Branches on the Tree of Life

ARTHROPODS

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Produced by BioMEDIA ASSOCIATES ©2006
Runtime: 26 Minutes. The DVD also contains 210-image Image Bank
and Guides for both the Program and the Image Bank.

Images and sequences in this Guide are from Branches on the Tree of Life: Arthropods.



This program was created from observations of arthropods, recorded over a 14 year period in natural habitats of western North America. "Natural habitats" include not only ponds, seashores, and forests, but also yards and gardens, excellent places to discover and observe arthropods.

Fossils of early arthropods can be found in 500 million year old sediments. They show the hardened exoskeletons and jointed appendages that characterize this group of animals. Arthropods have segmented bodies, and are believed to share a segmented ancestor with annelids. An early branch of arthropod life, the trilobites, underwent great diversity in the period roughly spanning 400-200 million years ago. They dominated the aquatic worlds of that time much as insects dominate terrestrial life today.

Early on, arthropods split into three evolutionary lines that persist today: the crustaceans, the chelicerates, and the uniramians. These names have come into current use based on a better understanding of evolutionary relationships among arthropods. They replace older class level names such as Arachnida (now Chelicerata), Myriapoda, Onychophora and Insecta. Myriapods, Onychophorans, and Insects share a common ancestor that had unbranched appendages and a single pair of antenna and so are now placed in an evolutionary branch--the Uniramia (uni-one, ramus-branch). Crustacea remains unchanged. We have referred to these three great lines of Arthropod life as "classes" but some taxonomists consider them to each be a sub-phylum. The program takes each evolutionary line: crustaceans, chelicerates and uniramians in turn and by observing representative members of the group, develops its characteristics, shows enough examples to give some idea of its evolutionary diversity, and shows some interesting natural history that can stimulate students in investigating these organisms on their own. Along the way we touch on some important principles of biology: adaptation, ecological niche, mechanisms that insure intraspecies matings, predator-prey relations, and concepts of biodiversity. Used with the other Branches on the Tree of Life programs, this program introduces students to the diverse world of living organisms accessible for direct observation and study.

CRUSTACEANS (Class Crustacea)

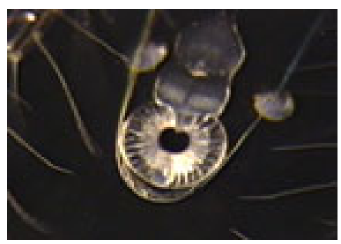
Characteristics: head and main body region fused forming a "cephalothorax." Two pairs of antennae.

Copepods

Copepods are mostly small organisms with five pairs of swimming legs, long first antennae, sexes separate and eggs carried externally. Copepods are easily collected from virtually any freshwater habitat. Most are suspension feeders, bringing in microorganisms on feeding currents set in motion by their mouth parts and swimming legs.

Ostracods

Also called "seed shrimp," ostracods have two shells the fully contain the body when closed. Ostracods scavenge and feed on detritus.



Cladocerans

The best known cladoceran is Daphnia, the water flea, common in pond plankton. In cladocerans the antennae are attached to the outside of the carapase, branched and covered with fine hairs offering a better grip on the water. Study the shots of free swimming Daphnia to see how the antennae are used in swimming. Some Daphnia species produce young by parthenogenesis. Holopedium, often found in lake plankton, suggests the diversity of cladocerans students may find in their plankton samples.

Eubranchiopods

This group includes brine shrimp. However the main evolutionary lines of eubranchiopods are found in temporary pools: tadpole shrimp, clamshrimp, and fairy shrimp. All grow rapidly, mate and produce resistant eggs that withstand freezing and drying.

Amphipods and Isopods

Most of these shrimp-like crustaceans lead aquatic or semi-aquatic lives. Land isopods, "sowbugs," live in moist habitats. To find amphipods, rinse aquatic vegetation into pan. Transfer the "scuds" to an aquarium for study.

Decapods

Crayfish, Lobsters, Crabs, and Shrimp, all with five pairs of walking legs. Crabs are an extremely diverse group. The examples show detritus feeders, algae eaters, the slender arrow crab, two kinds of filter-feeding crabs, and a tropical crab that harvests the coating of diatoms on sand grains, leaving the balls of sand as "finished work."

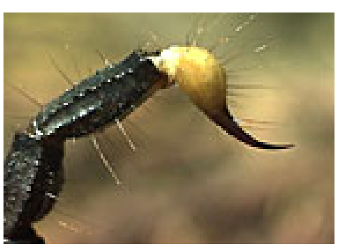
Barnacles

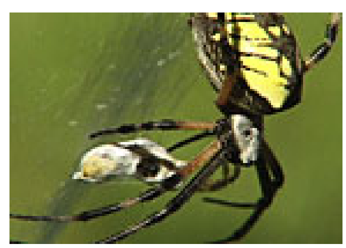
Early zoologists failed to realize that barnacles were crustaceans. The outer shell, cemented to the rock, and growing with the animal inside, left them confused about just how to classify these abundant animals. (Compare the scene of barnacle larvae with the scene of copepod larva and the barnacle's affinity to other crustaceans becomes evident.) The transition from the nauplius larva to the ostracod-like larva called a "cypris," and the settlement on an intertidal rock, was first clearly described by Charles Darwin, who used barnacles to bolster his theory of evolution through natural selection.

Barnacle mating

CHELICERATES, (Class Chelicerata)

Characteristics: Cephalothorax, chelicerae (feeding pincers), no antennae, a special pair of appendages (pedipalps) ahead of the walking legs that perform various function. This line of arthropod life is named for the pincer-like mouth parts found on many of its members. Extinct chelicerates include a giant scorpion-like beast named Eurypterus that must have made life difficult for early fish. Eurypterus is long extinct, but it's relative, the horseshoe crab is a common visitor to the sandy beaches of eastern North America.





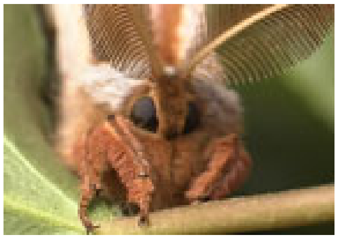
The main line of chelicerates is the arachnid line: scorpions, pseudoscorpions, whip scorpions (vinegaroons), spiders, harvestmen, ticks and mites. The program shows representatives from each group (excepting harvestmen, also known as daddy long legs.) An unusual observation is the predatory mite (Chelatus) feeding on dust mites. Forehead mites are found in around 95% of humans, a good chance for students to observe one of our more common commensals.

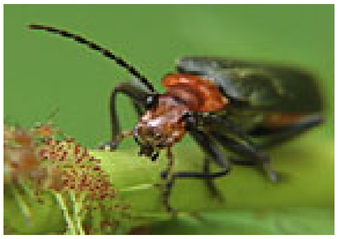
Thousands of species of mites fill the ecological niches appropriate to these small arachnids.

UNIRAMIANS (Class Uniramia)

This, the greatest line of arthropod life, probably originated from a small centipede-like creature with unbranched legs and a single pair of antennae. Such an organism was the ancestor of centipedes, millipedes and insects. Centipedes have fang-like mandibles with poison sacs and speedy locomotion achieved using one set of legs per body segment. Centipedes are predators and large species can deliver a painful series of bites if handled in a careless way.

Millipedes are for the most part slow moving creatures that feed on decomposing vegetation. Their defense is chemical, with some species producing cyanide gas—a powerful deterrent to predators. Millipedes have two pairs of legs per segment, and many small species live in moist forest humus and compost piles. The ancestors of centipedes and millipedes were the first terrestrial arthropods. They probably lived along wet shorelines and as plants began invading the land around 400 million years ago, terrestrial arthropods followed this greening.



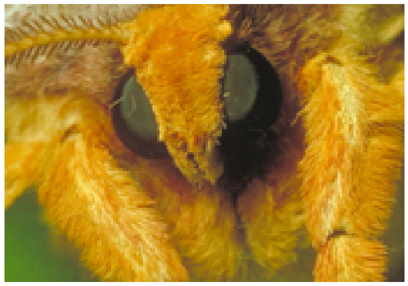


Visualizing the Insect Body:
The insect body plan became established around 300 million years. Insects have three main body parts, head, thorax with attachments for three pairs of legs and in flying insects, one or two sets of wings. An abdomen is clearly set off from the thorax. Insects have clear circulatory fluid kept flowing by a contractile tube on the dorsal side of the body. In most terrestrial insects air is taken in through spiracles, small openings along the body, and carried to the tissues through a branching network of trachea (air tubes). The size of the spiracle opening can be regulated to reduce water loss.

Malpighian tubules distributed through the insect's body remove metabolic wastes from the blood. We illustrate these internal features using the larval stage of a serphid fly--the rat-tail maggot. These transparent larva occupy the niche of manure feeder, living in puddles rich in organic waste material. This environment is abundant in food but lacks oxygen, a problem solved by the maggot's long snorkel tube which brings in air from the surface.

Various insect species have mouth parts adapted for their particular way of life. A twist on the chew and swallow approach is shown by insects with beaks or hollow fangs. The water tiger, larval stage of an aquatic beetle, feeds on fish, tadpoles, dragonfly larvae and other pond insects. It has no mouth, but rather a set of impressive fangs that, once fastened into its prey, inject digestive enzymes. The prey digests in its own skin, and the digested material is sucked back through the hollow fangs.





With so many of them around, insects have a potential problem mating with the correct species. Selection pressure works against crosses between closely related species as these matings may produce no offspring, or at best, offspring with varying degrees of sterility. This situation has encouraged the evolution of reproductive isolating mechanisms such as reciprocal courtship signals, lock and key reproductive parts, and pharamonal signals that are specific to the species. The female prometheus moth shown in the program landed on our lab window one evening--the first one seen in years. The next morning we found nine males clustering around her.

Social insects (some bees, wasps, hornets, ants, and termites) have turned reproduction over to a single, well cared for, individual—the queen. The individuals, or workers, all advance their genes into the next generation by caring for their mother, the queen. In this way an insect society is like a "superorganism" in which the individuals are analogous to its cells.

WORKING WITH ARTHROPODS IN BIOLOGY CLASS

Here is a list of easily collected arthropods that have proved to be excellent subjects for class room research projects.

Daphnia: These are easily collected from ponds and temporary pools using a plankton net or, improvised stocking net. Keep Daphnia in an aquarium and study its swimming behavior and its responses to light.

Cyclops: The ubiquitous little copepod found in the weedy shallows of ponds everywhere. An aquarium net will capture Cyclops. Remove the eggs from a gravid female and rear the larva in a petri dish so that they can be observed using a stereo dissection microscope. How many stages (instars) between egg and adult?

Ostracods: How many kinds live in a local habitat? How do the different species avoid competing with each other? Fresh water amphipods are easily collected using an aquarium net, or by simply lifting aquatic vegetation and rinsing it in a pan. Study these interesting crustaceans in an aquarium layered with organic material borrowed from the pond bottom.

Eubranchiopods: Brine shrimp can often be obtained from tropical fish stores, or reared from brine shrimp eggs. In what ways do these eubranchiopods respond to light? If you know of a vernal pool, look for clamshrimp, fairy shrimp, and tadpole shrimp. When the pool dries out, collect a dry mud cake, add water and see what hatches out.

Insects and spiders: Almost any insect or spider species (avoid black widows and brown recluse spiders) is worthy of a detailed behavioral study. You may, in fact, find yourself making original observations, as many arthropod species have yet to be adequately described by biologists. Start by asking yourself fundamental questions such as how does it feed, defend itself, seek out mates, respond to light, and other environmental factors. Rear the larvae. Make comparisons. Do some library research. And tackle what may be the most challenging question of all—what is it?