



An After School Program For High School Students

at

The Natural History Museum of Los Angeles County

Designed by the Research and Collections Branch and the Education
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The Project

The group of animals known as arthropods is by far the largest (most speciose) group of animals or plants on the planet. This group includes the insects (beetles, ants, butterflies, etc.), the crustaceans (crabs, lobsters, barnacles, and their allies), the chelicerates (spiders, scorpions, and their kin), and several less diverse and lesser known animal groups. There are more described species of arthropods on Earth than for all other groups of animals combined. Many arthropods have tremendous ecological, medical, and economic importance. Yet we know very little about the relationships of these groups to one another.

In the spring of 2001, a group of scientists representing five different institutions (Duke University and North Carolina State University in North Carolina; the University of Maryland and the University of Maryland Biotechnology Institute in Maryland; and the Natural History Museum of Los Angeles County in California) submitted a research proposal to the National Science Foundation to examine the relationships of 85 important insects, crustaceans, chelicerates, and other arthropods. These researchers plan to do this by extracting and comparing genetic information from a large number of genes removed from the tissues of these animals.

This project will provide new insights into the relationships of the major groups of arthropods and will tell us which group of marine crustaceans are the closest relatives to the insects, which represent the most successful invasion of land by any animal group. This grant will also support development of new statistical methods to estimate the dates of the major events in arthropod evolution. In addition to studying the relationships of arthropods, these scientists are committed to increasing public knowledge about the diversity, importance, and significance of arthropods.

The After School Program on Arthropod Diversity offered by the Natural History Museum of Los Angeles County, for which this booklet was designed, represents part of that commitment.

What is an Arthropod?

The word “arthropod” comes from two Greek words, arthro (jointed) and pod (foot). Thus, all arthropods are animals that have joints in their external skeleton, including all of their limbs. They also have the following features in common:

- The appendages (legs, claws, mouthparts, etc.) are all “jointed” and thus are composed of a series of articulating parts.
- They are “segmented,” with a series of repeating body sections both internally and externally (look at the abdomen of the grasshopper as an example).
- They are “bilaterally symmetrical,” meaning that it is usually easy to see that there is a midline with two roughly equal “mirrored” halves (just as you are “bilaterally symmetrical”).
- They are covered with an external skeleton, much like a suit of armor on a knight, which is called a “cuticle.” This is an amazing adaptation, and it gives the arthropods both protection and flexibility. In some groups the cuticle is very soft, whereas in others it is strengthened by minerals and is extremely hard and thick. (There are also some serious disadvantages to having an external skeleton - can you think of some?)
- Most have external eyes built into their cuticle; these are often multifaceted eyes called “compound” eyes with a complex structure. There may also be “simple” eyes, some of which can be internal and receive light through a transparent region of the cuticle. Compound eyes are not found in all groups, some groups have a large number of eyes, and some groups have (presumably) lost the eyes and have neither compound nor simple eyes.
- The circulatory system is “open,” meaning that they do not have true blood vessels that carry blood to and from the heart as we do, in a “closed” system of arteries, veins, and capillaries. Rather, their internal organs are “bathed” in an “open” circulatory system.
- There are many other characters that arthropods share that are not listed here, such as: a reduced coelom (internal body cavity); a complete gut (that is, with mouth and anus - not all animals are like this!), a ventral nerve cord (where is your nerve cord?), growth by molting (how else can you grow, if you have an external skeleton?), etc.

Today, arthropods are by far the most successful group of animals on the planet. They range in size from less than a millimeter to the giant Japanese spider crab, an animal with a legspan of more than 4 meters (~12 feet) across; fossil species (such as the eurypterids) were even larger. Arthropods are found in nearly every habitat on Earth, and they are incredibly important in terms of ecology, economy, medicine, and human health. We also know that arthropods have been around for a very long time, at a minimum 600 million years ago, living in an age we call the Precambrian Era. There are many groups of arthropods that have gone extinct and are now known only from fossils (one very common group of arthropod fossils is the trilobites).

Arthropod Diversity and Evolution

One very important question still asked today is: Do the different groups of arthropods share these features because they are related and descend from the same ancestor, or did they independently evolve these features (“convergent evolution”).

Today, we want you to become acquainted with some of the many different forms of arthropods and the features that they have in common.

What is an Insect?

There are more kinds of insects on Earth than all other kinds of arthropods put together. In fact, although we have only described about 1 million species, some scientists estimate that there may be 5 to 10 million or more insect species waiting to be discovered and described. Because the current total for ALL species described on Earth is only about 1.5 million, you can see how important insects are in the overall picture of Earth’s biodiversity.

Some of the features that insects have in common are:

- The insect body is usually recognizable as being divided into 3 regions: the head, the thorax (composed of three segments, each of which bears 1 pair of appendages), and the abdomen.
- The appendages of the abdomen are nearly always 3 pairs of legs.
- The eyes are large, paired, and compound, and there is often an additional pair or trio of “simple” eyes on the center of the head.
- There is only 1 pair of antennae.
- Wings are usually present on the second or second + third segments of the thorax (with the result that flying insects might have one, or two pairs of wings).
- Gas exchange occurs by a system of holes (called spiracles) and tubes (called tracheae) that allow gas to enter and exit the insect’s body.
- Some insects, such as crickets and grasshoppers, develop slowly and gradually, with only small changes during each molt (called hemimetabolous insects), whereas others, such as butterflies and moths, change drastically during a molt (and are called holometabolous insects).

Insects are almost exclusively terrestrial, although many species are aquatic or have an aquatic stage in their life cycle. Common examples of insects include flies, beetles (the most numerous kind of creature on earth in terms of numbers of species), butterflies, crickets, grasshoppers, cockroaches, ants, bees, wasps, dragonflies, termites, and many, many more. Their economic and medical importance cannot be overstated. Insects are involved with everything from pollination of important agricultural plants to the spreading of deadly diseases, and have affected mankind more than all other groups of arthropods combined.

What is a Crustacean?

Crustaceans are a group of arthropods that are most commonly found in the sea. They have the following features:

- The body is typically divided into 3 main sections, commonly referred to as the “head,” “thorax,” and “abdomen.” There is usually a dorsal protective covering called the cephalic shield or carapace (depending in part on how much of the body it protects). In many groups the head and thorax are covered by the carapace and referred to as the “cephalothorax.”
- The head is composed of 5 segments (and their associated appendages). The head segments are fused, thus making individual segments difficult to discern. These appendages are: 2 pairs of antennae, 1 pair of mandibles, and 2 pairs of feeding limbs called “maxillae.”
- Appendages are commonly “biramous” (branched) and have multiarticulate limbs. In many groups the limbs have become secondarily uniramous, having lost one branch during development.
- Gas exchange occurs across thin regions of the cuticle. In large-bodied arthropods, gases are exchanged across specialized cuticular regions called “gills.”
- Eyes are commonly present. Eyes may be compound eyes, simple eyes, or both. Compound eyes, when present, may or may not be on stalks.
- There is usually a larval form called a “nauplius.”

Crustaceans include the well-known crabs, lobsters, and shrimps, but these are only a few of the best known crustacean groups. Barnacles, although at first glance do not look much like arthropods at all, are actually crustaceans. So are the “pill bugs” or “roly polys” in local gardens. And there are a host of other important groups -- amphipods, copepods, krill, crayfishes, water fleas, seed shrimps, clam shrimps, fairy shrimps, and more.

Although most crustaceans are marine, there are also many species of freshwater crabs, shrimps, and other species, and there are small crustaceans that live in temporary pools in deserts (fairy shrimps, clam shrimps, tadpole shrimps, and their relatives). The world’s largest arthropod, the Japanese giant spider crab, is a crustacean with an impressive 4 meter (12 foot) span from leg tip to leg tip. There are even terrestrial species, such as the familiar garden pill bugs and the beautiful and enormous coconut crab.

What is a Chelicerate?

One group of arthropods is distinct in that the first pair of limbs on the body are small, pincer-like appendages. These limbs are called “cheliceræ,” and hence the group’s name, “Chelicerata.” This group is also the oldest, as far as we know, with fossils that are older than any known insect or crustacean fossil.

Features that set the chelicerates apart from other arthropods include:

- The body is typically divided into 2 main sections, often called a “prosoma” and “opisthosoma.” In order to be consistent in our comparison with other arthropods, we will refer to these sections as the “cephalothorax” and “abdomen.”
- There is no distinct “head.”
- There are never any “antennae.”
- The prosoma is usually composed of 6 “fused” segments, and each segment bears a pair of appendages.
- The 6 appendages that correspond to these segments are the cheliceræ, the pedipalps, and 4 pairs of walking legs (hence the 8 legs of spiders, scorpions, etc.)
- The appendages are “uniramous” (that is, they are not branched, which is not the case in some other arthropod groups, notably the crustaceans).
- They breathe by way of organs called “book lungs,” “book gills,” or, “tracheae.”

Like other groups of arthropods, chelicerates are very numerous and extremely diverse. There are about 75,000 described species. The group includes such familiar animals as spiders, scorpions, ticks, mites, and “daddy long legs.” There are also many lesser-known chelicerate groups. One extinct group of chelicerates, called the eurypterids, grew to over 2 meters (6 feet) long!

Other Arthropods

Although crustaceans, chelicerates, and insects are by far the most numerous arthropods, they are not the only ones. Rather, they are the “more successful” groups in terms of the numbers of species still living today and in terms of the number of different habitats in which they are found. Other groups of arthropods include creatures such as:

- Trilobites (now extinct, but extremely common as fossils)
- Pycnogonids (“sea spiders,” although not true spiders)
- Myriapods (centipedes and millipedes)
- Onychophorans (“velvet worms”)
- Tardigrades (“water bears”)