Plant Defenses

Grade Level: Middle School, High School
Ecological Concepts: Plant defense, **Herbivory**
Arizona Science Standards: Science as Inquiry; Life Science

Materials:
1) Magnifying lenses/loupes*
2) Writing/drawing materials
*May be borrowed from SCENE.

BACKGROUND
Plants are **autotrophs**, producing their own food supply through **photosynthesis**. Plants are **sessile**, literally rooted to the ground. Therefore, unlike most animals, plants cannot move away when threatened by a **predator** trying to eat it. A plant predator is called an **herbivore**. Instead of moving, many plant species have developed other defenses. Spines, thorns, a nasty taste, and toxins are some defenses against herbivory. Others are thick, waxy **cuticles**, hairy leaf surfaces, or being **ephemeral**. Plants that live and reproduce very quickly avoid herbivory by not being around long enough for many herbivores to find them.

Plants are eaten whole or in parts by various mammalian, bird, reptilian and **arthropod** species. In schoolyard habitats, likely herbivores are rodents (rabbits, mice), birds, and insects.

GUIDED INQUIRY
Observation/Exploration Period: Examine the plants in the habitat. What types of physical structures might provide plants a defense against being eaten? Look for spines, thorns, hairs, sticky substances, and others you may discover. Do some plants show signs of herbivory? Signs of herbivory include partially or totally eaten leaves and stems, cocoons, eggs on the plant leaves or stems, **mines** on the leaf surface, **galls** on leaves or stems, or insect frass (feces). You might even find tracks of birds, mammals, or lizards in the soil around the plant. This is indirect evidence of what might be preying on a plant.

Group Discussion and Question Period: Are some plants eaten more than others? Why do some plants or parts of plants have more signs of being eaten than others? Do plants have characteristics that attract or deter insects? Why don't we see many insects on some plants but lots on others? Does time of day or year change how much herbivory occurs?

Important aspects of guided inquiry are encouraging students to generate multiple hypotheses, and letting students make decisions about what data are important and create their own data sheets. Keeping these ideas in mind, the sample in the box below illustrates how ONE OF MANY possible investigations around this topic might develop.

Sample Hypothesis: Let's use the question, "Do plants have characteristics that attract or deter insects?" Let's consider the fact that the leaves of some plants are smooth and leaves of other plants are hairy. Our hypothesis might be, "Plants without a hairy surface will show more signs of herbivory because the herbivores can feed more easily on the leaf tissue."

Sample Experiment Design: Compare hairy leaves to smooth leaves. The **independent variable** will be plant type, hairy leaves or smooth leaves. The**dependent variable** will be number of signs of herbivory detected on the plants. **Randomly** choose four plants of a species with a hairy surface and four of a species with similar-sized leaves without a hairy surface. This will give four **replicates** of each **experimental unit**.

Look at the leaves and stems for signs of damage caused by herbivores. These would be holes in leaves, torn leaves, leaves completely gone, broken stems, **mines** or **galls** on leaves or stems. Depending on the size of the plant, survey and count signs of herbivory on every branch and leaf, or randomly choose two to five branches on which to count all signs of herbivory. If you know where all the plants are in the habitat and one is completely gone, that might be another instance of herbivory.

Sample Prediction: The plant species with a smooth leaf surface will have more signs of herbivory than the plant species with a hairy leaf surface.

Record Results: Record the number of herbivory instances per plant on the data sheet. If counting only a few branches per plant, add the numbers together for each individual plant to yield a number per plant. Total the number of instances per plant type.

Sample Analysis of Data and Presentation: Make a **bar graph** or **histogram**, with plant type on the horizontal axis and herbivory instances on the vertical axis. Calculate the **average** number of insects per plant type. Graph the average number on the vertical axis.

Discussion: Was your hypothesis supported? If yes, go on to test other hypotheses. If not, why not? What did happen? Why? This is a great opportunity to revise your hypothesis and do another test.

MORE:
(1) Middle School:
(a) Find the **mean**, **median**, **mode**, and **range** of the data.
(b) Collect potential insect herbivores in the habitat. These could be beetles, caterpillars, ants, etc. Prior observation of the plants and insects will give you an idea which insects to use. Place captured insects on a branch of each plant. Enclose the branch using **fine mesh netting**. Use at least two plants of each defense type (e.g., plant species with hairy leaves, and plant species without hairy leaves). Choose branches free of herbivory signs. After a set amount of time (a day, a week), remove the netting, count the remaining insects and the number of herbivory instances per plant. Average the data per plant type.
NOTE: The variable of interest in this experiment is herbivory, but it is good to know how may insects are still alive at the end of the experiment because if, for example, you place five insects on each of the branches, and on some branches all or most of the inscts die, while on others all or most live, that could explain the differences in instances of herbivory among the branches.
(c) Determine other possible plant defenses. Test these in similar experiments.

(2) High School:
(a) Calculate the **variance** and **standard deviation** of the averaged data.
(b) Conduct the experiment described in Guided Inquiry, above, at two different times of day or year. Test for a **correlation** between the two variables, number of insects and time of collection. Draw a **scatter plot** and calculate the sample **correlation coefficient**.
(c) Measure the height, length, and depth of each plant. Calculate the volume of each plant (height x depth x length). Use the **volume** of a sphere if plant structure more closely matches a sphere shape. Volume will mathematically correct for differences in herbivory instances that may be due to differences in plant size. (You cannot correct for differences in herbivory due to size of the herbivore unless you know what the herbivores are.) This means, if Plant A is twice as big as Plant B, that size difference may be the only reason Plant A had more instances of herbivory. By calculating the plant volume available for herbivory, and then dividing the number of herbivory instances by that volume, the resulting number, in # herbivory instances/volume will give a more accurate representation of which plant type really endures more herbivory.
(d) Do a **T-test** of herbivory instances per plant unit volume area. (T-test is a standard statistics test comparing means of two samples.)