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Invertebrates: A Resource for Teachers

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No BONES about it!

The animal Kingdom is divided into 30-34 phyla, of which, all but one includes invertebrates. It is estimated that 97% of all the animals on earth are invertebrates. The one distinction possessed by all invertebrates is the lack of a backbone, but all other major physical characteristics, such as body symmetry, internal and external body structure, habitat, diet, locomotion, and reproduction are widely varied.

Most invertebrates can be found in the following eight phyla: Annelida, Arthropoda, Cnidaria, Echinodermata, Mollusca, Nematoda, Platyhelminthes and Porifera.



The phylum Annelida includes approximately 9,000-12,000 species of wormlike invertebrates whose bodies are segmented. Bristle worms, mainly marine, make up the class Polychaeta; earthworms (mainly terrestrial and freshwater) make up the class Oligochaeta; and leeches (mainly freshwater but also some marine and terrestrial species) make up the class Hirudinea.



Included in the Annelids are hundreds of segmented marine worms, both tube-dwellers and free-movers. These long, soft bodied animals have no skeleton but can become more rigid by pressure resulting from their fluid-filled body cavity. Movement occurs when circular and longitudinal muscles alternately contract. The body of the feather-duster worm is encased in a parchment-like tube that extends a feathery head for feeding. These feathery tentacles are quickly withdrawn when suspected danger nears. The cilia trap particles of food and move it to the centrally located mouth. Cilia that are removed by predators or shed if attacked by predators can regenerate.

Countless invertebrates live at all levels of the rainforest. There are more insects (about 750,000 species) in the rainforest than any other type of animal. Some scientists speculate that 30,000,000 species have yet to be discovered. The invertebrate population provides many services for its ecosystem. Insects, for example, serve as pollinators, protectors, predators, prey, architects, gardeners, weapons, and food — just to name a few.

The phylum of invertebrates known as Arthropoda possess tough outer coatings (exoskeletons) and a jointed body and appendages. More than one million species of arthropods ("archo" for joint and "pods" for feet) have been identified, with countless species yet to be discovered. This large phylum has been subdivided into three living subphyla: Chelicerata, Crustacea and Uniramia.



Chelicerates are the scorpions, spiders, mites, horseshoe crabs, and sea spiders. Chelicerates have six pairs of appendages, which are unbranched. These include a pair of chelicerae (first pair of appendages that are used for feeding), a pair of pedipalps (second pair of appendages) and four pairs of walking legs. Chelicerates lack mandibles and antennae.

The subphylum Crustacea is very diverse. They all have branched antennae, chewing mouth parts called mandibles, four or five pairs of walking legs and two body divisions (cephalothorax and abdomen). The subphylum Crustacea includes invertebrates such as crabs, shrimp, crayfish, pill bugs, barnacles, and lobsters that can weigh as much as 40 pounds (18 kg). Microscopic examples include water fleas, copepods, and brine shrimp.

This subphylum is a significant group economically. Lobsters, shrimp, and crabs are major seafood sources for man. Crustaceans have a "crust" (or chitin) that may be used for protection and body structure. In some species, this "carapace" becomes very thick. This exoskeleton is shed (molted) as the animal grows.



Crustaceans are mostly marine arthropods though many, such as the crayfish, have invaded fresh water. One group, the sow bugs, have become terrestrial, living beneath stones and logs and in leaf mold. In the sea, large crustaceans such as crabs and shrimp are common bottom-dwelling arthropods. Many of the smallest species of crustaceans are an important component of the zooplankton (tiny floating or weakly swimming animals) which serve as food for other invertebrates, fishes, and whales.

Uniramia is the largest of the arthropod subphyla. It includes insects, millipedes, centipedes, etc. Uniramians are characterized by having uniramous (single branched) appendages. The majority of uniramians are terrestrial, although a few species are aquatic. It contains not only the class Insecta but also four closely related classes of long-bodied arthropods collectively known as myriapods: the class Chilopoda (centipedes), the class Symphyla (symphylans), the class Diplopoda (millipedes), and the class Pauropoda (pauropods).

Uniramians are mostly terrestrial and, in contrast to the other arthropod subphyla, they are believed to have had a terrestrial origin. Centipedes, symphylans, millipedes, and pauropods live beneath stones and logs and in leaf mold, insects are found in all types of terrestrial habitats and fresh water. The sea has remained the domain of crustaceans and only at its very edges are insects found.

Cnidaria is a diverse group of aquatic invertebrates including jellyfish, sea anemones, sea fans, hydras, and corals. They live in all oceans and a few species inhabit freshwater. The word cnidaria means "with stinging cells." Although they vary greatly in appearance, size, shape and color, all cnidarians have a radially symmetrical body. This means they are formed in a circle around the central mouth.



These simple animals resemble a hollow sack (the stomach) with one opening in the center that serves as both mouth and anus. The opening is usually surrounded by tentacles containing tiny stinging cells known as nematocysts that catch food by ejecting a poisonous harpoon-like hollow thread into the body of their prey.



All cnidarians are in one or two forms - a polyp (usually attached to a substrate) or a free-swimming medusa. Although some polyps can crawl or swim, most are attached to a base by a pedal disk. Most cnidarians are either a polyp or a medusa, however, some pass through both phases, starting as a polyp and later becoming a medusa.

Both the polyp and medusa are passive predators. The medusa catches food on its trailing tentacles as it floats about, and the polyp catches prey that happens to swim into its tentacles. The mouth and tentacles of the polyp face upward, while the mouth and tentacles of the medusa are under the bell, pointing downward. Included in this phylum are the following classes: Hydrozoa, Scyphozoa, Cubozoa, and Anthozoa.

Anthozoans are exclusively marine, polypoid cnidarians. They include the sea anemones and other anemone-like groups with skeletons (such as the "stony" corals) and without skeletons (such as tube anemones), sea pens, sea fans, blue coral, and black coral. Anthozoans occur from the intertidal zone to the depths of the trenches 3.7 miles (6000 m).





Sea anemones are basically formed by a single polyp with a radial shape and one central opening. The opening is surrounded by multiples of six tentacles that are covered with nematocysts. Unlike many corals, anemones are solitary. Even though they are colonial species, they are individual anemones living in aggregate groups.

Corals can contain millions of single-celled zooxanthellae. Zooxanthellae are single-celled plants or algae that live inside the body tissues of the polyp. They photosynthesize by using the energy of the sun to change carbon dioxide and water into carbohydrates and oxygen for use by their host. In this symbiotic partnership, the zooxanthellae benefit from the waste products of their host. Many anemones also use their nematocysts for capturing live prey which is then grabbed by the tentacles and fed into the central opening. Nematocysts can also be used as a defense against predators.



As the name of the group (Cubozoa) implies, box jellies are sufficiently distinct to be placed in their own class. Box jellies are similar in form to the "true" jellyfish, however, when viewed from above, they can be identified by their square "cube" shape.

In Hydrozoa, the polyp phase dominates the animal's life cycle. Most Hydrozoan polyps reproduce by budding to form a polyp colony that attaches to solid objects such as pilings or rocks. Some Hydrozoan polyps also bud to form a medusa, which is generally short-lived and small. This class also includes freshwater hydra (which lacks a medusa stage), fire coral, and the Portuguese man-of-war. In Hydrozoans, both polyp and medusa body forms are present. Many groups secrete a chitinous skeleton in the polyp stage. Some groups have a polyp stage that is colonial and secretes a calcareous skeleton, like a coral.



Included in Scyphozoa are true jellyfish (similar organisms are classified in the Hydrozoa and Cubozoa). True jellyfish are graceful, yet sometimes deadly creatures. Their stings may cause skin rashes, muscle cramps, or even death.

Some jellyfish go through both the polyp and medusa stages; however, the medusa phase is most prevalent. Jellyfish are basically umbrella-shaped animals with tentacles. These fragile graceful creatures are about 95% water. They float with the sea currents, but they can also move about by contracting and relaxing the muscles around the edge of their umbrella, also known as the bell. The tentacles that line the bell are armed with stinging nematocysts.

Long dangling oral arms from the center of the bell help move their captured food up to the mouth. In females, these arms also serve as "brood patches" for fertilized eggs. Jellyfish vary greatly in size. The Australian sea wasp, with a four to five inch (10 cm - 13 cm) wide bell, is one of the most poisonous of all jellies. The lion's mane jellyfish is one of the largest, often having a bell-width over ten feet (3 m) and ten feet (3 m) long tentacles. The brown sea nettle, found along the northwestern US-Canadian border, grows to have a bell diameter of three to four feet (0.91 - 1.2 m) with long, flowing, frilly white oral arms.

Echinodermata is the largest phylum to lack any freshwater or land specimens. The Echinoderms can be divided into three forms: star-like (sea stars, brittle stars), spherical (sea urchins, sand dollars) and cylindrical (sea cucumbers and sea apples). The body structure of echinoderms ("echino" for spiny and "derm" for skin) is made up of skeletal plates, spines, arms, etc. in multiples of five (pentaradial symmetry). They have a water-vascular system that operates even their tube feet and pinchers.

By muscular contraction and a water inflation/deflation system, these creatures can stretch and extend their hollow tube feet and move along most horizontal or vertical substrates. These tube feet can capture live prey and move it into the sea star's mouth.

Sea stars have five or more rays or arms that can be regenerated. A whole animal can even be formed from one ray and a portion of the central body. Sea urchins and sand dollars are somewhat round. Sea urchins have spines instead of arms that are coordinated with their tube feet for moving food to their mouth.



The mouth is kept toward the substrate where it scrapes and chews off algae and various organisms. Five paired rows of tube feet extend from their mouth up to the top of their body. Sand dollars move on their hairlike spines on the surface around their mouth. The five petals contain their tiny tube feet through which they breathe.

Sea apples and sea cucumbers are elongated and lay on a side instead of on the oral surface. The tube feet around their mouth have tentacles (often feathery looking) used for collecting food. Other tube feet scattered over their bodies are used for movement.



“Mollusca” comes from the Latin “mollis” meaning soft. Mollusks make up the second largest group of invertebrates, ranging in size from the tiny snail to the giant squid. Mollusks are found in nearly all habitats. In the sea they occur from the deepest ocean trenches to the intertidal zone. They may be found in freshwater, as well as on land, where they occupy a wide range of habitats.

There is much diversity within this group, however, they do have some structural likenesses. They are basically a soft-bodied group, with a head (except for bivalves), a muscular foot, a "visceral hump" containing body organs, and a mantle. The mantle secretes the shell (in many colors, textures, shapes, and sizes) and forms the pearl - the best-known product produced by mollusks. The mantle may also protect itself by secreting poisons or inks. Some have a rasp-like tongue (radula) that is covered with hundreds of teeth used for scraping algae and other organisms off rocks and surfaces.

Gastropods are the largest class of mollusks. Marine species have adapted to all types of habitats including freshwater and terrestrial. Found in the class of gastropods (“gastro” for stomach and “pods” for feet) or univalves are snails and the "no-shell" mollusks - nudibranchs or sea slugs.

Sea slugs are sometimes called "sea butterflies" because of their bright and numerous colors/patterns. Their bright coloration may be used for camouflage or to warn predators of their poison. Their gills may be feathery-looking appendages located in various locations on their backs. Some members of this group feed on anemones or other stinging creatures, stealing the stinging nematocysts and "recycling" them in their gill tufts to be used as a defense against their enemies.

Bivalves (“bi” for two and “valve” for shell) - mussels, clams, oysters, scallops, and cockles are also included in this group. Their two shells are usually in symmetrical parts, hinged together by a pair of tight, strong muscles. In bivalves, the head is replaced by a pair of large gills used for breathing and feeding. They are covered with cilia that continuously beat to siphon in food and water and carry away waste materials and water. Many bivalves lead a sedentary life, however, some like the scallop and cockle are very mobile, using a form of jet propulsion for movement.



The many clam (or *Tridacna*) species are probably the most famous of all bivalves. The largest, the *Tridacna gigas*, can weigh over 220 lbs (100 kg). Much of the color within the clam’s mantle results from its zooxanthellae.

Also in the mollusk group are the cephalopods (“cephalo” for head and “pods” for feet) - nautilus, squid, octopus, and cuttlefish. The nautilus is the only cephalopod with an external shell. Squids and cuttlefish only have a hint of an internal shell and some (such as the octopus) have no shell at all. A sharp bill or beak is used to bite their prey that they hold in their arms. The arms have developed from the single muscular foot found on other mollusks. Well-developed nervous systems with brains and eyes allow these cephalopods to be considered the most intelligent of all invertebrates.



The Phylum Nematoda consists completely of cylindrical-shaped roundworms. Nearly all roundworms are alike in their general body structure: a cylindrical body, a tapered tail, and a blunt head. There are two main types of roundworms: free-living and parasitic.

Free-living roundworms are more abundant than parasitic roundworms and just as harmful. They destroy plant roots, causing the entire plant to die and can deprive an animal of the nutrients it needs to survive. Free-living roundworms, unlike the parasites, live virtually every place on earth where other creatures live and many of them feed on rotting organic matter. Parasitic roundworms live within the tissues of plants and the body fluid or tissues of other animals. They survive off their host organism and only occasionally do harm to the organism.

Phylum Platyhelminthes consists of flatworms, tapeworms, and flukes. They range from brilliantly colored creatures that swim in the ocean to incredibly fascinating parasitic tapeworms that live inside human bodies. Flatworms are bilaterally symmetrical with a defined head and tail region and a centralized nervous system containing the brain and nerve cords. Clusters of light-sensitive cells make up the eyespots. The head region of the flatworm also contains other paired sense organs, which are connected to the flatworm's simple brain. Flatworms are hermaphroditic and capable of sexual and asexual reproduction. Their bodies have only a single opening, which serves as both a mouth and an anus.

Sponges (phylum Porifera, meaning "with pores") are one of the simplest multi-cellular sea animals. Sponges are groupings of cells with no real tissues or organs. The wall of the sponge has many small holes or pores through which water enters.

These stationary (sessile) animals vary in size, shape, and color. Some are shaped like vases and can grow to be over six feet (1.8 m) tall and/or wide. Small skeletal parts called spicules can be found in the body wall of the sponge. These spicules, which can be made of calcium carbonate or silica, support the structure of the sponge.

All sponges are filter-feeders, collecting food and oxygen from the water that flows through their body and out through a hole usually found at the top of the sponge. This filtering process creates a current of water. Scientists discovered that some sponges only four inches (10 cm) tall and one-half inch (1.3 cm) wide can filter as much as five gallons of water each day.

Examples of Arthropoda:

Common name:

Arrow crab
Bark scorpion
Painted lady
Gulf fritillary
Monarch butterfly
Goliath bird eating tarantula

Scientific name:

Stenorhynchus seticornis
Centruroides gracilis
Vanessa cardui
Agraulis vanillae
Danaus plexippus
Theraphosa blondi

Examples of Cnidaria:

Common name:

Tealia red anemone
Painted anemone
Brain corals
Tongue coral
Hammer coral
Bubble coral
Elephant ear mushroom coral
Staghorn coral
Starry cup coral
Moon jellyfish
Carpet anemone
Red mushroom coral
Leather coral
Finger leather coral

Scientific name:

Tealia crassicornis
Urticina crassicornis
Blastomussa (5 species)
Herpolitha limax
Euphyllia ancora
Plerogyra sinuosa
Rhodactis (7 species)
Acropora (more than 30 species)
Acanthastrea lordhowensis
Aurelia aurita
Stichodactyla haddoni
Actinodiscus nummiferus
Sarcophyton sp.
Sinularia (more than 160 species)

Examples of Echinodermata:

Common name:

Bat starfish
Ochre starfish
Sea apple
Spiny sea urchin

Scientific name:

Patiria miniata
Pisaster ochraceus
Pseudocolochirus violaceus
Diadema sp.

Examples of Mollusca:

Common name:

Giant Pacific octopus
Ruffled clam
Giant clam

Scientific name:

Octopus dofleini
Tridacna squamosa
Tridacna gigas

USEFUL VOCABULARY

anemone	usually a cylinder-shaped polyp with an oral opening at the top and a pedal disk on bottom attached to substrate
Annelida	the phylum comprised of symmetrical worms segmented both internally and externally
anus	the opening at the end of the digestive system through which waste leaves the body
arachnids	air-breathing arthropods characterized by simple eyes and four pairs of legs, including spiders, scorpions, mites, etc.
Arthropods	segmented invertebrates having jointed legs and an exoskeleton made of chitin (“arthro” - joint, “pods” – feet)
bilateral symmetry	matching or corresponding of one side to the other, if divided into two parts
bivalve	a mollusk having two shells hinged together (clams, oysters, scallops, mussels)
calcareous	chalk-like or containing calcium carbonate
calcium carbonate	a white, water-insoluble powder in various forms
carapace	a shell or shield covering part of the body of an animal
cephalopods	mollusks having tentacles attached to their heads, including nautilus, squid, cuttlefish, and octopus (“cephalo” – head, “pods” – feet)
chitin	a tough, semi-transparent, horny substance, the principal component of the exoskeletons of arthropods
cilia	tiny, hair-like outgrowths, projections
Cnidaria	with nematocysts (stinging cells) such as anemones and jellyfish
colonial	colonies or groups of plants or animals of the same kind living in close association
corallimorpharians	a group of coral-like colonial anemones
crustaceans	aquatic arthropods typically having a hard shell or crust, including shrimp, lobster, crabs, and barnacles
decapods	having ten feet or legs (such as crustaceans with five pair of walking legs, cephalopods with ten arms)
decomposition	the process of breaking up into simpler compounds through chemical change; rot
Echinodermata	the phylum made up of spiny animals that have a pentaradial symmetry, (“echino” - spiny, “derm” – skin)
exoskeleton	a hard structure that develops on the outside of a body for protection
filter feeders	animals that collect food and oxygen from the water that flows through the body and out through openings
Gastropoda	a class of mollusks (snails) typically having a one-piece coiled shell, flattened muscular foot, and a head with stalked eyes (“gastro” – stomach, “poda” – feet)
gorgonians	a genus of corals, usually with branching, horny or calcareous skeletons
hermaphroditic	having both male and female sex organs or other sexual characteristics

invertebrate	an animal lacking a backbone
mantle	a protective layer of skin (epidermis) in mollusks or brachiopods that secretes a substance to form the shell
marine	of the sea
medusa	a free-swimming, bell-shaped jellyfish with mouth and tentacles on the underside
Mollusca	the phylum made up of animals that typically have shells completely or partially enclosing a soft body
molt	the shedding of the hard exoskeleton, feathers, etc. at regular intervals
nematocysts	the organ with hollow tubes with threads that can be ejected to sting and capture prey or for protection
pentaradial symmetry	five identical parts arranged around a center
photosynthesize	growth resulting from the combining of water and carbon dioxide, with help from sunlight and chlorophyll (“photo” – light, “synthesis”)
phylum	a main subdivision of the animal kingdom
pollinator	an animal that carries pollen from one flower to another
polyp	a sedentary animal form that has a base (usually fixed), body sack, and an upward end with tentacles and mouth
Porifera	the phylum made up of sponges; “with pores”
radial symmetry	the matching or corresponding of parts on a line coming out from a center point
radula	raspy, file-like tongue found in some mollusks for scraping algae, etc.
sclerite	limestone crystals, spicules, plates, or similar hard parts
sedentary	not migratory, staying in one place, sitting, attached to something
segmented	divided into segments, portioned
sessile	non-moving animals, stationary, permanently attached to a base
silica	a natural substance used by some animals for support in skeletal structures
solitary	not living in groups or colonies
skeletal	of or relating to a skeleton
spicule	spur; a small part (silica or calcareous) of the skeletal components
substrate	foundation, the base on which an organism lives
symbiotic	two dissimilar organisms living together in a relationship that is usually beneficial to one or both
symmetry	a match, a repeat or correspondence in form, size, and arrangement of parts
toxins	poisons
tentacle	slender, flexible appendages in animals, particularly invertebrates
visceral	affecting the organs in the body cavity
zooxanthellae	single-celled plants safely protected inside the tissue of coral, most anemones, and various other invertebrates; able to photosynthesize, the zooxanthellae provide oxygen for use by their host in return for respiration