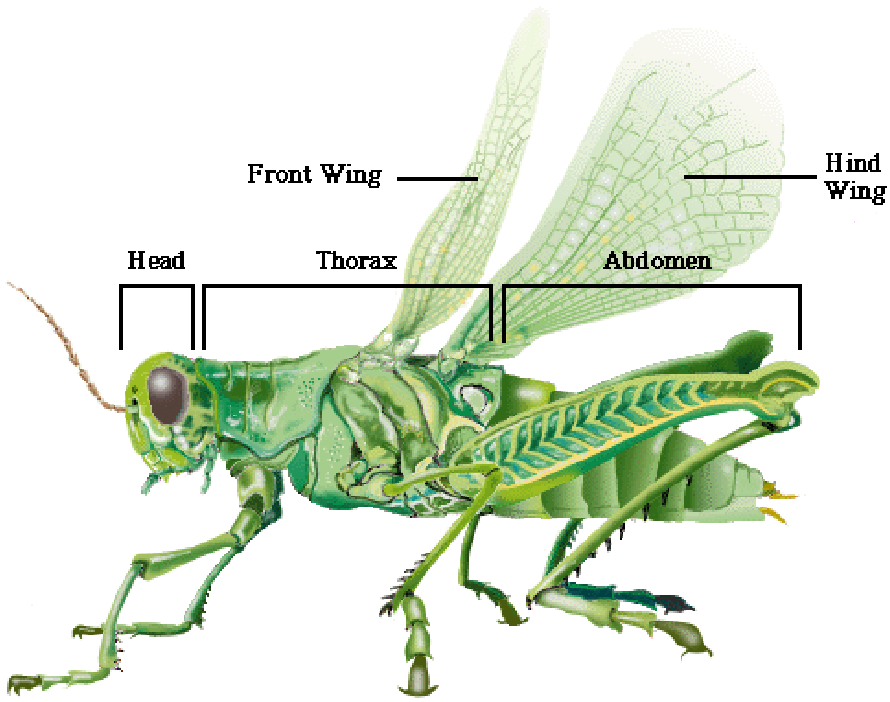
Predators and Prey: Adaptations and Coevolution in Insects and Plants

A teacher resource guide complied by Sarah Jandricic

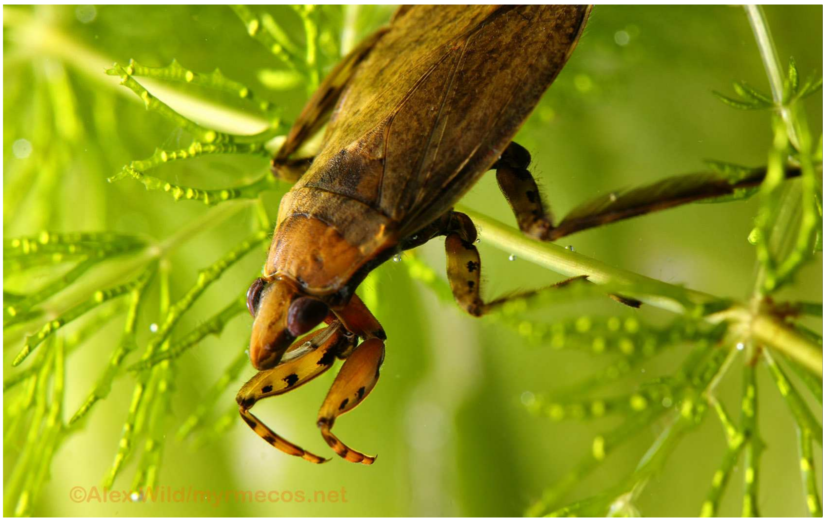
Background Information:

Insects are a group of organisms which have exoskeletons (a hard outer covering which is shed in a series of "molts" in order to grow larger), 3 body segments (head, thorax, abdomen), 6 legs, 2 antennae, 2 compound eyes, and often, 1 or 2 pairs of wings. Fully developed wings are only present in the adult stage of insects. The immature stages (called "larvae" or "nymphs") can look like small adults or appear quite different from their adult stages -- sometimes it's hard to believe caterpillars and grubs turn into butterflies and beetles!



The body parts of a typical adult insect.
From: http://wings.avkids.com/Book/Animals/beginner/insects-01.html

A predatory insect is one that hunts, catches and kills another animal (mostly other insects). A predator may eat the prey itself or use it to feed its young. Dragonflies, ground beetles, and praying mantises are all examples of insect predators. **Prey** is any insect that is killed and used for food. Common types of insect prey include mosquitoes and gnats, as well as plant feeding insects like butterflies and grasshoppers. The predator-prey relationship is important in maintaining balance between insect species. Without predators, certain species of insect prey would drive other species to extinction through competition. Without prey, there would be no predators.



A giant water bug. An aquatic insect predator which feeds on other insects, but also small fish and frogs. Its strong front legs grasps prey while a straw-like beak injects a toxin that first paralyzes, then liquefies its prey.

Picture taken from: http://myrmecos.net/wp-content/uploads/2011/03/insect_wallpaper9.jpg

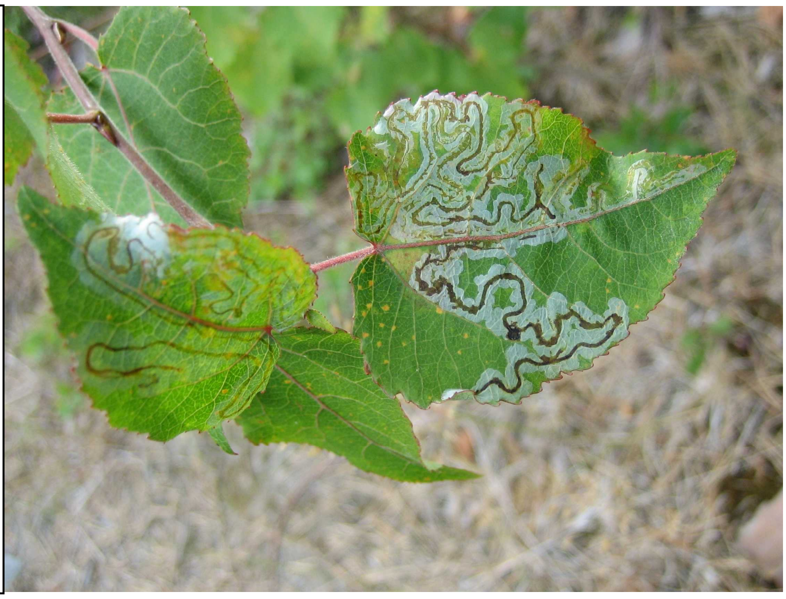
Why Are There So Many Different Kinds of Insects? Adaptation and Coevolution:

Adaptation is when organisms evolve to become better suited to their habitat. Adaptation can be a response to living or non-living factors in the environment, and is one of the major explanations for the diversity we see in insects (with over 6 Million species on Earth)! The **evolution of flight** was a major event that helped drive insect diversity, as insects were able to travel to and adapt to new habitats. The **evolution of flowering plants** was another important driving force. As insects followed plants onto land, they used plants for both food and shelter. Early insect herbivores bit or chewed vegetation, but as plants and insects ***co-evolved***, other forms of herbivory, such as sap-sucking, leaf mining, gall forming and nectar-feeding, developed in insects.

Leaf "mines" formed when caterpillars feed between the tissue layers of leaves. Other types of insects that feed this way include certain flies and sawflies (a type of insect closely related to bees).

Caterpillar leaf-mining has been associated with trees such as oaks and poplars for over 20 Million years.

Photo taken from: http://www.joensuu.fi/biologia/nyman/InsectsOnAspenLeafminers.htm



Coevolution is the evolution of 2 or more species, each of which adapts to changes in the other. At first glance, it might seem like everything is co-evolving; don't virtually all organisms interact with other species and influence their evolution in some way? However, in the true sense, coevolution *only occurs when there is reciprocal evolutionary change.* In other words, first Species 1 evolves in response to pressures exerted by Species 2; *then* Species 2 evolves in response to this change in Species 1. The evolution of both species continues in this step-by-step way. Some of the best examples of coevolution have happened between insects and the plants they feed on, and has lead to some very interesting and specialized plants and insects!

*A Pseudomyrmex*s ant, which protects the bullhorn acacia plant from herbivores and encroaching plants. In exchange, the acacia provides special shelters (hollow thorns) and food for the ants (the orange globules pictured, known as Beltian bodies, are rich in proteins and fats). This is one of the most extreme examples of insect and plant coevolution.

Photo taken from: http://ecolibrary.org/page/DP161

Examples of Adaptations in Predatory Insects and their Prey: Adaptations that are beneficial to insect prey, such as chemical and physical defenses, ensure that the prey species will survive. At the same time, insect predators must undergo certain adaptive changes to make finding and capturing prey less difficult.

ADAPTATIONS OF PREDATORY INSECTS (to be better at catching prey)	**ADAPTATIONS OF PREY INSECTS (to avoid being eaten)**
They can move extremely fast, striking at prey before they can react.	Prey insects have become very good at evading predators, by running, jumping or flying.
Predators usually have large eyes, for detecting prey, as well as good senses of smell and/or hearing.	"Crypsis", the ability to avoid detection, is often used by prey. Examples include camouflage, mimicry of things like leaves, or only being active at night.
Predators use strong mouthparts or specially developed forearms to grab and crush prey. Other predators use stingers or inject toxins using their mouthparts to disable prey.	Many insects have defensive body coverings, such as horns or irritating hairs to make them unpalatable or prevent them from being crushed. Others use chemical defenses, such as spraying irritants.

Examples of Adaptations of Insect Herbivores and Plants: The diversification of insects as they adapted to new plants species represented a major selective force in plant evolution. This led to the selection of plants that had defensive adaptations to avoid being eaten by insect herbivores. Of course, over millions of years, insects evolved a few adaptations of their own to get around these plant defenses.

ADAPTATIONS OF PLANTS (to avoid being eaten by insect herbivores)	**ADAPTATIONS OF INSECT HERBIVORES (to evade plant defenses)**
Plants produce defensive chemicals that can poison or trap insects. These are "constitutive" defenses, meaning they are always active in the plant.	Some insects have evolved to either *excrete* or *sequester* plant defensive chemicals, preventing them from getting sick.
Plants can give off chemicals that "call" insect predators to defend them. This is an "induced defense", meaning it's only turned on when insects feed on the plant.	Insects can suppress the plant's ability to "call for help" through chemical changes in their saliva.
Some plants use physical defenses, such as thorns or "trichomes" (plant hairs), which can slice up delicate insects.	Some insects can spin webbing that allows them to walk over the plant trichomes.

Teacher Resources:

http://www.kendalluk.com A wonderful website that tells you everything you could want to know about insects! Topics include insect identification, life cycles, insect defenses, as well as fun rhymes and songs about bugs! A must-see!

http://www.ucmp.berkeley.edu/education/lessons/clipbirds/ provides a great class activity (using birds as an example) that illustrates how certain adaptations can be advantageous and lead to greater survival and reproduction in a species. Appropriate for Grades 6-12.

http://www.wischik.com/marcus/essay/def.html Where you can learn more about different ways plants protect themselves.

http://www.cals.ncsu.edu/course/ent425/tutorial/Ecology/defense.html Where you can learn more about how insects defend themselves.

Activities Used in Class:

The "Caterpillar game" (Grades 2-7). This activity demonstrates how certain adaptations can give one species an advantage over another, depending on the environment. Caterpillar and leaf cutouts are attached.

Print out the caterpillars provided on 3 different colors of construction paper (ex. blue, orange and yellow) and the leaves on 2 different green colors of construction paper (ex. light and dark green). Pass out at least 3 of each color of caterpillar (making sure to keep the starting numbers of all 3 colors of caterpillar the same). Give each student a leaf to "feed" their caterpillar as well. Make sure the 2 colors of leaves are randomized among the students. Tell the students that the different colors represent different caterpillar species. Have the students to take a look around and tell you what they see in terms of how many of each species there are (they should tell you that there are equal numbers of each caterpillar species).

Have the students to pretend to have their caterpillars take a bite out of their leaf. Now explain that the dark-green leaf (vs. the light green) was from a plant that contained some kind of toxin that is poisonous to insects! This is a type of plant CHEMICAL DEFENSE. But, the blue species of caterpillars have somehow ADAPTED to deal with this plant defense, and are able to get rid of the poison. Tell the students holding red or yellow caterpillars to hold up their caterpillars if they ate a poisoned leaf, and collect these "dead" caterpillars. The yellow and orange caterpillars that didn't eat a poisoned leaf can survive and reproduce! Give these students an extra caterpillar of the same color to pass to a friend. Since the blue caterpillars are able to eat any kind of leaf (poisonous or not), ALL of them can reproduce and pass a blue caterpillar to a friend.

Like in the beginning, have everyone hold up their caterpillars, and ask the students what they see now. They should see that because the blue caterpillars had an ADAPTATION that allowed them to overcome the poisonous plant's defense, they have survived, and now there are more of this species. Ask them why they think this is. Explain that there are more of this blue species in this particular environment, because they have evolved a trait that gives them an advantage over the other caterpillars.

For older students, ask them what would happen if there was a "fitness cost" to be able to detoxify the plant chemical. For example, maybe it takes more energy to be able to keep this detoxification mechanism active all the time, and so the blue caterpillars have less energy to devote to reproduction. The students should hopefully understand that in an environment that only contains NON-poisonous leaves, that the orange and yellow caterpillars would then have the advantage, and reproduce more (because they don't have this "fitness cost").