring as separate individuals. However, most species are *hermaphrodites*, the testes and ovaries developing on the same animal. Sperm swim out from the testis and enter the ovaries of other individuals. Ovaries each contain a single egg. Once fertilized, this egg develops a protective ornamented shell and frequently enters a stage of arrested development or dormancy. When favorable conditions return (often in the following spring), development resumes and the young hydra develops directly without a larval stage.

Keeping Hydra In The Classroom

Hydra are easily maintained in a freshwater aquarium and do not need filtration or aeration systems. In any freshwater aquarium, ammonia will tend to accumulate, so the water should be changed every few weeks. Always use freshly collected pond water or rain water; chlorinated tap water will usually kill hydra as well as the smaller creatures upon which they feed. Hydra are voracious and will feed and reproduce rapidly if given an abundant supply of food. Small crustaceans, such as *Daphnia* and *Cyclops* are ideal prey, but a large hydra population will deplete crustaceans rapidly. If you have a lake or river in the vicinity, small crustaceans such as these can be readily collected in large numbers with the aid of a *plankton net*. In the absence of prey, hydra can obtain a certain amount of food by absorbing organic molecules directly across the ectoderm. If food is unavailable, reproduction will cease and hydra will use their own tissues for energy, shrinking to an indefinitely small size before they finally die.

Experiments With Hydra

Try placing 2 or 3 hydra in a watch glass and studying their response to mechanical stimuli. Touch a tentacle with a mounted needle and note how the response is locally graded, maximum contraction occurring at the point of contact and diminishing further away. This is due to the simple nervous system which is organized as a nerve net, each nerve cell conducting impulses over a short distance. A few of the nerve cells have long axons like vertebrate neurons and conduct impulses over large distances. These serve to effect a rapid contraction or escape response if strong stimuli are encountered.

Feeding behavior can be studied using *Daphnia* or similar crustaceans. Using a low-power dissecting microscope, observe how the crustaceans are paralyzed following contact with the tentacles. In *Daphnia* you can readily see the heart beating at the back of the head; is this affected by the *neurotoxins*? Local accumulations of glutathione stimulate waving movements of the tentacles, which fold over the victim on contact. The feeding response is completed with the swelling of the mouth region and

ingestion. You can also stimulate the feeding response using your own prepared solutions of glutathione, which can be obtained from chemical suppliers as reduced glutathione. Dissolve this in freshwater to make solutions of various concentrations (see Table 1). Once the hydra are extended in a watch glass, gently pipette off most of the water and replace it with one of the glutathione solutions. What concentration is required to stimulate movement in the tentacles, and stimulate distention and opening of the mouth?

Hydra are beautiful animals for light microscopy. Pipette one onto a slide with 3 to 4 drops of water, and add a cover-slip. Identify the two major tissue layers - ectoderm and endoderm. If you have *Chlorohydra*, the zoochlorellae will be conspicuous in the endodermal cells. The addition of the cover slip will trigger discharge of numerous cnidae. See the long thread and 3-barbed base of the toxic penetrant cnidae. Look carefully for volvents and glutinants - these are considerably smaller with a more slender base. Undischarged cnidae can be seen in the ectodermal cells as refractive capsules topped by a stiff sensory bristle, which emerges from the cell surface.

Table 1. Instructions for Mixing Various Concentrations of Glutathione Solutions.

Solution	Measure out.....	Add....
Stock Solution (1mM)	0.306 g Glutathione	Up to 1 liter distilled water
1uM	1 ml Stock Solution	Up to 1 liter distilled water
5 uM	5 ml Stock Solution	Up to 1 liter distilled water
10 uM	10 ml Stock Solution	Up to 1 liter distilled water
20 uM	20 ml Stock Solution	Up to 1 liter distilled water

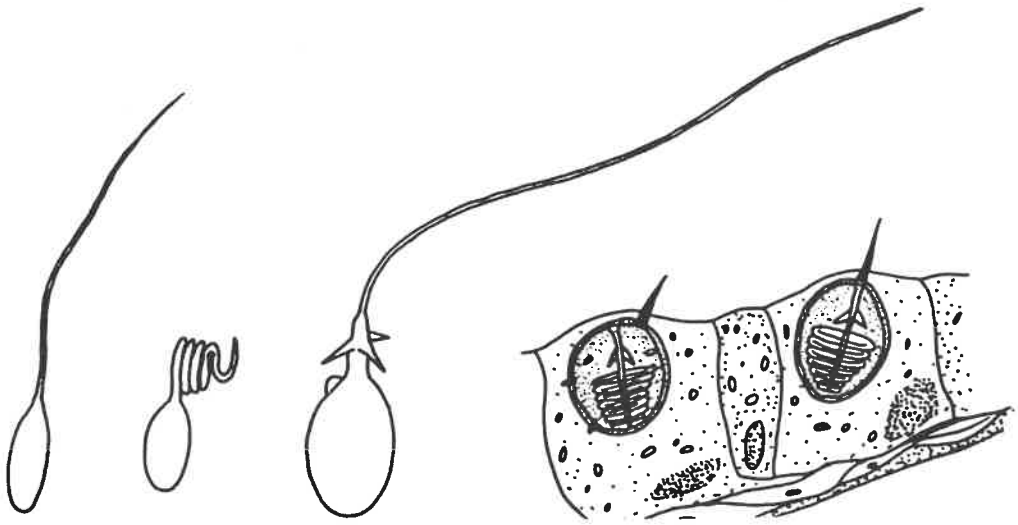


Figure 1. Cnidae: left to right: glutinant, volvent, penetrant, and ectoderm of hydra tentacle with undischarged cnidae.

Glossary

Algae - large group of plant-like organisms that carry out photosynthesis but lack tissue differentiation as seen in true plants. Most species are single-celled and microscopic, such as zoochlorellae. A few are colonial and may form large tissue sheets as seen for example in kelps and other seaweeds.

Carnivorous - meat eating.

Cnidaria - the animal phylum, formerly called Coelenterata, which includes soft-bodied creatures with stinging tentacles and radial symmetry.

Dioecious - having separate sexes, ie. eggs and sperm produced by separate individuals.

Eutrophication - the enrichment of a body of water with nutrients, resulting in excessive growth of microbes, deoxygenation, and a deterioration of the water quality for human uses.

Hermaphrodite - having both male and female reproductive capacities, ie. production of eggs and sperm) in the same individual.

Neurotoxins - poisons that affect the nervous system of an animal.

Organelle - a sub-cellular structure such as a cnida, but also including chloroplasts which perform photosynthesis, mitochondria which perform cellular respiration, and ribosomes, which function in the synthesis of proteins.

Permeability - the ability of a membrane to allow substances to pass through it.

Photosynthesis - the metabolic process whereby green plants, algae, and some bacteria, harness the energy of sunlight and use it to fix atmospheric carbon dioxide into sugars. Photosynthesis is the primary source of organic matter that feeds ecosystems.

Plankton net - a very fine-meshed net, tapering to a small tube, and used for capturing minute creatures that float in water.

Radially symmetrical- having a body plan in which body parts are symmetrically arranged around a central axis.

Sessile - living attached to another object.

Symbionts - are species living with a cooperating host species in a relationship that is mutually beneficial.

References

Campbell, R.D. 1987. A new species of *Hydra* (Cnidaria: Hydrozoa) from North America with comments on species clusters within the genus. Zoological Journal of the Linnean Society 91.

Lenhoff, H.M., 1983. Hydra: Research Methods. Plenum Press, New York.

Thorp, J.T. and Kovich, A.P. 1991. Ecology and Classification of North American Freshwater Invertebrates. Academic Press, San Diego.

Written by:

Dr. Jonathan Wright, Department of Biology Northern State University, Aberdeen, SD.

Reviewed by:

Nels H. Troelstrup, Jr., Ph.D., South Dakota State University, Brookings, SD 57007.

Publication of the *Hydra* fact sheet was funded by the South Dakota Department of Game, Fish and Parks, Division of Wildlife, Pierre, SD.