Introduction to the Invertebrates

An invertebrate is any animal without a backbone. Invertebrates make up 95% of all species of animals on the earth, and the variety of invertebrates is enormous. Scientists group or "clas sify" all of these different types of animals into broad categories called phyla, on the basis of their patterns of symmetry and on the basis of their overall body plan. There are 5 particularly important invertebrate phyla (and another 23 or so less important phyla). The major invertebrate groups are classified as:

- Phylum Cnidaria: sea anemones, corals, and jellyfish
- Phylum Annelida: segmented worms
- Phylum Mollusca: clams, snails, and squids
- Phylum Arthropoda: lobsters, beetles, crabs, and flies and scorpions
- Phylum Echinodermata: sea urchins, sea cucumbers, and starfish

Various guidelines are used by taxonomists (zoologists who initially describe new species and classify animals) to establish the Classification System for the Animal Kingdom, just as librarians use a guideline, the Dewey Decimal System, for arranging books in a library. Pattern of symmetry is an important consideration for determining relationships at the phyletic level of classification, but symmetry alone does not provide sufficient information to determine phyletic status. For example, lobsters are bilaterally symmetrical, with a left side and a right side, with a front end and a rear end, and with a top side (called the "dorsal" side) and a bottom side (designated "ventral"). Since we ourselves exhibit this same set of relationships, bilateral symmetry does not seem to be particularly unusual, except that humans walk upright and we call our dorsal side our "back" and we call our ventral side the "front." All vertebrates, including people, are bilaterally symmetrical, and, indeed, so are most invertebrates. Lobsters and all of their millions of relatives, from butterflies to crabs and all other members of the Phylum Arthropoda, are also bilaterally symmetrical. But arthropods are not related to vertebrates, even though both groups exhibit similar patterns of bilateral symmetry. This is because arthropods and vertebrates have extremely different body plans, with different types of skeletons and muscles, and different patterns of plumbing. Vertebrates have internal skeletons of bone, whereas arthropods have external skeletons made of an animal plastic called chitin. The muscles that move our fingers lie outside of and around the bones of the hand, whereas the muscles that move the pincers of the claws of a lobster are inside the claw, beneath the chitinous shell, its external skeleton. The basic architecture of these two groups of animals is so different that they cannot have had a common ancestor, and so we classify arthropods and vertebrates as belonging to separate phyla, on the basis of both their body plans as well as their patterns of symmetry.

Worms are also bilaterally symmetrical, with a front end and a back end, with left and right, and a dorsal and a ventral surface. But worms don't have rigid skeletons, like crabs or cats. Instead they move by using hydraulic pressure, in the same way that the brake fluid in a car transmits the force of the driver's foot to the brake pads on the wheels. The muscles of a worm are located in the tube-like body wall. When these muscles contract they increase the hydraulic pressure of the body fluids inside the worm's body, extending the front end of the worm and permitting it to squeeze through holes between rocks and to burrow in the soil. Worms thus have unique body plans that indicate ancient ancestral relationships, and most worms are classified by taxonomists as members of the Phylum Annelida.

Clams and snails and squid, in the Phylum Mollusca, are also bilaterally symmetrical, with a left and right, a top and bottom, and a front and a back. But snails often have a twisted shell, producing a confusing dorsal symmetry, and clams don't have heads, so it is tricky (but rather fun) to figure out which is the front end and which is the back end of a clam. Clams and snails have external skeletons, like arthropods, but their external skeletons are not made of animal plastic. Instead the skeleton is constructed of calcium carbonate, the same material used for construction of bones, but the calcium carbonate in the shells of molluscs is deposited in a much harder form than bone, in the form of the minerals calcite and aragonite. Squids and octopus don't have external shells, but they have the same body plan exhibited by Nautilus, which does have a snail-like shell, so we include squids and octopus in the Phylum Mollusca also.

Members of the Phylum Cnidaria, the sea anemones and jellyfish, are not bilaterally symmetrical but instead they are oriented in distinctive radial patterns with tentacles in multiples of 4 or 6 around a central mouth. Their entire body plan is also unique, with a mouth and a stomach but no anus at all. Food captured by tentacles that ring the mouth enters the stomach cavity, and when the food is finally digested the remnants are expelled through the mouth. Cnidarians have exceptionally simple nervous systems, arranged radially around the mouth; they have no heart or any other complex organs. Some cnidarians, such as sea anemones and corals, live attached to the sea floor. Jellyfish, or medusae, can move through the water column because they have a rather unique, flexible "skeleton" formed of a jelly-like substance called "mesoglea," which stretches the radial muscles after each contraction, permitting rapid swimming. Cnidarians capture food with tiny stinging capsules, called cnidae or nematocysts, within specialized cells, called cnidocytes, on the tentacles. The current name of the phylum, "Cnidaria," emphasizes the importance of these stinging cells for the biology of this entire group of animals, and this name has replaced the more familiar phylum name Coelenterata.

Sea urchins, starfish, and sea cucumbers are members of a large assemblage of marine animals classified as members of the Phylum Echinodermata. Echinoderms all exhibit radial symmetry, but they are all structured exclusively in pentamerous patterns, with the 5 arms of starfish being the most distinctive expression of the 5-pointed, radial organization of the body plan. Sea urchin skeletons look almost perfectly round, but if one looks carefully, the holes and tubercles on the shell are clearly organized into pentamerous radial sectors. The skeletons of echinoderms are internal structures of carbonate, as are the skeletons of vertebrates, but the mineral in the skeletal ossicles is magnesium calcite. Sea urchins have rigid skeletons, with the mouth opening on the lower surface, called the "oral side", next to the surface of the sea floor, and with the anus upward, on the top of the body, called the "aboral" side. Sea cucumbers have tiny skeletal elements and a flexible body wall, but they are oriented differently, moving across the sea floor like huge worms, with the mouth, or oral end, at the front and the aboral end, with the anus, at the rear. In cross-section, sea cucumbers are obviously pentamerous and radial in their body plan, but now this 5-part symmetry is stretched out lengthwise, and, functionally, the sea cucumber looks like a fat, bilateral worm.

These 5 phyla are all distinctive and important groups of invertebrates, but within each group there are also distinctive subgroups, such as starfish as opposed to sea urchins. Taxonomists have categorized these distinctions by dividing each Phylum into Classes, Classes into Orders, Orders into Families, and Families into Genera. Finally, animals are sorted into unique species, the individuals of which reproduce only with one another. Every species is designated by a unique two-word Latin name, a genus and a species name. For example, the common two-spot octopus on our coast is formally named Octopus bimaculatus. Notice that the first word in the name begins with a capitalized letter, that the second word in the name is in small case, and that both the genus and species names are underlined. We need universal, scientific names for each species because people in different parts of a country, and in different countries, invariably use different, local names for the same species or similar names for different species. This would result in incredible confusion if we could not keep our information on each species in the right category. For example, if the books in the Library of Congress were all shelved at random, it would be difficult, if not impossible, for a historian to learn anything about the history of literature in Iceland. Just so, must we keep our zoological library in order, with all the species correctly named and properly classified.