Lessons from a “Living Fossil”: An Integrated Study of Horseshoe Crabs

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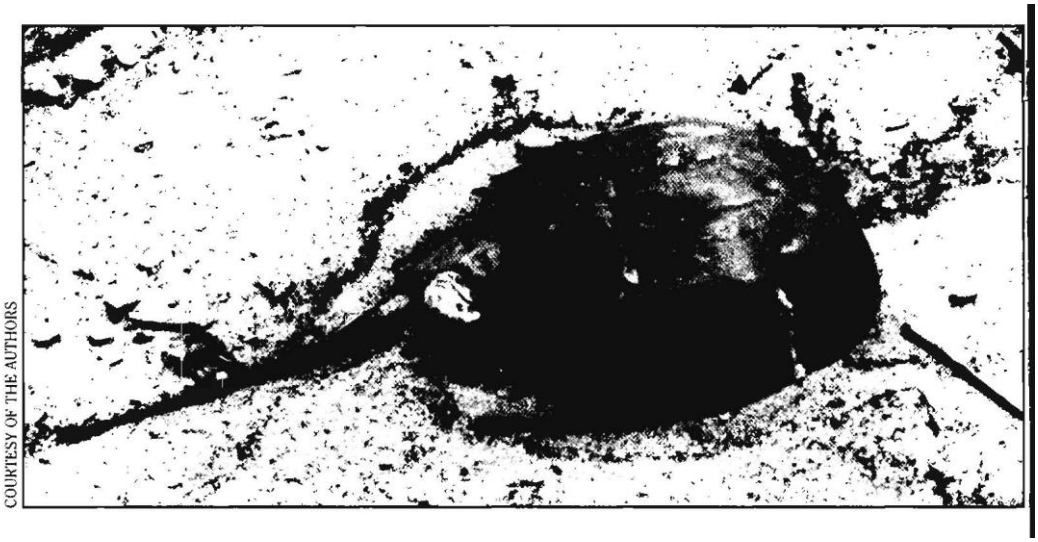
After visiting the Delaware Bay with my university class to observe the mating of horseshoe crabs, I decided to develop a teaching unit about Limulus polyphemus for my elementary science classes. Because horseshoe crabs have lived on Earth for millions of years, this arthropod is often called a "living fossil."

The horseshoe crab first appeared in Devonian times, some 360 million years ago. Its closest relatives are spiders, ticks, and scorpions. Limulus polyphemus inhabits the eastern shore of North America from near Nova Scotia to the Yucatan Peninsula. It has three other cousins that dwell on Asian shores, but Limulus polyphemus is the only horseshoe crab that lives on the Atlantic Coast.

Also often called a king crab because of its large size, the horseshoe crab is not really a crab at all. The name originates from the fact that the front part of its body, when turned over, resembles a horseshoe and its legs look like those of a crab. The male is smaller than the female, but almost all other characteristics of the male and female are the same with the exception of pedipalps, which are modifications on the front legs that allow the male to grasp the shell of the female when mating.

Horseshoe crabs have two median eyes, which are simple eyes, and two lateral eyes, which are compound eyes. Study of the compound eyes has led to a better understanding of the eyes of humans because the horseshoe crab's visually guided behavior can be monitored and the neural network studied. Scientists also use horseshoe crab blood for testing new drugs (the horseshoe crabs are then safely returned to the sea). Shell coloring ranges from gray to black depending on age—the older the horseshoe crab, the darker the color and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the duller the sheen of the shell. Also, the older they are, the more likely they are to be covered with barnacles and snails.

Horseshoe crabs mate in late May and early June at the new and full moons when the tides are highest. The female lays tiny, greenish-gray, pearl-like eggs that are a main food supply for migrating birds. The eggs are laid in shallow nests high enough on the shore to protect them from the sea for at least two weeks.

About 14 days from the time of spawning and as a result of wave action, tiny horseshoe crabs emerge from the eggs and begin a slow journey to the sea. This is the only time in their lives that the horseshoe crabs spend much time swimming. Because they are top heavy, they swim on their backs. Much like loggerhead turtle hatchlings, these miniature horseshoe crabs are food for migrating birds and other creatures of the shore.

A Biology Beginning

My students and I began our unit last year by examining dead horseshoe crabs I brought back from Delaware. The best time for collecting the dead horseshoe crabs on the beach is in May or June, when they come ashore to mate. If you are not in a location where horseshoe crabs are readily available, preserved specimens can be ordered (see Resources). When handling the crabs. students must wear safety goggles and gloves.

I had found two large horseshoe crabs with all parts intact, several juveniles, and several molts. Many people think that they have found a dead horseshoe crab lying on the beach when indeed what they have found is a molt. Dead horseshoe crabs still have their internal organs and will therefore have an odor. The molts are more transparent, they have no odor, and there is a large slit in the front of the shell where the molting crab has exited.

Like other arthropods, horseshoe crabs cannot grow without leaving their exoskeletons and expanding. The horseshoe crab's shell splits along the front edge, and the crab is more susceptible to predators because of its soft shell for as much as 24 hours while its new shell dries. Horseshoe crabs molt periodically for about nine years until they have reached adult size—as adults, they do not molt.

The children noted the horseshoe crabs' brittle shells and telsons. The tel- son (tail) looks like a spear and is used by the crab to right itself if it is turned over on its back. It is also used in locomotion by acting as a rudder. Horseshoe crabs with a missing or partly missing telson are doomed if they land on their backs. When I was in Delaware, as we traveled down the beach, we tried to right every crab we saw that looked alive, but we were fighting a losing battle because there were so many of them.

The students and I brainstormed about what horseshoe crabs might eat, what might eat them, and other hazards. Several students came up with the hypothesis that sharks might eat horseshoe crabs. They also thought that horseshoe crabs would eat fish until they thought about how the horseshoe crab would catch the fish. Students thought that because horseshoe crabs crawl on the bottom of the ocean, they might be scavengers. In reality, horseshoe crabs are carnivores that subsist on soft-shell crabs, clams, mussels, and worms.

There is little meat on the horseshoe crab to eat, although Native Americans ate the meat at the base of the horseshoe crab's tail, and some ate their roe, or eggs. There are historical records of the telson being used as a spear for fishing by Native Americans and also of dead horseshoe crabs having been used for fertilizer, as they are today. Humans are the horseshoe crab's worst enemy. The growing use of synthetic fertilizers has slowed the need for harvesting horseshoe crabs for fertilizer; however, horseshoe crabs are still killed because they are pests to people who fish because they eat valuable shellfish.

I explained to students that horseshoe crabs are poor swimmers and walk/crawl along the bottom of the ocean as adults. Like their relatives the scorpions and the spiders, horseshoe crabs are solitary creatures and do not venture very far from where they were hatched, a maximum of 6.4 km. Instinctively, as adults, they make their way to the beaches in the spring to lay or fertilize eggs. Their ancestors, along with those of the cockroach and the coelacanth, have lived on Earth much longer than humans.

Integrated Activities

Our study of the horseshoe crab integrated many disciplines. The derivation of the horseshoe crabs' Latin name, Limulus polyphemus, brought literature into our unit. We discussed the meaning of polyphemus (many limbs) and we read the story of Arachne since some of the horseshoe crab's closest relatives are arachnids.

We studied the derivation of scientific names and the life and work of Carolus Linnaeus, the Swedish naturalist who developed binomial nomenclature (the two-word naming system for living organisms). Students learned the sentence "King Philip came over from Greece singing songs," a mnemonic device for kingdom, phylum, class, order, family, genus (always a capital letter), species, and subspecies. Students then knew the horseshoe crab as genus: Limulus, species: polyphemus.

In social studies, we located sites where cousins of Limulus polyphemus live and completed range/ distribution maps. At first, we asked students on the Kidsphere electronic mailing list (kidsphere-request@vms.cis.pitt.edu) what they knew about the horseshoe crab. Now we also communicate with other schools that we've contacted through our Web site (http:// www3.guilford.k12.nc.us/spages/ grn/home.html) or through people at our school having contacts at other schools.

In mathematics class, we talked about determining mass, measuring, tagging, taking a census, and sampling the population of horseshoe crabs. With younger students, we counted the number of legs, eyes, and tails that each horseshoe crab had. Students also tried counting the number of eggs in a photograph of a horseshoe crab egg deposit. This proved quite difficult and demonstrated to the students how tiny the horseshoe crab's eggs are.

We measured body length and intereye distance, the distance between the eyes. (Intereye distance is used to determine age—the greater the intereye distance, the older the horseshoe crab).

Other animals lend themselves readily to studies such as this. The cicada has an interesting life cycle and can be collected easily in the fall. Octopi can be purchased at the fish market and are good for observation purposes. Squid are also interesting creatures to examine. I have used squid in a lesson connected with a unit on rockets because of the squid's reliance on jet propulsion.

A Continuing Study

Students question why the horseshoe crab seems to have so few predators, how they are able to breathe when they are out of water for long periods, and how the horseshoe crab eats. The students are also fascinated by the fact that horseshoe crabs swim on their backs. Our study of horseshoe crabs keeps growing, and we look forward to discovering more about these unique creatures next year.

Resources

Hall, W., Jr. *The Horseshoe Crab.* (1994). Marine Advisory Service (MAS) Bulletin. Newark, DE: Delaware Sea Grant College Program.
Hall, W., Jr., and Shuster, C., Jr. *Horseshoe Crab Model.* MAS Bulletin supplement. Newark, DE: Delaware Sea Grant College Program. James, S. (1989). Introducing ... horseshoe crabs. *Science and Children, 26(7),* 12-14.
Rudloe, J., and Rudloe, A. (1981). The changeless horseshoe crab. *National Geographic, 159(4),* 562-572.
Spitsbergen, J. (1980). *Seacoast Life.* Raleigh, NC: North Carolina State Museum of Natural History.
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Togg Films. (1982). *The Great Horseshoe Crab Field Trip.* [Videocassette]. Orey, PA: Bullfrog Films.

Classroom Materials

Preserved horseshoe crab specimens are available ($2.55 to $6.95, depending on size) from Carolina Biological Supply, 2700 York Rd., Burlington, NC 27215; (800) 334-5551.

MAS bulletins on the horseshoe crab and other marine studies topics (up to five titles free; additional titles are 254 each) and the *Horseshoe Crab Model* MAS Bulletin supplement ($1) are available from the University of Delaware, Marine Communications Office, Newark, DE 19716-3530; (302) 831-8083.
The Horseshoe Crab: A Living Fossil, a Hyperstudio presentation by Helen Cook and Catherine E. Matthews, is available at http://www3. guilford.k12.nc.us/spages/grn/crabzone.stk

Also in S&C

Huff-Benkoski, K.A. (1997). Ocean connection. (In the Schools) *Science and Children, 34(4),* 35-36.
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