TwoOldGuys™ Study Guides
BI114 Biological Concepts for Teachers
Chapter 2. Diversity of Life
2.3. Bugs

Based on Indiana's Academic Standards, Science, as adopted by the Indiana State Board of Education, Nov 2000.
Numbers refer to the age-appropriate grade-level for the content.

Review

We developed a tentative definition of life, and applied it to all known life-forms consistent with the cognitive development of the 8th grade mind. To outline the known living things, we expanded the 20-Questions classification scheme to include several ranks of taxa which are recognized as artificial: Kingdom, Phylum, Class, Order, Family, and Genus; plus one real taxon: the species.

The artificial taxa are defined by enumeration. We have already covered the Mammals and Birds. This section will continue to develop definitions by enumeration for the major taxa with which your students should be familiar.

Arthropods (phylum Arthropoda)

Bugs are useful creatures for the elementary classroom. They are small, easy to take care of, and unlikely to attract the attention of animal rights [anti-cruelty] groups. Plus they are easy to find –simply ask your students to bring them in, and you will get more bugs than you can imagine. A former student of mine couldn't find any grasshoppers during a summer class, so offered a neighbor boy 5¢ each for some and

ended up paying $5.00 for the beasts! A few (bees, wasps, spiders, ...) are poisonous, especially to persons allergic to their stings, so should be avoided.

If you are not fond of bugs, they can be kept in jars for easy observation without requiring any handling. Students can count legs, draw the bugs, can use bugs for compare and contrast investigations. Also, as described at greater length in Appendix B, Laboratory Exercises, students can use bugs for a number of actual scientific studies.

grades K: to 3:

Bugs are small animals
with six or more legs
with a shell, or external skeleton (made of fingernail)

The defining characteristic of the bugs is their shell (or external skeleton) which is made of material similar to fingernails. Most of the animals we normally think of as bugs live on land, although some of them, such as mosquitoes, spend part of their life in the water. A number of animals which we do not generally think of under the name bugs, such as shrimps and lobsters (and the fresh-water lobsters called crayfish, crawfish or crawdads), live in the water, but meet the definition of bugs, so should be called bugs.

Among the bugs that live on land, some have six legs [Insects], or eight legs [Spiders and Daddy-longlegs], or more [Sowbugs, Centipedes, Millipedes]. Among the bugs that live in the water, some have walking legs only [Crabs], some have both walking legs and swimming legs [Lobsters and Crayfish], and others have only swimming legs [Shrimps].

grades 4: to 8:

Arthropods (phylum: Arthropoda)

Bugs (Insects) are one class of Arthropods
Arthropods are animals with external skeletons

The larger taxon to which Insects belong is the Arthropods. The defining characteristic of the entire phylum Arthropods is the external skeleton (shell). The chemical material from which these external skeletons are made is typically chiton, which is similar to the material from which fingernails are made. Some of these creatures have rather thin skeletons (like house flies) which squish easily. Others have very thick, hard skeletons (like beetles and crabs).

All Arthropods are considered to be segmented (like an earthworm), but sometimes the segmentation is not easily seen.

Cold-blooded; multiple hearts; two "brains"

The Arthropods are cold-blooded animals. As a reminder, this means that they *do* regulate their body temperature, but allow far more change in temperature before responding.

None of your students, up to and including secondary school, can be expected to correctly find the multiple hearts in a dissection. Some secondary students can dissect well enough to locate and identify the "brains" of a grasshopper. The head brain is easier to locate, but is far from impressive; while the body brain can best be found by those students who can trace the central nerve cord along the belly side of the beast [most of the students who achieved this were motivated by the magic words: "extra credit"]. Based on my assessments of secondary and of college freshman non-major student learning in dissection exercises, I have serious reservations about the value of dissections for any population of students below secondary level.

The two brains serve opposite functions: the body brain can be called the "just do it" brain; and the head brain, the "just say no" brain. A more technical way to express this is to note that the body brain provides the 'urges' to begin some activity, and that the head brain suppresses these urges. Secondary students seem to find this concept more intriguing than do older students.

Development in leathery-shelled egg

Arthropod eggs do not have shells, although the animals do have shells. The terrestrial [land-dwelling] insects lay eggs with thick skin, usually described as "leathery." Arthropods can lay 10's to 100's of eggs. The parents simply lay the eggs, then abandon them. The young are born able to take care of themselves. One spectacular exception is the Wolf Spider, which does not lay the eggs, but carries them in the abdomen where they hatch and the young crawl out, then ride on their mother's back until they are mature enough to feed themselves.

Insects (class: Insecta)

The segments of the Insect body are grouped into distinct body regions, consisting of a head, thorax (body), and abdomen (tail):

- head = several segments, one small brain
    - 1 pair antennae, 2 compound eyes, 3 pair mouthparts
- thorax = 3 segments; one large ganglion (body brain)
    - 3 pair legs, 0 - 2 pair wings
- abdomen = up to 11 segments
    - each with ganglion (except last 1 or 2)

The head has two antennae which generally point forward. These antennae serve as chemical sensors (similar to your senses of smell and

of taste). Two large nerves run from the antennae to the top of the brain. Most, if not all, Insects have a pair of compound eyes, and may also have simple eyes. Although numerous books have shown "insect vision" by taking a picture through the lenses of the compound eye, this is probably not accurate. The picture through the lenses shows a mosaic of numerous separate images, but it is more likely that each eye of the compound eye 'sees' one pixel. Two large nerves run from the compound eyes to the sides of the brain, where the pixels are probably assembled to a visual image. Two additional large nerves run from low on the sides of the brain to the mouthparts, probably to carry motor information to coordinate eating. Two remaining very large nerves run from the bottom of the brain to the rest of the Insect as the 'spinal cord.'

The thorax consists of three fused segments each with a single pair of legs. There are lines around the shell [exoskeleton] of the thorax, that are interpreted to be the 'edge' of the segments. A large ganglion lies on the center of the skeleton plate on the belly side. This ganglion is believed to be the fused ganglia of the three thoracic segments, with large nerves running out to each of the legs. Most, but not all, adult Insects have two pair of wings, attached to the first and second thoracic segments. Each wing rests on the side skeleton plate as a fulcrum, with an attachment to the edge of the back skeleton plate. Muscles extend from the belly skeleton plate to the back skeleton plate, and provide the muscle action for flight. Unlike humans who can contract only about 20% of their muscles at a time, the flying Insects can contract 100% of their flight muscles simultaneously. Therefore, the Insect flight muscles are five times as strong (per gram of muscle) as are human muscles.

The abdomen consists of up to about 11 non-fused segments. These segments have no legs, and each has a small ganglion. The last one or two segments do not have ganglia, and are considered to be a true tail.

Fossil Insects have been found as far back as the Devonian (400 million years ago) or perhaps Silurian (440 million years ago). The fossil

Insects look very similar to the Modern Insects. The earliest known fossil is a winged insect resembling a wasp. One of the early fossils from the Devonian is a cockroach. One well-known group of fossil insects are the Carboniferous dragonflies with large wingspans since they are repeatedly mentioned in television portrayals of the Carboniferous period. The most famous Insect fossils are Carboniferous (350 Myr BP) and Permian (270 Myr BP) animals trapped in amber (which is fossilized resin from trees). These fossils probably consist of actual remains that never decomposed because of the resin covering them.

Ganglion refers to a group of nerve cells, such as the "funny bone" in your elbow.
BP means Before Present (this has recently been replaced with BCE = Before Current Epoch); Myr is million years.

grades 6: to college:

Orders of Insects [examples]:

The following descriptions of the orders are paraphrased from Ross (chapter 7).

- **Odonata – dragonflies**. These are medium to large sized predators (on other insects, particularly biting flies and mosquitoes), with two pairs of nearly identical wings on a long slender body. The compound eyes are large and protruding. Fossils from the Carboniferous (350 Myr BP) have wingspans up to 30 inches (0.76 meters).
- **Cursoria - cockroaches, walkingsticks**. Some of these are wingless; and others, winged. Those with wings have the second pair larger, membranous compared to the first pair which is leathery. The second pair of wings folds under the first pair when

not flying. The roaches have flattened bodies; the mantids have distinctive front legs resembling arms with elbows and 'hands;' while the walkingsticks are long slender animals with long spindly legs.

- **Orthoptera – grasshoppers, crickets and locusts**. These are medium to large insects with hind legs modified for jumping, and with large heads. The first pair of wings are leathery covers for the membranous second wings which fold in pleats like a fan. The locusts (famous as plagues, or giant swarms which are extremely destructive to vegetation, on various religious/ethnic groups), also known as short-horned grasshoppers, have antennae that are no longer than the head and thorax, and point forward. The long-horned grasshoppers (including katydids) are generally green and have long antennae (longer than the body from head to tail) which normally sweep backwards. The long-horn grasshoppers also include some species that form giant swarms which are extremely destructive to agriculture. The crickets are generally black or dark brown with long antennae (length of the body or longer). Crickets are typically soft bodied and flightless.
- **Hemiptera - true bugs**. The bugs are small to medium insects, often with particularly foul smell [stink bugs]. Bugs have piercing, sucking mouthparts used to extract sap from plants. The first pair of wings are half thick and hard (like a beetle, Coleoptera) and half thin and transparent (like a dragonfly, Odonata), and the second pair of wings are somewhat fly-like (Diptera).
- **Homoptera [a sub-order of Hemiptera] – cicadas and aphids**. The Homoptera are included here primarily to note that the insects that sing a buzzing noise in the trees, commonly called "locusts," are in fact cicadas. These large insects have faces that resemble the grill of a classic Mercedes Benz automobile, and wings that

resemble transparent moth wings (Lepidoptera). The aphids and other Homoptera (such as leaf hoppers, scale insects, spittle bugs, etc.) are important as plant parasites, being the plant world's equivalent of mosquitoes.

- **Hymenoptera - bees, ants, wasps**. These are mostly small to medium, with a few large wasps and bumblebees. Most species have similar front and back wings that are hooked together so they function as a single pair. Many are social, forming hives with complex social behavior and a distinct caste system. Nearly all of the solitary (non-social) species have young that are parasitic on animals (mostly insects) or plants (the larvae live inside galls). There is generally a narrow constriction [waist] separating the thorax and abdomen. A large number of species have stingers on their tail, with a poison chemically related to the poison of the pit-viper snakes [rattlesnake].
- **Coleptera – beetles**. These insects range from small [lady-bugs] to the largest living Insect [a South American rhinoceros beetle]. All have hard shells, and the first pair of wings are comparably hard. The second pair of wings can be folded (not always neatly) under the first pair when not flying. Most are predators on other insects.
- **Lepidoptera - moths, butterflies**. These are very small (1 -2 millimeters, or 1/32 – 1/16 inch) to large insects (wing span 6 inches, or 15 cm). The "body, wings, and other appendages are covered with scales which are often brilliant in color and arranged in showy patterns." (Ross, 352).
- **Diptera – flies**. The flies have only a single pair of wings, the front pair. The second pair of wings are reduced to a balance organ. Most flies are associated with decaying material, with maggots as the larvae. A few are blood suckers, such as mosquitoes, horse flies, etc.

other Arthropod Classes

Millipedes (class Diplopoda)

- head: 2 short antennae, simple eyes, 2 pair mouthparts
- no thorax
- segmented abdomen; 2 pair legs per segment

Centipedes (class Chilopoda)

- head: 2 long antennae, 2 compound eyes, 3 pair mouthparts
- no thorax
- segmented abdomen; 1 pair legs per segment
    - 1st segment has 1 pair poison claws pointed forward

Shrimps, lobsters (crayfish), sowbugs (class Crustacea)

- head; 2 pair antennae, simple or compound eyes often stalked, 4 pair mouthparts
- thorax; 4-20 segments with 1 pair branched legs per segment
    - head and thorax may be fused as cephalothorax
- abdomen; 1 - many segments with or without "legs"

Spiders, ticks, mites (class Arachnoidea)

- cephalothorax; 2 pair mouthparts plus poison fangs, 4 pair legs
- abdomen; 1 - many segments without "legs"

The horseshoe crab is the most primitive known living Arthropod. It may be closely related to the Trilobites.

Because at least some of your students can be expected to be familiar with this class, you need to know the most familiar of the orders in the class. The orders are as follows:

- Scorpions (order: Scorpionida)
- Daddy Longlegs, or harvestmen (order: Phalangida) ["Daddy Longlegs" may be a Native American name for these beasts, since the true spiders were called Spider Old Woman by some Native American linguistic groups.]
- Spiders, or Spider Old Woman (order: Araneae)
- Ticks and Mites (order: Acarina)

Trilobites (class Trilobita)

These are known only as fossils, dating from the Cambrian [600 - 500 Myr BP] and Ordovician [500 - 440 Myr BP]

Other phyla of lower animals

Peripatus (class Onychophora)

The missing link between worms and arthropods.

These are earthworm-like creatures with one pair of short stubby legs on each segment. The first pair of legs are directed forward, and are used as arms for feeding. Living specimens are known from New Zealand, and no fossils have been found.

Earthworm (phylum Annelida)

Earthworms, or segmented worms, have very obvious segments. Although these animals are frequently dissected in schools, I am not

convinced that the students learn anything from the dissection. Rather, I suspect that even at secondary level, the students "fake" their lab reports to pretend that they saw what the book says they should have seen. I would not recommend dissections at elementary levels.

Roundworm (phylum Aschelminthes)
Flatworm (phylum Platyhelminthes)

The lower worms are mostly small, and obscure creatures that you will not likely encounter in your teaching career.

Jellyfish (phylum Cnidaria)

Unless you teach at a sea coast school, you will also not encounter Jellyfish. If you do encounter any jellyfish, remember that they are all poisonous.

Works cited

Ross, Herbert H. *A Textbook of Entomology*. New York: John Wiley & Sons, 1956 (Chapter 7).