Sea Urchin Information

Charles Coleman, July 2, 2005

Basic biology

Sea Urchins (Phylum Echinodermata, Class Echinoidea) have been evolving for around 500 million years. There are about 950 described species. The echinoderms branched from the cnidarians (corals, anemones, jellyfish) a phylum that in also radially symmetrical, and began the deuterstome line. The bilaterally symmetrical planula larvae of the cnidarians probably became sexually mature (neoteny), giving rise to the flatworms and the subsequent protostome line of evolution.

Urchins are spherical, ranging from squash ball to softball in size. Their mouth is located nearest the substrate (the oral surface) and their anus, genital pore and madreporite are located on the upper (aboral) surface (periproct). The exterior of the urchin is formed from fused skeletal plates covered by connective tissue, nervous tissue and a ciliated epidermis, and is thus not strictly speaking an "exoskeleton". It is referred to as the "test". Various appendages cover the test. The genes that control the formation of these appendages are very similar to the genes involved in appendage formation in a wide range of phyla, including for example, arthropods, annelids, and ascidians. (1)

The appendages: a) spines: these attach to the test with a ball and socket joint. Musculature permits them to move in any direction. They provide protection and some locomotion. b) Pedicellaria: There are several types. Tridentates have 3 pincers that come together to grasp objects. They are borne on stalks and move like small spines to clean the surface and move objects. The globiferous pedicellaria are small stalked sacks and can contain poison. c) Sphaeridia are stalked ovoid bodies that likely act as statocysts. d) Tube feet: These locomotor devices are unique to echinoderms and extend from a water canal system. Water enters this system via the madreporite and passes via a tube (stone canal) to the ring canal that circles the mouth on the oral side. Five radial canals extend from the ring canal. At intervals the tube feet pass out through the test. Each can be extended or contracted by compression of a bag-like ampulla that is located at the spot on the radial canal where the tube foot emerges. Two parallel rows of tube feet form an ambulacrum that radiates from the mouth. There are five of these ambulacra, hence 5-fold symmetry. If the ampulla is expanded while a tube foot is in contact with an object, the foot attaches by suction.

Within the test the mouth leads to an oesophagus and intestine before exiting via the aboral anus. Gonads terminate at the aboral gonopores. Five gills emerge around the mouth.

Nutrition: Urchins are primarily herbivores and use an elaborate jaw system of 5 teeth to rasp at algae. The teeth are attached to an arrangement of bones that form a complex system of levers called Aristotle's lantern. The 5 pointed teeth come together to make a "5-jawed" bite. These jaws are sufficiently strong in some species to dig a dished crevice in rock. The urchin sits in this hollow. They may also consume detritus that is passed to the mouth by the pedicellaria. The grazing of urchins is significant. Lobsters prey on urchins and when the lobsters were over-fished, the urchin population grew to over-graze the kelp forest. The high density of urchins resulted in disease, but not to the point of restoring balance (2). When storms and disease destroyed both the urchins and coral off Jamaica, algae took over instead of slower growing coral. Only when the urchins became reestablished did coral growth begin again. The urchins consumed the competing algae. (3) Irregular urchins (heart urchins/sea biscuits, sand dollars) burrow and are deposit feeders.

Urchins are eaten by man, sea otters, lobsters, crabs, fish, (seals and sea lions??), starfish, seagulls, bacteria.

Habitat requirements include crevices for intertidal species, an algal food supply (kelp is a favorite for certain northern species), clear, clean, well-aerated and unpolluted water. (The Environmental Protection Agency uses urchin fertilization and development success as an indicator of water quality.) Urchins can graze and denude an area of sessile organisms (algae, ascidians, worms, and amphipods) that does not include mussel beds. Fish and nocturnal crabs keep urchins at bay in mussel beds (9). In New England, vertical rock walls are usually inaccessible to urchins. Storms, disease and predation control the urchin population so that it tends to fluctuate. Removing urchins (Diadema Antillarum) from an isolated reef resulted in a tenfold increase in algal growth (9).
Some urchins species may live for 30 years. A sand dollar study showed they reached 95% of their max size in 5 years. Five to eight years might be an average lifespan. (5)
Reproduction. Urchins are dioecious and look alike. They release eggs or sperm to accomplish external fertilization. Some cold water species brood their eggs, using spines to hold the eggs in place. Heart urchins and sand dollars also do this. Otherwise, the larvae enter the plankton and are dispersed. Much is known about their embryology since it is an easy deuterostome system to study.

In the Galapagos, the white sea urchin (Tripneustes depressus) is being studied closely because there is a proposal (1999) for an urchin fishery for human consumption. (7) The ecology of urchins, as described above (2, 3) has been shown to be closely linked and balanced with their food supply and predators. As a general rule, speciation increases near the equator and decreases as one moves toward the poles (8). Fishing aggressively for a specific species is probably more likely to upset the ecology of an equatorial species than a more northern species that occurs in vast numbers. Common urchins in the Galapagos include the "pencil urchin" Eucidaris thouarsii, the "crowned urchin" Centrostephanus coronatus, the "Galapagos green urchin" Lytechinus semituberculatus, the "Flower urchin" Toxopneustes rosens, the "giant sand dollar" Clypeaster europacificus, the "heart urchin" Lovenia cordiforms, the "grooved heart urchin" Agassizia scobiculata, the "white urchin" Tripneustes depressus. (11)

Something to ponder: Bindin is a protein that mediates the attachment of egg and sperm in urchins. Allopatric species of Tripneustes have unchanging and similar bindin. Sympatric species have constantly altering bindin, both between separate species and within species. Altered bindin prevents hybridization. Why is the mutation rate greater for sypatric species? (10)

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