Exploring the Native Plant World

A Life Science Curriculum

3rd–4th Grade

Survival in the Native Plant World

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Welcome to the Lady Bird Johnson Wildflower Center

The Lady Bird Johnson Wildflower Center is dedicated to North America's native flora. Our mission to inspire the conservation of native plants guides all that we do.

At the Wildflower Center, we apply nature's principles to designed landscapes. The Wildflower Center nestles gently into 284 acres of Central Texas Hill Country, and the landscape and the buildings reflect our Hill Country home. The Center's focus on native plants, resource conservation, and ecologically sensitive design reflects our deep concern for the environment.

Founded by former First Lady Lady Bird Johnson and actress Helen Hayes in 1982, the Lady Bird Johnson Wildflower Center encourages the conservation and restoration of native plants in all types of landscape situations. The Center's extensive environmental education program and national Native Plant Information Network combine to extend its mission across North America. Our commitment to education and young people is the foundation for all we do: Education is at the core of our mission, and children are the keys to our future. Together we can work to make a difference.

For more information about the Lady Bird Johnson Wildflower Center, please visit our web site at www.wildflower.org.

Exploring the Native Plant World

A Life Science Curriculum for Pre-Kindergarten through Grade 6

This curriculum is divided into four grade-specific modules: Pre-K/K (Shapes and Patterns); 1-2 (Changes); 3-4 (Survival); 5-6 (Adaptation). The focus is to provide a basis for the study of botany and biological systems and to serve as a foundation for future botanical explorations. Children in pre-kindergarten and kindergarten are introduced to the shapes and patterns found in nature, beginning with the shapes in flowers and continuing through explorations of patterns in time throughout a plant's life. First and second graders find that plants change over time (as does everything on earth) and plants take care of their needs with specialized parts. In the third and fourth grade unit, students learn more about how plants survive and that this survival is carried out through a variety of relationships with other plants and animals and abiotic, or non-living, factors. In the final unit, fifth and sixth graders discover the concepts and mechanisms of natural selection and natural communities, as well as human impact on these communities.

Exploring the Native Plant World was designed using the Texas Essential Knowledge and Skills (TEKS) and the National Benchmarks for Science Literacy. A primary goal of this curriculum is to teach botanical principles through all elementary grades in order to build an ecologically literate citizenry. By focusing on native plants, this curriculum also provides an opportunity to learn more about imperiled ecosystems.

In the end, we will conserve only what we love;
We will love only what we understand;
And we will understand only what we are taught.
—BABA DIOUM, Senegalese conservationist

In today's culture many of us are urban dwellers. Too few children have the opportunity to engage in and observe the natural world. As educators and environmental specialists we can introduce nature to children from all walks of life. Studies show that just as there is a critical time in a child's life when he develops language, there is a time in a child's life when she develops an appreciation of the natural world. Our challenge is to open that window of opportunity and welcome children to a lifetime of exploring and understanding nature's wonders.

If we sustain plants, they will sustain us.
It is that simple. And it is that important.
—RICHARD H. DALEY, former director,
Arizona-Sonora Desert Museum

What is a native plant?

A native plant is a plant species that occurs naturally in a particular region, state, ecosystem, and habitat without direct or indirect human actions. Native plants are a part of the natural neighborhood, a component of the local ecosystem, and they function with other organisms within that ecosystem. They are a critical component of nature's web, and they have evolved and adapted to meet climatic and environmental changes over time without intervention or assistance from humans.

Native plants provide food and habitat for animals of all kinds (including humans). They filter the air and reduce soil erosion. Because native plants fill a niche, or specific function, within their ecosystem, they seldom grow beyond the needs and capacities of that ecosystem. The interaction and interdependence of plants and animals within that niche make up our biological community.

Native plants are in crisis

Farming, ranching, urban development, and chemical application have significantly reduced many of the Earth's native plant communities. Species have become endangered or extinct, natural habitats have degraded, soil erosion has increased, and the genetic diversity so essential for stable, balanced ecosystems has declined. Since the early nineteenth century more than 200 of America's native plant species have been lost, and more than 5,500 species are endangered or threatened. This means that other organisms dependent on those species have lost or might lose an important part of their food chain.

In many places well-meaning landowners have replaced native plants with non-native species in yards or landscapes. Non-native species often require more water, fertilizer, and herbicides than native plant species. Moreover, non-native plants occasionally escape cultivation and become aggressive, invasive weeds, choking out both native and other non-native plants.

The importance of native plants

There are several important reasons to garden with native plants. They are adapted to the particular combination of soil, temperature, nutrients, and rainfall of their region. Once established they require little, if any, supplemental water, fertilizer, pesticides, or other chemicals. In planned landscapes around schools, homes, commercial developments, or roadsides, native plants require far fewer additional resources.

Besides the practical benefits of using native species, these plants provide habitat for a host of regional animals. Native plants are a welcome mat for the birds, butterflies, and so many other animals that enjoy the habitat. Using native plants in a garden or landscape can provide ecological, economic, and aesthetic benefits—it's a win-win situation for both the gardener and the natural community.

A good way to start protecting and preserving native plants is by learning about your region's native plants. Remember that your region is unlike any other in the world. There are subtle differences everywhere. Visit the Lady Bird Johnson Wildflower Center's Native Plant Information Network (NPIN) for help in learning what native plants belong in your neighborhood. NPIN has regional fact sheets, which include species recommendations, plant and seed sources, and contact information for local native plant organizations. These resources provide tools that can help you teach about your region's native plants and their importance to our future.

Introduction

Survival in the Native Plant World

In nature there are neither rewards nor punishments—there are consequences.
—Robert G. Ingersoll, 1881

Nature is not sentimental, it's true. Besides the variety of endings for plants and animals, there are giant obstacles on the road to success just to begin life. The potential for life is all around us, and all the seemingly random destructive forces work as a fine honing tool, shaping the bits and pieces of habitats so that they fit tucked in close together.

3rd and 4th Grade Unit

In this unit of *Exploring the Native Plant World,* students build on their knowledge of what plants must do to survive. Plants need certain ingredients to make food, and they need their friends and partners. Plants have evolved ways to defend themselves, strategies to ensure the survival and continuation of their species, and ways to fit into their habitats.

Photosynthesis

First, of course, is the miracle of turning air and sunshine into food through the process of *photosynthesis.* Although the abstract concept of matter made by arrangements of atoms and molecules is a difficult idea for grade school students, the *Food Factory Game's* concrete modeling teaches children to recognize new patterns formed from combinations of basic ingredients.

Survival

Plants do not survive in a vacuum; they are part of a complex web of life in which we all sway together. In *Cohorts Combinations,* the different relationships and dependencies of native plants with other plants and animals are explored, leading to the students' growing realization and understanding of nature's complexity.

Being stationary, plants have fewer of the immediate avoidance responses used in animal survival; however, the responses are there, and students will learn where to look for them. Survival mechanisms are not just for the individual plant but also for the genes of the entire species to be carried into the future in a small treasure box of potential, the *seed.* Lessons on pollination and seed dispersal show how a plant ensures the production of offspring so that a species can continue.

Interdisciplinary

Interdisciplinary connections bridge student knowledge and prevent artificial boundaries from developing. Science and math lessons go hand-in-hand when students are quantifying data and results. Science and language arts pair up naturally as children observe the natural world around them and begin the monumental task of describing and explaining their observations. Using the classic children's novel *The Secret Garden,* students learn the skills necessary to interpret their observations of the natural world.

All of these activities are designed to build good observation skills, develop systems to collect, organize, display, and explain data, and furnish a strong basis for future learning. Before we can understand anything, we must first see it clearly. So, let us begin.

Unit Overview

Survival in the Native Plant World includes activities that (1) highlight the often complex and subtle relationships between organisms, (2) teach students how to model abstract molecular processes, and (3) reinforce close observation of the natural world.

Suggested time: Two weeks

Objectives

Before your field trip, students will learn:

- Plants make their own food to survive.
- Plants have a variety of relationships with other plants and animals that affect their survival.

During your field trip, students will learn:

- Plant reproduction is necessary for future survival.

After your field trip, students will learn:

- Plants have different survival strategies.
- Changes in the environment may affect plant survival.

Survival in the Native Plant World addresses the following National Benchmarks for Science Literacy:

Concepts

- All foods are traced back to plants.
- In addition to providing food, organisms interact with each other in various ways.
- Interdependencies include pollination and seed dispersal.
- For a particular environment, some plants survive well, others less well, and some not at all.
- Changes in a habitat are sometimes good, or sometimes not, for an organism.
- Sometimes decisions have unexpected consequences no matter how carefully the decisions are made.
- Features used for grouping depend on the reason the grouping is being made.

Skills

- Write instructions that others can follow to carry out a procedure.
- Make sketches to aid in explaining procedures or ideas.
- Use numerical data to describe and compare objects and events.
- Keep records of investigations and observations.
- Offer reasons for findings and consider reasons suggested by others.

Lesson 1:
Plants make their own food to survive

ACTIVITY 1.1

Suitcase for Survival:
Explore the needs of living things

Before Activity

Gather materials:

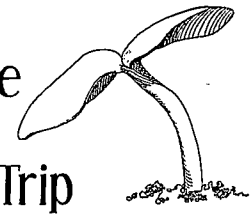
- __ a suitcase
- __ assorted items representing basic human needs, such as:
  - food (can of sardines)
  - water (water bottle with wacky straw)
  - clothes (tutu)
  - shelter (umbrella or tent)
  - protection (plastic sword)
  - warmth (neck scarf and mittens)
  - transportation (roller skates)
  - air (inflated balloon)
  - light (flashlight)

During Activity

1) Tell students you soon will be taking a trip. The place you are going has red rocks and no atmosphere. Invite them to guess your destination (Mars).
2) Ask students to think about things you will need on Mars, such as clothing, air, food, and shelter. As students name things, pull the representative items from the suitcase.

3) When the suitcase is empty, ask students what things in the suitcase *plants* would also need on Mars (such as food, water, air, light, etc.). Have students help you write a list of plant needs on the chalkboard.
4) Remind students that pollen and seeds are also part of a plant, just like the leaves and roots. Even though the plant itself does not need transportation, for example, the pollen and seeds do. Reiterate that plants need the same things people do. Almost everything plants need must be "carried" with them—in the same way that people carry a suitcase.

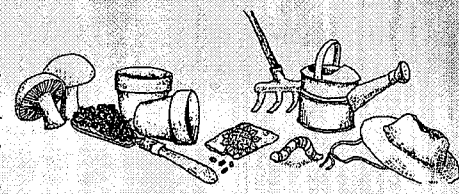
Before Your Field Trip



To prepare for your field trip, your class will:

- *explore the needs of living things*
- *discover how plants breathe through their leaves*
- *observe the process of capillary action*
- *experiment with capillary action in the stems of plants*
- *simulate photosynthesis in a role-playing game*
- *research and present information about plant cohorts*
- *conduct an experiment to learn about plant parasites*
- *explore how insects and animals carry pollen*
- *compare how far seeds travel using different dispersal methods.*

Seeds

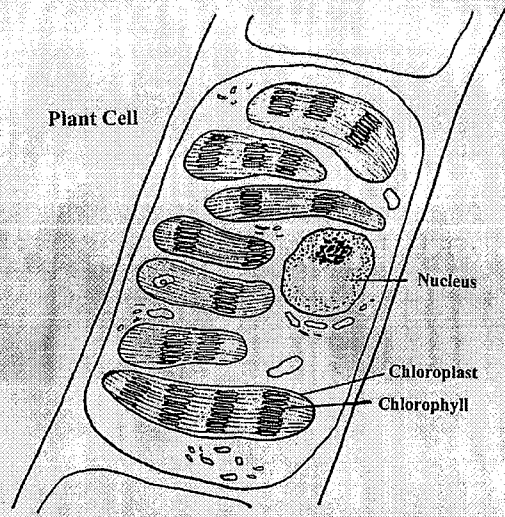


Seeds represent an evolutionary step forward for plants. A seed is a small package containing the *embryo*, or baby plant. The seed offers the enclosed embryo some protection from a changing environment and contains a "sack lunch" called the *endosperm*, which feeds the developing plant until it is able to begin photosynthesis and make its own food. This "survival package" allows seeds to wait for the perfect environmental conditions to germinate.

Definitions

Capillary action: the movement of water along a surface.

Chlorophyll: green pigment that collects light energy used in photosynthesis; found in chloroplasts.



Chloroplast: cellular structure containing chlorophyll; site of photosynthesis.

Guard cells: special epidermal cells that surround the stoma; they control the opening and closing of the stoma through water loss and absorption.

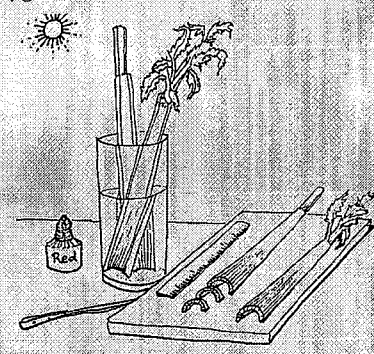
Transpiration: the loss of water vapor from the stomata.

Phloem: the food-conducting tissue of plants.

Photosynthesis: the process that uses light energy to convert carbon dioxide and water into food and oxygen.

Stoma, pl. stomata: the tiny pore, bordered by guard cells, found in leaves and stems; gases pass in and out of the plant body through them.

Xylem: water-conducting tissue of plants.



The Scientific Method

Question: What do we want to know? This is often restated as a problem.

Plan: How can we find the answer, using materials and procedures? This step depends on previous knowledge.

Results: What happened? Are the results reliable? Repeating trials are important to science, to see if we get the same results more than once.

So what?: What do the results mean? What conclusion(s) can we make from the results?

ACTIVITY 1.2

Breathing Plants:

Discover how plants breathe through their leaves

Before Activity

Gather materials:

__ adhesive labels

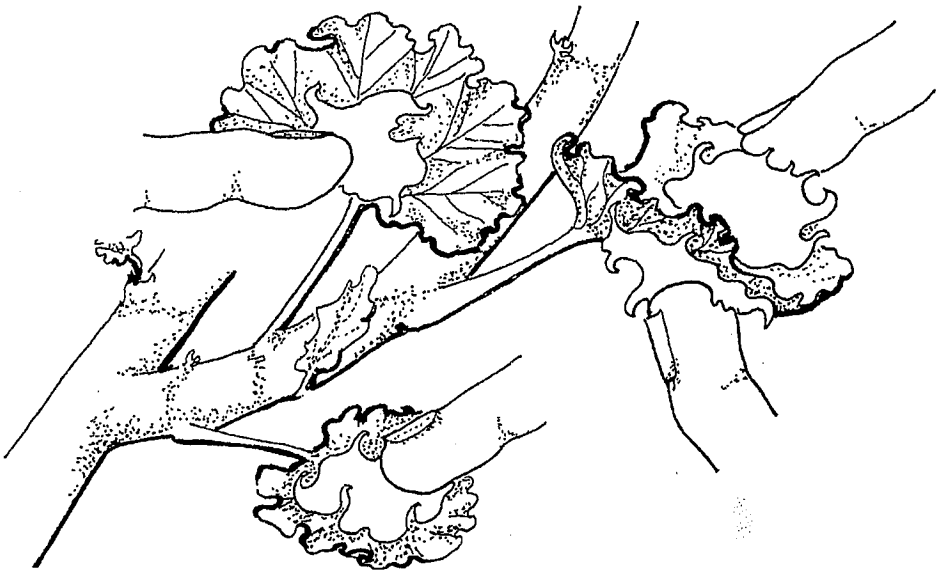
__ geranium or other potted plant

__ Vaseline

During Activity

1) Explain to students that plants breathe through their leaves. They breathe in carbon dioxide and breathe out oxygen (which is just the opposite of animals and people). Ask students to consider how plants and animals/people need each other to breathe. What happens when big forests are cut down, such as tropical rainforests in Southeast Asia and South America? Tell students they will learn more about how plants breathe in this activity.

2) Use Vaseline to coat three plant leaves and label those leaves (top, bottom, and top and bottom):
   - top of one leaf
   - bottom of one leaf
   - both top and bottom of one leaf.



3) Put the plant in a sunny location and water regularly. Have students observe the plant for three weeks and record their observations.

4) Have students explain what happened. Did all of the coated leaves change? What does that tell us about how plants breathe?

ACTIVITY 1.3

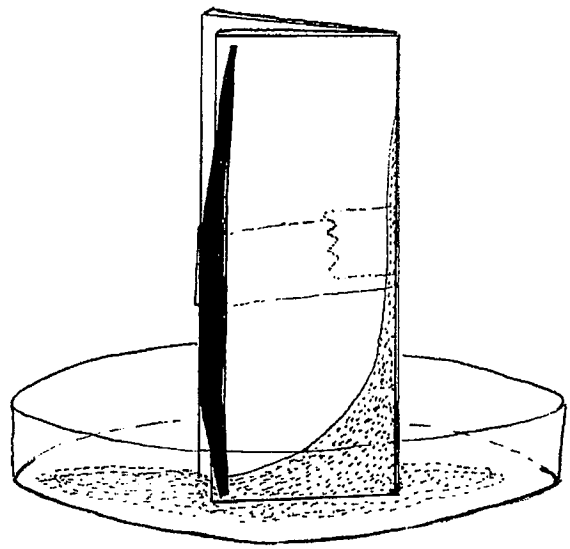
Going Up!: *Observe the process of capillary action*

Before Activity

Gather materials:

- __ two glass slides
- __ toothpick (if using glass slides)
- __ clear tape (if using glass slides)
- __ petri dish or other shallow dish
- __ darkly colored water (food coloring)

• With the glass slides, make a "slide sandwich" by slipping the toothpick lengthwise between the long edges on one side of the slides and then taping the "sandwich" together.



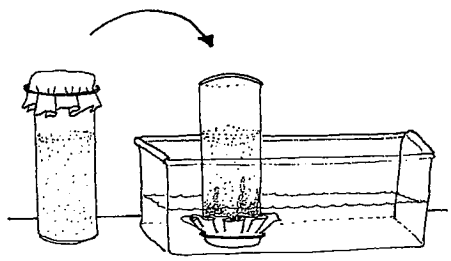
During Activity

1) Remind students that plants get water and nutrients from the soil through their roots. How does water get from the soil through the roots, up the stem, and into the leaves of a plant?

2) Fill the petri dish with colored water. Show students the "slide sandwich." Then place the slides or frame in the petri dish.

3) Hold the slides up to the light. Have students observe the water as it moves upward. Where does the water move higher? Invite students to hypothesize what might cause the water to move higher when the space is smaller.

Activity Extension: Tower of Mud



Fill a clear tennis ball can three-quarters full of dry sand and then fasten a piece of fabric over the top of the can with a rubber band. Place the sand-filled can upside-down into a clear pan or bowl containing 4 inches of water.

Students will notice that the sand is getting darker, from the bottom up. Explain that the water is traveling up through the narrow spaces between the small sand particles.

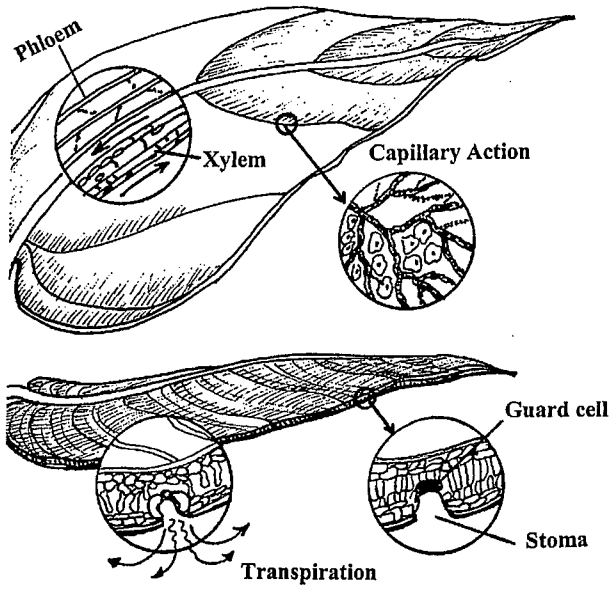
ACTIVITY 1.4

Pulling the Water Chain: *Experiment with capillary action in the stems of plants*

Before Activity

Gather materials:

- __ fresh bunch of celery, with leafy tops
- __ small or medium bucket or tub filled with about 6 inches of water
- __ red or orange food coloring
- __ knife and cutting surface



During Activity

1) Tell students that the class is going to conduct an experiment to learn more about capillary action.
2) Cut off the bottom inch of the celery bunch while it is submerged in the tub of water. Stand the bunch upright and then remove all leaves from *half* of the stalks. Finally, add food coloring to the water.
3) Have students hypothesize how capillary action might be different between stalks with leaves and stalks without. List their hypotheses on the chalkboard or a flipchart, indicating how many students chose each one. Have students create a bar graph showing this information.
4) Place the celery tub in a sunny location and remove two stalks every 20 minutes—one with leaves and one without. Cut each stalk in five centimeter sections, from the bottom edge up, until no color can be seen in the celery. Continue until no stalks remain or until the colored water has been siphoned to the top of at least one stalk.
5) Have students evaluate their hypotheses and decide which one was supported by the results of the experiment. Do leaves make a difference in the speed of capillary action? Celery stalks with leaves have a greater amount of transpiration. Water leaving the plant through the leaves helps pull more water into the plant and up the stems.

Activity Extension: Plant Siphons

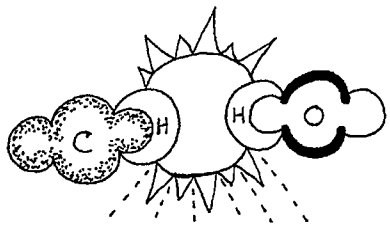
Use a fresh carrot (with green top) and several fresh celery stems to illustrate differences in capillary action among plants. Put the carrot and celery stems in two separate glasses of colored water—dark green or blue for the carrot and red or orange for the celery.

After several days cut open the vegetables and find the areas where the colored water has traveled. Where in the plant are the water transportation tubes located? Point out that different plant types have their water transportation tubes arranged differently.

Teaching Tip

You may want to use two bunches of celery in this activity. Put the second bunch in a separate bucket with one or two cups of sugar instead of food coloring. Remove only enough leaves to allow students a chance to taste them.

When the main activity is finished, have students taste the remaining celery leaves on the second bunch. They will be able to taste the difference between the leaves before and after the water arrives. Explain that the sugar is carried by the water up the celery stalks in the same way that minerals and other nutrients are carried by ground water up the stems of rooted plants.



ACTIVITY 1.5

Food Factory:

Simulate photosynthesis in a role-playing game

Before Activity

Gather materials:

__ *Photosynthesis Badges* templates, pages 33-36

__ *Photosynthesis Puzzle* templates, pages 37-38

__ two trays

__ cloth or paper bag

- Photocopy and prepare the appropriate number of various *Photosynthesis Badges*:

  one *Light Makes It Happen* badge

  two *Green Guard* badges

  two *Styling Xylem* badges

  approximately 25 *It's a Blast Being a Chloroplast* badges, depending on your class size

- Photocopy one set of the *Photosynthesis Puzzle* template (page 37) on cardstock and cut out to use as patterns.

- Use the puzzle patterns (page 37) to make *Photosynthesis Puzzle* pieces from colored cardstock or fun foam:

  15 big red "O"s

  30 little red "o"s

  30 blue "H"s

  15 purple "C"s

  15 yellow "Sunlights"

- Make 15 carbon dioxide "molecules" by fitting together 1 purple carbon puzzle piece with 2 small red oxygen puzzle pieces. Stack the carbon dioxide "molecules" on a tray for the *Green Guard* students to pass out.

- Make 15 water "molecules" by stacking 1 large red oxygen puzzle piece with 2 blue hydrogen puzzle pieces. Stack the water "molecules" on a tray for the *Styling Xylem* students to pass out.

- Put the sunlight puzzle pieces in the bag for the *Light Makes It Happen* student to pass out.

During Activity

1) Place the two trays and the bag on a table.

2) Have 2 students wear *Styling Xylem* badges, 2 students wear *Green Guard* badges, and 1 student wear *Light Makes It Happen* badges and stand near the table. Have the remaining students wear *It's a Blast Being a Chloroplast* badges and pair up at other tables or desks.

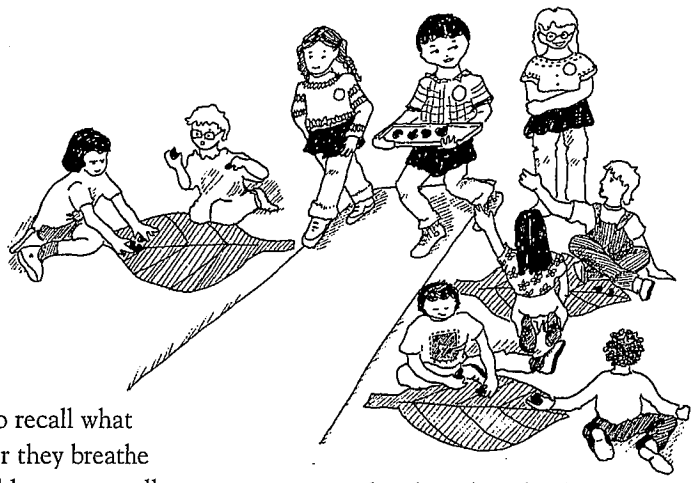
3) Explain to the chloroplasts that they live inside the leaf and are the chefs who combine ingredients to make food for the plant. Ask the chloroplasts what ingredients they need: Water (H_2O) is one ingredient; carbon dioxide (CO_2), a kind of gas found in air, is another.

4) How do plants get water? The water travels from the carrying tubes (xylem) leading from the roots to the leaves. Have the two *Styling Xylem* students carry the water tray and hand out an H_2O "molecule" to each pair of chloroplasts.

5) How do plants get carbon dioxide? Explain to students that there are trap doors in the leaves with guards at the openings. The guards open these doors at certain times to let carbon dioxide in. Have the two *Green Guard* students carry the carbon dioxide tray and hand out a CO_2 "molecule" to each pair of chloroplasts.

6) Tell the chloroplasts to fit the ingredients (puzzle pieces) into an arrangement that will hold together and be

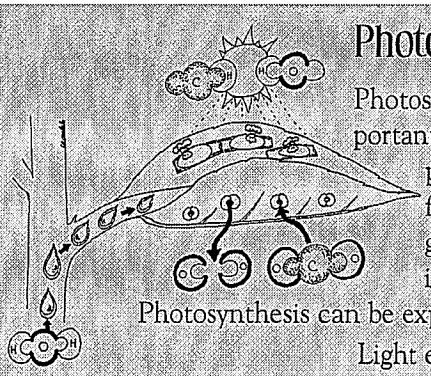
food. Allow a few moments for the chloroplast pairs to rearrange their puzzle pieces (atoms) before pointing out that they have more atoms than they need to make food.



7) Help students figure out which atoms to get rid of: Ask them to recall what plants breathe *out* after they breathe carbon dioxide in. Hold up two small oxygen puzzle pieces and explain that together they make an oxygen "molecule" that the leaf breathes out. Have the *Green Guard* students carry their tray around to collect all the oxygen "molecules" from the chloroplasts.
8) Allow a few more moments for the chloroplasts to arrange their puzzle pieces into food. Then look around and announce that this plant is going to starve because no one has made food yet. Something is missing.
9) Ask students what other ingredient a plant needs to make food besides water and carbon dioxide. As soon as they have identified *sunlight* as the missing ingredient, have the student wearing the *Light Makes It Happen* badge take the bag of sunlight puzzle pieces and give each one to each pair of chloroplasts.
10) With the right kind and number of ingredients, the chloroplast pairs now are able to fit the puzzle pieces together in the correct arrangement.

Point out to students that the food made by a leaf is a type of sugar. All sugars have these atoms in varying proportions.

Photosynthesis



Photosynthesis is probably the single most important process on the earth. This food-making process by plants creates the base of the food pyramid, by providing all living organisms with energy and, perhaps most importantly, oxygen.

Photosynthesis can be expressed using this simple equation:

$$CO_2 + H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} \text{Food} + O_2 + H_2O$$

Light energy, collected from the sun, is used to combine carbon dioxide and water into a simple sugar, which the plant then uses as a food source. Oxygen and a little water are released as waste products.

Photosynthesis takes place in chloroplasts—small structures found in the cells of leaves that contain the pigment chlorophyll. An easy way to visualize this is to think of a balloon filled with green paint. The paint is the *chlorophyll* and the balloon is the *chloroplast*.

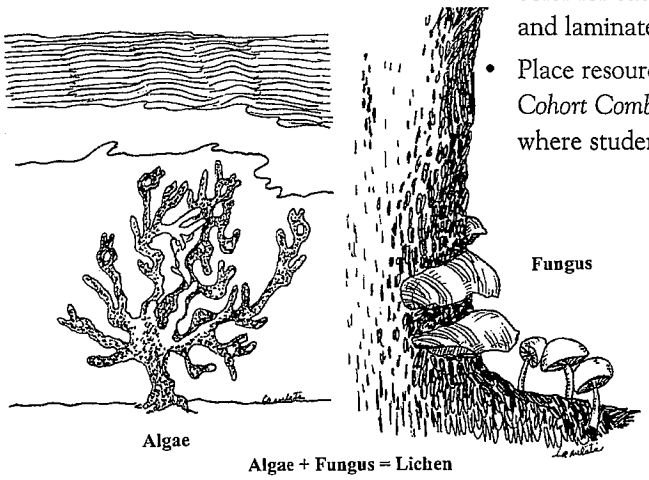
Teaching Tip

To reinforce the location of the processes for food making, you may set up the classroom with chloroplast pairs working on green leaf-shaped mats. Arrange the mats in two rows, one on either side of a long strip of brown butcher paper representing the plant stem. The Styling Xylem students can deliver water only by walking up and down the stem.

Lesson 2: Plants have a variety of relationships with other plant types and animals that affect their survival

Teaching Tip

You may want to take students to a natural area near your school and have cohort partners look for their organisms (one or both, if possible). However, although some cohort relationships are ongoing throughout the year, most occur during particular seasons, especially the spring and summer. Likewise, certain cohort organisms can be challenging (if not impossible) to find in nature, such as the night-flying Mexican Long-Tongued Bat or the Venus's-Flytrap. If possible give students an opportunity to see these organisms in the classroom or in photographs.



ACTIVITY 2.1

Cohort Combos: *Research and present information about plant cohorts*

Before Activity

Gather materials:

- ___ *Cohort Combos Information Sheets* template, pages 39-41
- ___ *Cohort Combos Puzzle* template, pages 42-47
- ___ various textbooks, reference works, and other resources that provide information on pollination, seed dispersal, parasitism, and mutualism

- Photocopy and staple five sets of the *Cohort Combos Information Sheets* template.
- Photocopy at least one classroom set of *Cohort Combo Puzzle* pieces on cardstock. If making more than one set (to use for review), use a different color for each. Cut out puzzle pieces and laminate if they are to be reused.
- Place resource materials and sets of *Cohort Combos Information Sheets* where students can easily access them.

During Activity

1) Hand out the classroom set of *Cohort Combos Puzzle* pieces, one per student. Tell students to find their "cohort," the person who has the matching piece of their puzzle. When all the cohorts are together, tell each student pair to make a hypothesis about how their partnership might work.
2) Give cohort partners 20-30 minutes to conduct research on how their two organisms are connected, using the Internet, reference books, and other resource materials you have provided. Do the cohorts depend on each other? Does one cohort accidentally assist the other? Does one cause problems for the other? Tell students they will be making short dramatic presentations about their findings.
3) Have each student pair *act out* their cohort relationship without words so the class can figure it out. Or you may want the student pairs to invent a dialogue to include in their dramatization.
4) After each presentation, ask the class to identify what kind of symbiotic relationship the cohorts have: Helps both (mutualism), helps one (commensalism), or hurts one (parasitism).

Symbiosis

Symbiosis is a partnership between two types of organisms. In the plant world there are three kinds of symbiotic relationships—plant-plant, plant-insect, or plant-animal. Some of these partnerships are advantageous to both; this is called *mutualism.* Some benefit only one partner, without really having an impact on the other; this is called *commensalism.* And some benefit only one partner and harm the other; this is called *parasitism.*

Plants, insects, and animals that have symbiotic relationships are called *cohorts.*

ACTIVITY 2.2

The "*Wand*er" of Pollen:

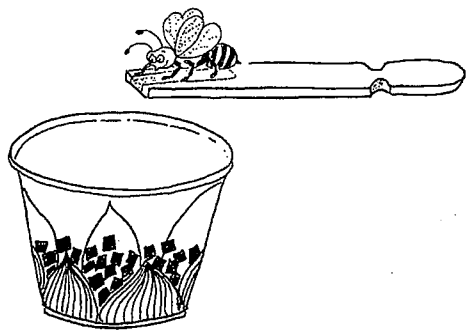
Explore how insects and animals carry pollen

Before Activity

Gather materials:

- __ clear plastic cup
- __ colored markers
- __ tray
- __ bag of marbles
- __ felt dots
- __ paint stir stick
- __ the "hooked" portion of adhesive-backed Velcro (strip or dots)

- Use colored markers to draw flower petals around the plastic cup. Put marbles in the flower cup and place on the tray.



- Make a wand by covering the bottom 3 inches of the stir stick with the "hooked" Velcro.

During Activity

1) Explain that plants use many different methods for pollination. One way to discover a plant's method for pollination is to see what kind of pollen it has—sticky or non-sticky.
2) First, demonstrate how some plants depend upon the wind to carry away their *non-sticky* pollen. Explain that the Velcro wand represents insects (bees, beetles, butterflies, flies) and animals (bats, hummingbirds) that visit flowers to feed on their nectar. Stir the wand in the flower cup and pull it out to show that the marbles (i.e., non-sticky pollen) did not stick to it. Then, blowing like the wind, gently tip the flower cup with your finger. The marbles will flow out and travel away.
3) Next, demonstrate how other plants depend upon insects and animals to carry away their *sticky* pollen. Replace

the marbles in the flower cup with felt dots. Again, blowing like the wind, gently tip the flower cup with your finger. The felt dots stay inside or very near the cup, showing that the wind cannot carry away sticky pollen. Then stand the cup upright again with the felt dots inside and stir the Velcro wand in the cup once more. Show students how the felt dots grip the wand, in the same way that sticky pollen grips visiting insects and animals and thus is carried to the next flower.

Activity Extension: Why Wind?

Wind-dependent plants must produce huge amounts of pollen for the species to survive. Illustrate this for students by giving them each a flower cup and having them sit in a semicircle on the floor. Tip your flower cup full of marbles onto the floor and have them try to collect some of this "wind-borne pollen." Remind students that flowers can't move quickly with a purpose, so to be fair they should close their eyes.

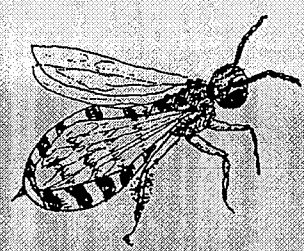
Have students discuss how many of the pollen marbles actually reach another flower. What would happen if students sat farther apart? What if they sat closer together? Can they think of other things that might change the odds?

Pollination Makes the World Go 'Round

Pollination is the first step in a plant's reproductive cycle and involves the transfer of pollen from one flower to another flower of the same species. Many different insect and animal pollinators carry pollen and these "work horses" of the natural world ensure continuation of plant species.

Pollinators do not get up in the morning and "go off and pollinate." Pollination is really a lucky result of a pollinator's search for food. While looking for the food "reward" such as nectar, pollen, or food bodies, the pollinator brushes up against anthers and stigmas, picking up and depositing pollen.

The relationship between plants and pollinators is often complex. Many pollinators have coevolved with the plants they pollinate and, in some cases, the relationship is very specialized. But some generalizations can be made about pollinators and the plants they visit.

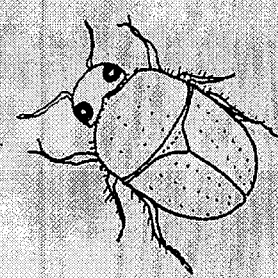


Bee Pollination

Bee-pollinated flowers are generally brightly colored and predominantly blue. They tend to be fragrant and sweetly scented and sometimes have distinctive markings (visible only to bees who can see UV light) called honey or nectar guides. Penstemons and bluebonnets are bee-pollinated species.

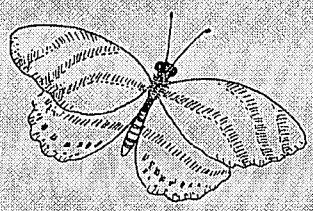
Beetle Pollination

Beetles prefer flowers that are large, white or dull in color and give off a strong fruity, yeasty, or spicy fragrance. Magnolias are a good example of beetle-pollinated flowers.



Butterfly and Moth Pollination

Butterflies are notoriously lazy pollinators and prefer flowers that provide a nice place to sit while they sip their nectar. They are also attracted to flowers that are sweetly scented and can accommodate their long tongues. Butterflies pollinate sunflowers and lantana, while many yuccas are moth-pollinated.



Moths, like their butterfly cousins, are also attracted to fragrant flowers, but, because they forage at night, they prefer white or light colored flowers that stand out against the night.

Hummingbird Pollination

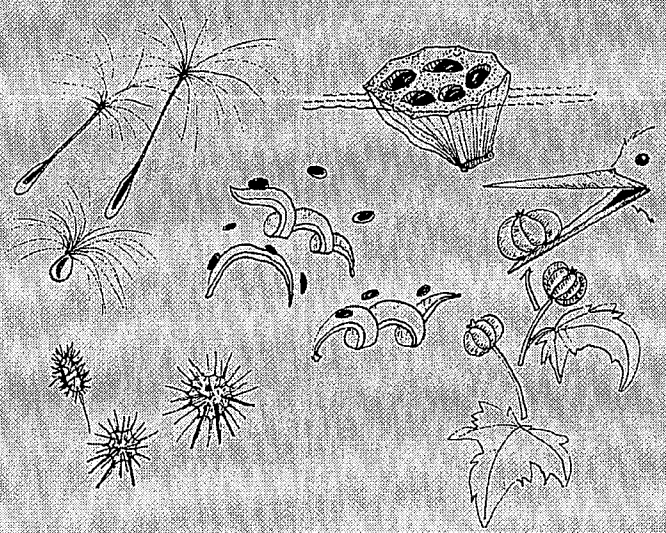
Hummingbirds have keen eyesight and are attracted to bright red, tubular-shaped flowers, which accommodate their long bills. Hummingbirds do not have a well-developed sense of smell, so hummingbird-pollinated flowers are not necessarily very fragrant. Hummingbirds pollinate standing cypress and coral honeysuckle.

'Round, 'Round, Get Around, I Get Around!

If pollination and fertilization successfully occurs, flowers will set fruit containing seed. The next step is to disperse, or move, that seed. Because plants are not mobile, they have evolved methods and strategies to move their offspring into new territory.

Wind Dispersal

Many plants disperse their seed via the wind. Small size and light weight, curved wings, inflated sacs, parachute-like plumes, bristles, and hairs all catch the wind and carry seeds to far-off places.



Water Dispersal

Water-dispersed seeds have to stay afloat long enough to get where they are going. Adaptations to accomplish this include air sacs that act as buoys, trapped air that keeps the seed floating, and waxy outer coverings that prevent seeds from becoming waterlogged and sinking.

Animal Dispersal

Not only do insects and animals act as pollinators, many also complete the job by moving the seed. Birds and mammals eat seeds or collect and store them, moving them long distances. Small hooks, sticky appendages, and sticky oils are just some of the ways seeds catch rides to far-off places on feathers, fur, and clothes.

Other Ways to Get Around

Many seeds are "shot" from their fruit, while others can actually "corkscrew" themselves into the ground. People are probably the best seed dispersers, carrying seeds from garden to garden and country to country.

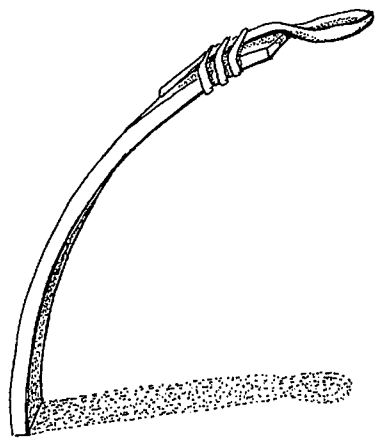
ACTIVITY 2.3

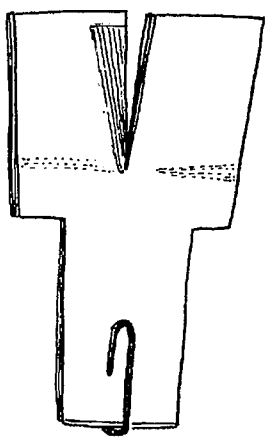
Flung, Flown, or Ferried?: *Compare how far seeds travel using different dispersal methods*

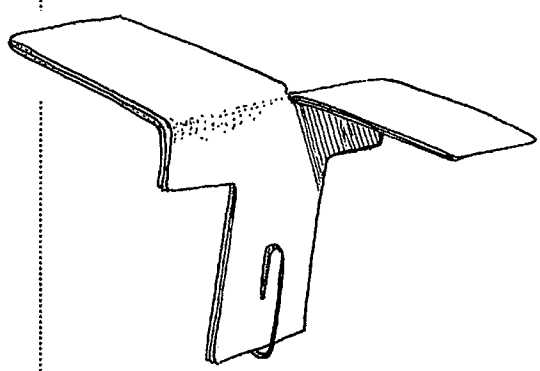
Before Activity

Gather materials:

- __ plastic spoons
- __ plastic rulers
- __ rubber bands
- __ paper clips
- __ ping-pong balls
- __ scissors
- __ tape
- __ plain paper
- __ graph paper
- __ Copies of *Flung, Flown, or Ferried? Data Sheet*, page 48







During Activity

1) Explain to students that just as different kinds of plants use different methods to disperse their pollen, they also use different methods to disperse their seeds. Some have built-in catapults to throw their seeds; others use the wind, birds, or animals to carry their seeds away.
2) Have students use plastic spoons, plastic rulers, and rubber bands to create catapults for throwing ping-pong balls. Have them use scissors, plain paper, and tape to make various whirligigs and spinning rotor shapes for transporting paper clips (see page 48).
3) Have students measure how far "flung" ping-pong balls or "airlifted" paper clips can go. What is the farthest distance these "seeds" can go? (Use the data sheet for recording.)
4) Next, have students use reference works and other resource materials to research the distances that birds and animals can travel. How far do different species of Hill Country birds (such as mockingbirds, blue jays, or cardinals) typically fly? How large are the territories of fur-bearing Hill Country animals (such as opossums, raccoons, or rabbits)?
5) Have students compare the distances seeds can travel depending upon whether they are dispersed by catapult, wind, bird, or animal. Ask what kind of graph would best show the large differences in distances. Help them try different types of graphs and decide on which shows the information the most clearly and accurately. A bar graph is likely the best type of graph.

Lesson 3:
Plant reproduction is necessary for future survival

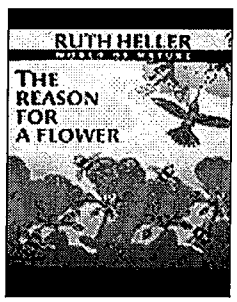
ACTIVITY 3.1

The Reason for a Flower:
Read a book about pollinators and seed types

Before Activity

Gather materials:

__ *The Reason for a Flower* by Ruth Heller



During Activity

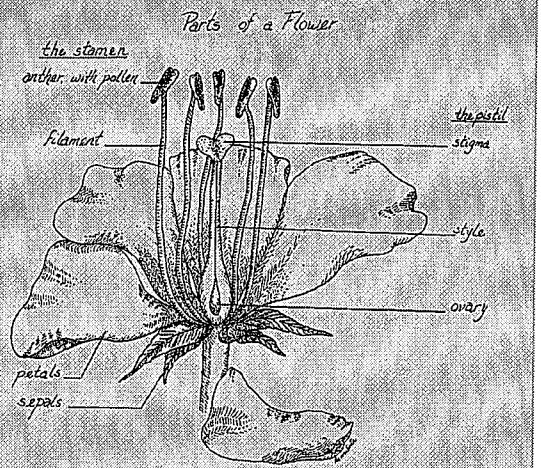
1) In the picnic area, read the book *The Reason for a Flower* aloud. (The book emphasizes the diversity of creatures that visit flowers and how they help with pollination and seed dispersal.) Have students name or point out the insects and animals on each page to make sure they can see all the hidden ones.
2) When students are ready, lead them to the Theme Gardens.

Flower Power

A typical flower has four sets of parts. Each set of parts plays an important role in the life cycle of the plant.

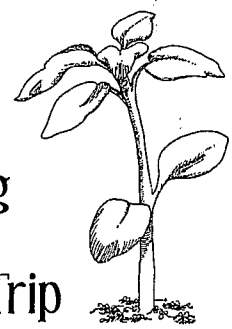
Sepals are the outermost set of floral parts. These leaf-like structures enclose and protect the developing flower bud.

The next set of floral parts are the *petals*. Petals are generally brightly colored and work to attract pollinators to the flower.



Stamens are the male reproductive structures. A stamen consists of an *anther*, where pollen is produced, and a *filament*, which supports the anther.

The female reproductive structures, called *pistils*, are the innermost set of floral parts. A pistil consists of a sticky *stigma*, connected to a long neck, or *style*, leading to an inflated *ovary*, containing the eggs, at the base.



During Your Field Trip

While on your field trip your class will:

- *read a book about pollinators and seed types*
- *explore the characteristics of different native plant pollens (spring-fall)*
- *observe pollinators at work (spring-fall)*
- *collect and categorize seeds according to dispersal method (fall-winter)*
- *explore a variety of nectar guides*
- *identify possible pollinators for various flowers (spring-fall), and/or*
- *identify evidence of insects and collect hidden seeds (fall-winter).*

Teaching Tip

If you plan to do Activity 5.3 at school later, you may want to bring the acrylic transparencies and markers with you on your Field Trip.

Teaching Tip

Minimal pollination takes place at the Wildflower Center from late November to early March. If your class is visiting during this period, skip Activity 3.2: Flower Dust and Activity 3.3: The Perfect Fit. Instead, substitute Activity 3.4: Seed Sort.

The Importance of Pollination to Plants and Pollinators

Why is pollination important to the insects and animals involved? It means survival for the pollinators, as well as for the plants they pollinate.

A mutual trade has developed between plants and their pollinators. Plants provide high energy foods—in the form of nectar, pollen, and food bodies—as an enticement and reward to the insects and animals that visit them. In their search for these rewards, pollinators inadvertently transport pollen from one flower to another. The end result: pollinators get fed and plants set seed.

Teaching Tip

Before doing this activity, identify any students with bee sting allergies!

If students do have severe allergies, be sure they have their epipens handy. Ask these students to help you hand out materials or other tasks that keep them away from the flowers.

Always be prepared to deal with bee sting allergies—and other serious allergic reactions—on any outing. (Remember—the Wildflower Center has provided a first aid kit in the Field Study Pack.)

ACTIVITY 3.2

Flower Dust: *Explore the characteristics of different native plant pollens*

Before Activity

Gather materials:

- __ one pollen board for each student pair
- __ one hand lens for each student

During Activity

1) Tell students that they will be collecting and studying pollen. Explain that flowers and pollen have a job to do, so the students must not pick any flowers; instead they will simply collect some pollen. Demonstrate by gently bending a blossom over and shaking the pollen free onto a pollen board.
2) Arrange students into pairs and give each pair a pollen board. Divide the student pairs into three groups, assigning each group an area in the Theme Garden for pollen collection. Tell students *not* to disturb any insect or bird pollinators visiting a flower; instead they should go to flowers that do not have visitors.
3) Give students 8-10 minutes to collect pollen. Circulate among the different Theme Garden areas, pointing out flowers with pollen. Be sure to identify flowering grasses for pollen collection. Remind students to stay on the sidewalks.
4) Have students gather together to examine their pollen samples with hand lenses. Some of the pollen will be larger, some stickier, and some might even be different colors. Do the bigger flowers have bigger pollen grains? Do all of the flowers have available pollen, or is it only present on some? Are there special areas or structures that hold the pollen?
5) Discuss why plants need pollination to survive.

ACTIVITY 3.3

The Perfect Fit: *Observe pollinators at work*

Before Activity

Gather materials:

- __ one bee wand for each student pair
- __ one butterfly wand for each student pair

During Activity

1) Have student pairs spend about 10 minutes observing pollinators and the types and characteristics they see at work in the Theme Gardens. Remind students to stay on sidewalks and *not* to disturb the pollinators they see.
2) Have students regroup for discussion. Were the flowers visited by two or more kinds of pollinators? What do the pollinators hang on to when collecting their food? How many kinds of flowers did they see bees pollinating? Do bee-pollinated flowers have any special characteristics, such as scent or color?
3) Give each student pair one bee wand and one butterfly wand. Have students *carefully* try to fit their wands into different flowers in the Theme Gardens. Tell them to use the wands to identify the type of pollinator best suited to each type of flower. Once again remind students not to disturb any pollinators they see. (However, they may observe the pollinators for clues.)

Theme Garden Pollinators

Students in the Theme Gardens will easily find flowers that depend on bees, butterflies, and moths for pollination. However, they probably will need help identifying flowers that are pollinated by hummingbirds or flies. Ask students if they have seen any flowers with the characteristics described below.

Hummingbird-pollinated flowers: The color red is not visible to most insects but is very visible to birds. Red flowers usually have a very deep tube, inaccessible to insect pollinators. Because hummingbirds have enormous energy demands, these deep tubular flowers have large amounts of nectar that is out of reach from insects that could not properly transport the pollen.

Fly-pollinated flowers: Flies are attracted to rotting food to lay their eggs, and so they will visit flowers with a similarly nasty aroma.

Bees

Bees visit flowers to feed on the nectar (and also to collect pollen to feed their larvae). They eat the nectar with a tongue that extends out through a sucking tube. Body hairs on the legs and abdomen of bees act as brushes that pick up the pollen, which they comb out and force into pollen baskets on their third pair of legs.

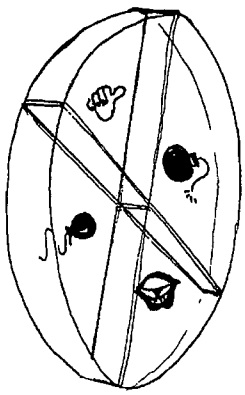
Bees can see color, although in a different light

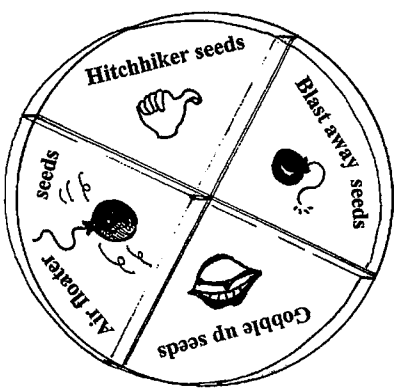
spectrum than ours (ultraviolet). Bee-pollinated flowers are generally showy and brightly colored, usually in shades of blue or yellow (the color red appears black to them). Many bee-pollinated flowers also have special markings, which humans cannot see—called *nectar guides*—that lead them straight to the nectar. Nectar guides also are associated with landing platforms that provide a place for bees to sit.

Some of the more unusual bee-pollinated flowers have spring-loaded traps or complex passageways that force the bee to follow a particular route. This ensures the bee will collect and deposit pollen in the proper locations. For example, the anthers of penstemon (*Penstemon* spp.) are arranged so they tap the bee's back as it moves into the flower in search of nectar.

Butterflies

Like bees, butterflies are attracted to flowers by a combination of sight and smell. However, butterflies can see the color red and like to visit red, blue, and yellow flowers. Butterflies like to sit while they sip their nectar and tend to prefer flowers that offer a sturdy landing platform. Nectar guides or mechanical tongue grooves on the flower petals guide a butterfly's long tongue to the rich nectar located at the base of long, slender floral tubes. Butterfly-pollinated flowers include milkweeds (*Asclepias* spp.), lantana (*Lantana* spp.), and phlox (*Phlox* spp.).





ACTIVITY 3.4

Seed Sort: *Collect and categorize seeds according to dispersal method*

Before Activity

Gather materials:

- __ one seed sorting plate for each student pair

During Activity

1) Tell students they will be collecting and studying seeds to see how they are dispersed. Explain that seeds have an important job to do, so students will collect only one seed from each plant type.
2) Arrange students into pairs and give each pair a seed sorting plate. Divide the student pairs into three groups, assigning each group an area in the Theme Garden for seed collection. Remind students to stay on the sidewalks.
3) Give students 8–10 minutes to collect seeds. Then have students gather together to examine their seeds and discuss possible dispersal methods. Have students sort their seeds into the labeled plate sections according to how the seed is dispersed. Did anyone find a seed that does not fit into the travel types listed on their seed plates?
4) To close this activity, have students scatter the seeds along the Meadow Trail. Then lead them to the classroom.

ACTIVITY 3.5

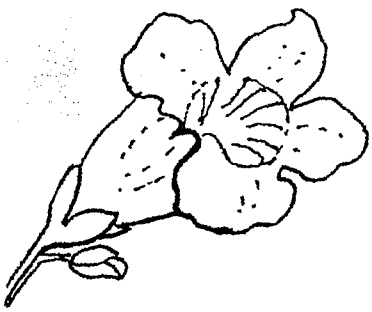
This Way to the Nectar Café:

Explore a variety of nectar guides

Before Activity

Gather materials:

- ___ four *Flower Patterns* template, pages 49-52
- ___ markers and crayons
- ___ two flower photos
- ___ ultraviolet light box with painted flower model



During Activity

1) Show students photographs showing nectar guides on various flowers.
2) Give each student a flower pattern to color. Tell them to include nectar guides on their flower designs. Let students work on their flowers a little while and then hold up a flower photo. Ask if anyone created nectar guides that are similar.
3) Repeat with the other flower pattern.
4) Have students gather around the ultraviolet light box to see how nectar guides (normally invisible to people) look to insects. To create your own, use a large wooden box with a UV light attached underneath the top. Place a silk flower painted with UV nectar guide lines inside.
5) The colored flower creations are yours to keep. Feel free to take them back to your school at the end of your Field Study Trip.

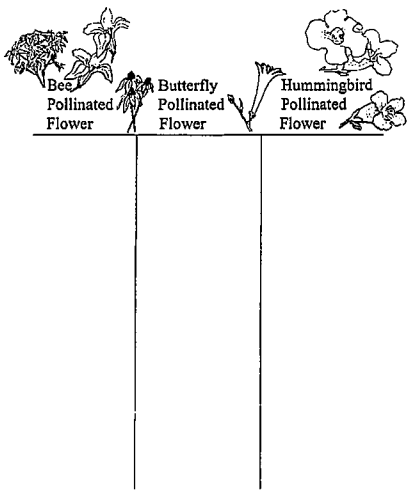
Teaching Tip

If your class is visiting the Wildflower Center from late March to early November, you might want to introduce students to nectar guides on flowers in the Courtyard before entering the classroom. Point out the nectar guides on several flowers and then give students 2-3 minutes to search for nectar guides on other flowers.

You may want the class to take a bathroom/drinking fountain break as they make the transition into the classroom.

Teaching Tip

Minimal pollination takes place at the Wildflower Center from late November to March. If your class is visiting during this period, skip Activity 3.6: The Birds and the Bees and do Activity 3.7: The Bugs and the Seeds instead.



ACTIVITY 3.6

The Birds and the Bees:

Identify possible pollinators for various flowers

Before Activity

Gather materials:

- __ clipboards with pencils
- __ *Pollinator and Flower Survey Sheet* template, page 53
- __ hand lenses
- __ bee puppet
- __ small shaker of "pollen" (cornstarch and glitter)

During Activity

1) Give each student or student pair a clipboard with pencil, a survey sheet, and a hand lens. Explain that they will be conducting a survey of flowers and pollinators as they walk on the Meadow Trail (if at the Wildflower Center), or choose a meadow trail near your school.
2) Lead students to the Meadow Trail to begin their survey. Tell students to look for as many different kinds of flowers as they can find.
3) To record the plants on the survey sheets, students can draw the plant, write the plant name if they know it, or make up a name. (For example, a common flower such as the Indian Blanket could be called "fire wheel," "hubcap," or "big brown eye.") Beside each plant on their surveys, students should write what kinds of insects or animals would be likely to pollinate that flower.
4) At the end of the trail walk, return to the classroom and discuss what the surveys reveal.
5) Have students sit in a circle with their flower creations (Activity 3.5: Nectar Guides) and ask who would like to be "pollinated." Use the bee puppet and small shaker to lightly pollinate students' hair and/or flower creations with cornstarch and glitter. (You may want students to take turns visiting the bathroom and water fountain during this activity.)
6) If at the Wildflower Center, leave the Field Study Pack, clipboards, and other materials neatly in the classroom before returning to the School Group Picnic Area.

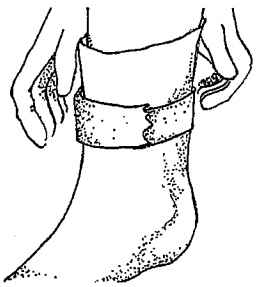
ACTIVITY 3.7

The Bugs and the Seeds:
Identify evidence of insects and collect seeds

Before Activity

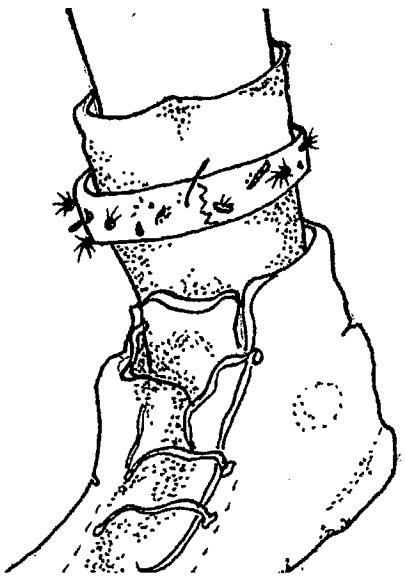
Gather materials:

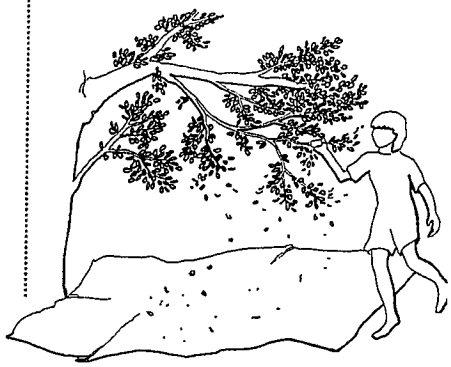
- __ masking tape
- __ clipboards with pencils
- __ *Insect Evidence Survey Sheet* template, page 54
- __ hand lenses
- __ white cloth
- __ bee puppet
- __ small shaker of "pollen" (cornstarch and glitter)

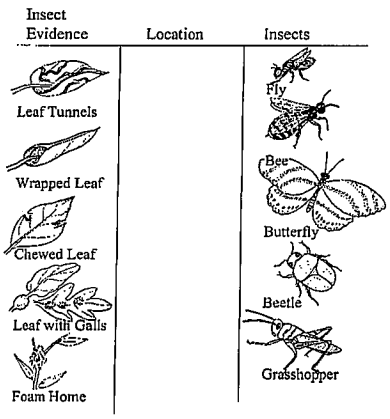


During Activity

1) Give each student a 12-inch-long strip of masking tape. Tell students to wrap the tape, sticky side *out*, around their shoe or sock. These are seed collectors.
2) Give each student or student pair a clipboard with pencil, a survey sheet, and a hand lens. Explain that they will be conducting a survey of insect damage on plants as they walk on a meadow trail.
3) Lead students to a meadow trail to begin their survey. Tell students to look for evidence of insects on the plants along the trail. In the "location" column, students will write where on the plant they saw the insect damage.
4) Midway on the trail walk, lay the white cloth under a bush or small tree and shake the plant vigorously. Invite students to examine the cloth to see what kinds of insects fell from the plant.
5) Gather the class on the benches in the Oak Grove and ask them how a plant might protect itself from these insects. Make a list of possible plant defenses.
6) At the end of the trail walk, return to the classroom and have students remove their masking tape seed collectors. Tell them to compare with their partners the variety of seeds collected. Can they find seeds that travel by wind, water, hitchhiking, and ingestion?







Activity Extension: Seed Cycle

To extend this activity into the spring, have your students take their masking tape seed collectors back to school. Let them plant their seeds—either in a window garden or in a designated (and protected) spot on the school grounds—and discover what plant species they collected!

Lesson 4:
Plants use different means of protection to survive

After Your Field Trip

To follow up on your field trip your class will:

- *identify similar methods of defense among animals and plants*
- *invent a plant with an effective method of defense*
- *explore how plants use scent as a defense method*
- *explore how different plants tolerate different growing conditions*
- *observe plants growing in succession stages*
- *compare lichen growth in low and high pollution areas*
- *measure the effects of air pollution on leaf growth*
- *observe the effects of acidic water on plant survival*
- *match plants with the environments they need to grow*
- *observe the success rates of native seedlings vs. non-native seedlings.*

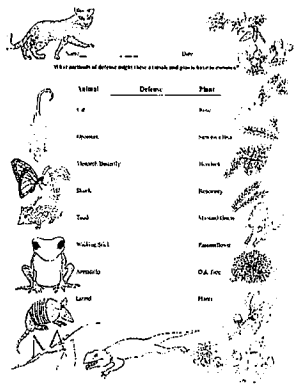
ACTIVITY 4.1

Defense, Defense: *Identify similar methods of defense among animals and plants*

Before Activity

Gather materials:

- ___ *Defense, Defense* template, page 55
- ___ pictures of various plants and animals
- Photocopy a class set of the *Defense, Defense* template.



During Activity

1) Ask students to name some defenses that animals use to protect themselves from dangers in their environments, such as armor, sharp claws and teeth, strong smell, bitter taste, poison, playing dead, giving up parts, camouflage, and mimicking.
2) Give students the *Defense, Defense* handouts to complete. Display pictures of plants and animals to help students identify possible plant defenses.
3) Discuss students' answers on the handouts.

Plant Defenses

Did you know that roses and cats have something in common? Both have defenses that scratch or puncture. A rose's thorns and a cat's claws keep predators away.

The opossum is known for playing dead when all else fails. The hog-nosed snake flips over and lies still when picked up by people. Even spiders will fold in their legs and crouch as if dead when they feel threatened. The sensitive briar reacts to being touched by folding up its leaves and looking small and shriveled. Like the opossum, hog-nosed snake, and spider, the sensitive briar may be reducing its chances of becoming a meal.

Monarch butterflies feed on milkweeds, which store chemical compounds called alkaloids in their stems and leaves. Monarch butterflies store these alkaloids in their bodies, which make them taste bad. Birds and other predators avoid the Monarchs because they know they will taste bad. Plants also store chemicals in their stems, roots, and leaves, which make them taste

bad to animals that might want to eat them. Animals learn to recognize these plants and avoid them.

Skunk spray can be smelled for miles, and is avoided by all living creatures with a working nose. Aromatic plants, such as sages, use their strong scent to repel insects. Most strong-smelling herbs do not experience insect hordes, and may be planted to protect other plants.

Toads have a gland that releases a chemical when they are handled. This chemical has a bitter taste, which causes predators to drop them. Mustard greens also taste bitter, discouraging animals that might want to eat them.

The walking stick uses its shape to fool possible predators into thinking it's a stick or twig. The passionflower vine uses small bumps to fool butterflies into thinking their leaves already have eggs laid on them, sending butterflies to other plants to deposit their voracious offspring.

The armadillo is protected by its coat of "armor." Like armadillos, trees have thick bark to protect them from the effects of weather, insects, and disease.

Lizards, such as the five-lined skink or green anole, abandon their tails to escape from predators. Most plants can survive the loss of one or more stems, roots, or leaves.

ACTIVITY 4.2

Plant Warriors:

Invent a plant with an effective method of defense

Before Activity

Gather materials:

- craft supplies, including construction paper, glue, yarn, paints, crayons, scissors, etc.

During Activity

1) Invite students to create a plant that uses one of the defense methods they have learned about. Remind them that a successful plant design increases the plant's chances of producing good seeds. Their designs can focus on protecting the plant itself or on protecting the plant's seeds.
2) Set up a Hall of Warriors for students' plant inventions. Each plant should have a card that identifies its name, location, and potential enemies, as well as the defense that helps protect the plant.

Teaching Tip

Remind students that plants do not have freedom of movement. No karate-chopping vines!

Teaching Tip

This activity requires a large space. You may want to take your class to the auditorium, the gym, or the playground.

ACTIVITY 4.3

Siren of Smell:

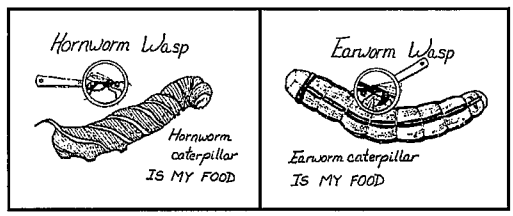
Explore how plants use scent as a defense method

Before Activity

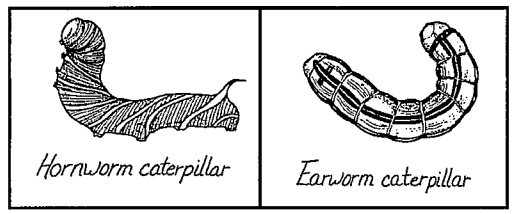
Gather materials:

- __ 15-21 cards, depending upon class size
- __ 10 *Siren of Smell Nametags* templates, page 56
- __ 30 plastic film canisters with lids
- __ 30 cotton balls
- __ vanilla extract and peppermint extract

• Prepare cards: 5-7 labeled "earworm," 5-7 labeled "hornworm," and 5-7 blank.



• Prepare nametags: 5 labeled "earworm wasp" and 5 labeled "hornworm wasp."



• Soak 15 cotton balls with vanilla extract and put them in empty film canisters. Soak another 15 cotton balls with peppermint extract and put them in the remaining film canisters. Use adhesive dots, nail polish, or some other marking system to identify which canisters are vanilla and which are peppermint.

During Activity

1) Select 10 students to be "wasps" and give them nametags to wear. Give half of them hornworm cards and the other half earworm cards. Explain that the wasps are *insect* predators; they eat other insects. Earworm wasps eat earworms and hornworm wasps eat hornworms. Earworms and hornworms are *plant* predators; they like to eat the leaves of mallow plants.
2) Tell the remaining students they will be mallow plants. Have them stand in a straight line at least two arm-lengths apart. Give each mallow plant a card—earworm, hornworm, or blank. Explain that the cards tell the plants whether or not their leaves are being eaten and, if so, by what insect. Have these students look at their cards and then put them *face down* on the floor by their feet.
3) Tell the wasps to "fly" in front of the mallow plants to guess which ones they think are being eaten by their insect prey. Have the wasps pick a plant by putting a hand on the plant's shoulder.
4) Tell the mallow plants to show the wasps their cards. How many wasps were able to find a meal? (Remind students that the earworm wasp *only* eats earworms and the hornworm wasp *only* eats hornworms.)
5) Explain that mallow plants use scent as their defense system against plant predators like the earworm and hornworm. They put out "smell signals" to attract the worm-eating wasps—a different smell for each different kind of

worm. The plants want the worms to be eaten before the worms eat them!

6) Collect, shuffle, and again hand out cards to the mallow plants. Have them look at their cards and then put them on the floor again. Then give each plant two film canisters—one with peppermint extract and one with vanilla extract.
7) Tell the plants who have an earworm card to secretly open the peppermint-scented film canister. Tell those who have a hornworm card to secretly open the vanilla-scented film canister. Then tell *all* the plants to hide *both* canisters behind their backs.
8) Tell the wasps to "fly" in front of the mallow plants again. This time have them try to find the right plant by smell. Again, have the wasps pick a plant by putting a hand on the plant's shoulder. Tell wasps that the earworm wasp is attracted to a peppermint scent, and the hornworm is attracted to a vanilla scent.
9) Tell the mallow plants to show the wasps their cards. How many wasps were able to find a meal this time?

The Smell of Survival

Scent plays a role in attracting pollinators to many plants. Beetle-pollinated flowers emit a strong fruity or spicy odor, while fly-pollinated flowers often smell like decaying meat.

Plants not only use scents to attract pollinators, they also use them to repel potential predators. Many sages, for example, have highly aromatic foliage that discourages herbivores such as deer from eating them.

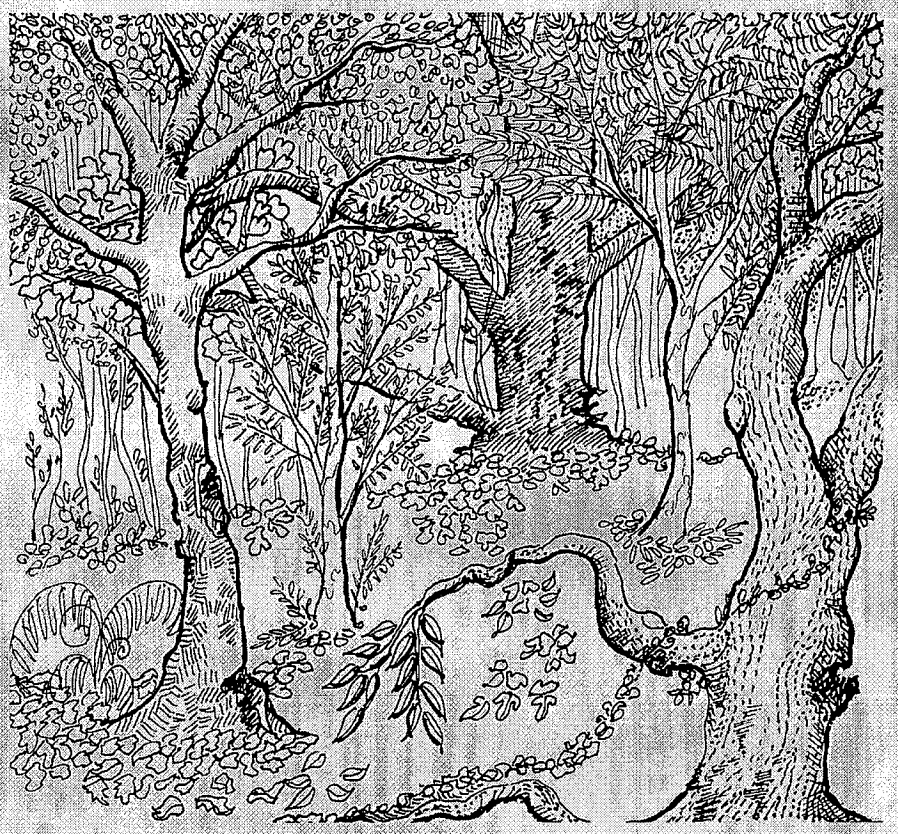
Some plants also use scent to attract "defenders" when they are being attacked. Research has shown that certain plant species, when being eaten by insects, will emit a scent that attracts the predators of those insects (usually another species of insect). These predators eat the insects eating the plants, thus "saving" the plants.

Lesson 5:
Changes in the environment may affect plant survival

Habitat Tolerance

Changes in habitat may or may not affect the survival of a plant. Most plants can tolerate a moderate range of environmental conditions and can survive the occasional extreme such as a cold winter or hot, dry summer. Some plants can tolerate huge environmental extremes and may actually benefit from surviving a very cold winter or long, hot, dry summer. On the other hand, seemingly minor changes in temperature or moisture can often result in the death of one plant species, while another species is unaffected or actually thrives.

One of the many benefits of native plants is that they have had millions of years to become adapted to the environmental extremes in the regions in which they live, giving them the ability to survive the occasional drought or flood.



ACTIVITY 5.1

Pick-a-Plant: *Explore how different plants tolerate different growing conditions*

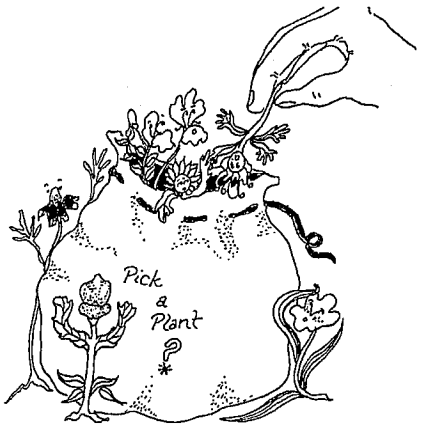
Before Activity

Gather materials:

- __ *Pick-a-Plant* template, page 57
- __ *Pick-a-Plant Seed Packets* template, page 58
- __ *Pick-a-Plant Overhead* template, page 59
- __ 5-10 seed packets for different kinds of plants
- Photocopy a class set of the *Pick-a-Plant* template.
- Photocopy a class set of the *Pick-a-Plant Seed Packets* template.

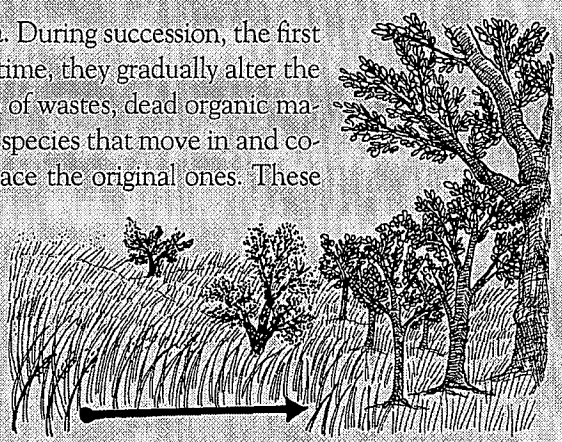
During Activity

1) To introduce students to the idea of range of tolerance, ask them to guess the human range of tolerance for heat and cold. How hot can people stand it to be for more than a few days? How cold? Explain that animals, insects, and plants all have particular ranges of tolerance. Some plants are tolerant and can grow in a wide range of conditions, while other plants have very specific requirements.
2) Give each student a *Pick-a-Plant* handout. Help students study the table of information for the four imaginary plants, compare the ranges of tolerance, and answer the questions.
3) Pass around the purchased seed packets and discuss with students the range of tolerance information on the packets, such as temperature and rainfall requirements and light needs in terms of planting location. Use the *Pick-a-Plant* overhead to help explain the information on the purchased seed packets.
4) Have students use their *Pick-a-Plant Seed Packets* handouts to write seed packet directions for the imaginary plants, based on the range of tolerances chart from #2.



Succession Stages

Plant communities go through stages as they age. This is called *succession.* During succession, the first plants to appear (called *pioneer species*) colonize the environment. Over time, they gradually alter the environment as they carry on their normal activities. The accumulation of wastes, dead organic material, inorganic debris, etc. changes the environment, favoring different species that move in and coexist with the existing species. In some cases, the new species may replace the original ones. These new species, in turn, continue the modification of the environment. The new changes, in turn, favor new species, which colonize the environment. And so the cycle continues. The process of succession does not happen overnight; rather, it requires many, many years to occur.



Eventually the plant communities (and other organisms associated with the plants) in the environment remain the same for longer and longer periods of time. This is called the *climax vegetation.* This state of equilibrium will continue until some disturbance or climatic change takes place, altering the environment in such a way that the succession process begins anew. Charles Darwin was able to observe succession on a small scale. He collected a cup of mud and, over a six-month period, recorded more than 537 plants growing in the cup.

ACTIVITY 5.2

Plants in Place:

Observe plants growing in succession stages

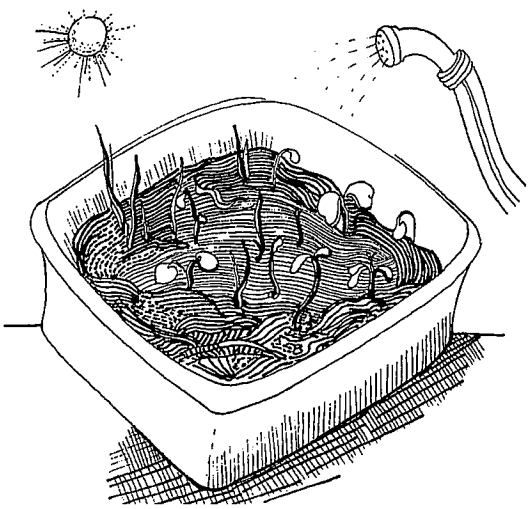
Before Activity

Gather materials:

- __ large clay pot
- __ mud collected from the edge of a pond, lake, or river

During Activity

1) Put the muddy soil in the clay pot. Place in a sunny location and keep watered.
2) Have students observe, measure, and create a table to record the kinds of plants that grow in the pot. Which ones sprouted first? Were they the largest plants, or did others that sprouted later grow taller? Which plants were most common? Which were least? How many of the plants could students recognize?



The Effects of Pollution

Pollution affects all living organisms. And plants are no exception. Polluted water is absorbed by plant roots and transported throughout the plant. Air pollution particles, such as soot and car exhaust, coat leaf surfaces, preventing the leaves from absorbing the sunlight necessary for photosynthesis. Both of these types of pollution often kill plants and plant communities.

Herbicides used to eradicate unwanted plant species are often indiscriminately applied and kill desirable species. Changes in the earth's ozone layer as a result of pollution affect plant populations. Acid rain, resulting from the burning of fossil fuels, also contributes to the loss of plants.

ACTIVITY 5.3

Lichen Survival: *Compare lichen growth in low and high pollution areas*

Before Activity

Gather materials:

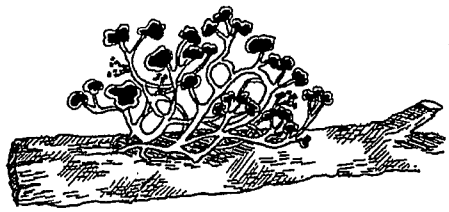
- __ *Lichen Survey* template, page 60
- __ two acrylic transparencies for each student pair
- __ one marker for each student pair
- __ one sheet of graph paper for each student pair

- Photocopy a class set of the *Lichen Survey* template.
- Locate trees with lichen in a rural area and in an urban area near the street. (See Teaching Tip at right.)

During Activity

1) Give students the *Lichen Survey* handouts and review with them the three types of lichens. Explain that students will be collecting data on whether lichens are affected by automobile pollution.

2) Arrange students into pairs and explain that each pair will measure lichen growth on two trees: one tree growing close to a busy city street and another tree growing far from a busy street.
3) Give each student pair two acrylic transparencies and a marker. Explain the technique they will use to collect data: As one student holds an acrylic sheet around a tree trunk at chest level, the other will use the marker to draw circles to outline the lichen patches underneath.



4) Take students to collect data in the areas you previously located. Tell students to label the acrylic sheets "urban" or "rural" so they can tell which is which when they return to the classroom.
5) When you return to the classroom, give each student pair a sheet of graph paper. Have students place one acrylic sheet on top of the graph paper and count the number of squares inside each circle to estimate the area. Tell them to record the number of squares. Then have students repeat the process with the other acrylic sheet.

6) Write the estimates for "rural" and "urban" tree lichen growth areas in separate columns on the chalkboard. Have students add and divide each set of estimates to find the average.
7) Have students compare the average area of lichens growing on the "urban" trees to the average area growing on the "rural" trees. What conclusions can they draw about the effects of automobile pollution on the growth of lichens?

Teaching Tip

This activity requires comparing lichen growth on rural and urban (road-side) trees. If you cannot easily arrange a field trip to a wooded rural area, you may want to consider the following alternatives.

If you have access to a large, heavily treed urban or suburban park, you may arrange for your class to collect data there. They can find "urban" trees at the park's edge (as close to a busy roadway as possible) and "rural" trees at the park's center (as far from roadways as possible).

If your school is in a quiet neighborhood located near a major roadway, you may lead your class on a neighborhood field trip to collect data. Select "rural" trees on quiet streets, such as cul-de-sacs. Be sure to get permission from homeowners if they are at home!

Teaching Tip

For the sake of convenience, you may wish to do steps 2-4 in this activity before class. However, your students might have a clearer sense of what automobile pollution is if they accompany you to the parking lot and help collect the pollution sample.

ACTIVITY 5.4

Watered in Pollution:

Measure the effects of air pollution on leaf growth

Before Activity

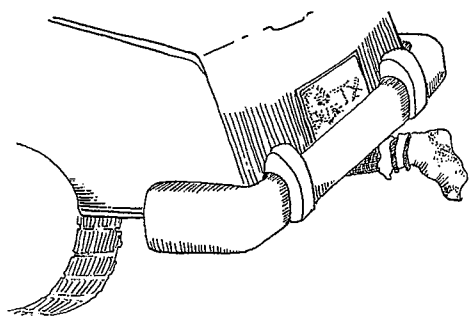
Gather materials:

- __ pair of white socks
- __ two tall glasses of water
- __ rubber bands
- __ two plant cuttings, same size
- __ automobile parked at the school

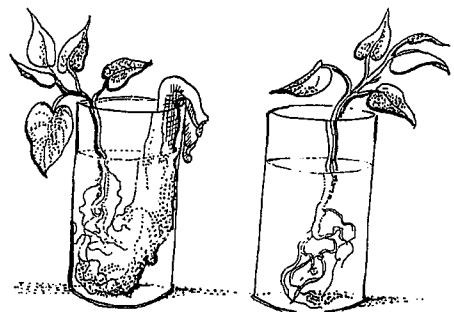
• Ask an auto mechanic whether it is safe to run your car (or whichever car you plan to use for this activity) for several minutes with a sock filter on the exhaust pipe.

During Activity

1) Tell students this activity is an experiment to see whether automobile pollution affects leaf growth in plants.
2) Collect a sample of air pollutants by slipping a clean white sock over your car's *cold* exhaust pipe. (Wait at least one-half hour after turning off the engine.) Fasten the sock to the exhaust pipe with a rubber band, leaving several inches of sock toe space on the end.



3) Turn on the car and allow the sock to filter impurities from the exhaust for several minutes. Turn off the engine and wait at least one-half hour for the exhaust pipe to cool.
4) When the exhaust pipe is cool, remove the sock and rubber band. Handle the sock carefully to avoid touching the pollutants.
5) Put the dirty sock into a tall glass of water and its clean mate into another. Then put a plant cutting into each glass as well.



6) Have students observe the cuttings for three weeks. Once or twice a week have them measure the number and size of leaves on each plant cutting to measure the effects of pollution. What conclusions can they draw about the effects of automobile pollution on leaf growth? Have them create a simple table graph or chart to organize, examine, and review their data collected. Remind students that leaves are the food factories for plants. What happens to a plant if it has fewer and smaller leaves than it should?

ACTIVITY 5.5

Acid Rain:

Observe the effects of acidic water on plant survival

Before Activity

Gather materials:

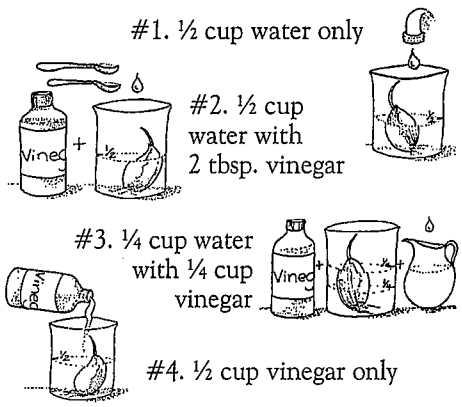
- __ four garlic cloves or onion sets rooted in water
- __ vinegar
- __ measuring cup
- __ measuring spoons
- __ four clear containers, labeled #1 – #4
- __ four different species of potted plants

• Root garlic bulbs or onion sets in water 10 days prior to beginning this activity. Be sure to keep the bottom third of the bulbs wet.

During Activity

1) Explain to students what acid rain is, how it is caused, and how it affects the survival of many plants. Tell them that vinegar is a weak acid and, like acid rain, it can affect a plant's ability to survive.

2) Prepare four different vinegar solutions in the four clear containers:



3) Place a rooted garlic bulb or onion set in each marked container and place in a well-lit location.

4) Have students observe the plant roots for two weeks and record their observations. How are the roots affected by the acidity of the water? What other effects do the students observe?

5) What was the weakest vinegar solution to cause a plant to stop growing? Make more of this solution and use it to water the four potted plants of the same species. Have students observe the plants for two weeks, then record their observations in a table or chart to examine their data and share their results. Do all of the plants have the same tolerance for acidity?

Teaching Tip

Remind students about the role of a "control" in conducting an experiment. Explain that container #1 serves as a control to show how roots react to plain water. This helps them recognize the effects on the plant roots of low, medium, and high acid content.

Factors of Plant Health

Many environmental factors contribute to a plant's overall health and growth. Water and mineral requirements vary from species to species, as do temperature tolerances. While some plants can tolerate periods of flooding, other plants like hot and dry conditions.

Soil pH is another environmental factor affecting plant growth. Some plants, such as mountain pinks and bluebonnets, prefer soils with an alkaline (or basic) pH. The limestone or caliche soils found in the Texas Hill Country are an example of alkaline soils. Other plants, like magnolias and azaleas, prefer soils with an acidic pH. The red clay of East Texas is an example of an acidic soil.

ACTIVITY 5.6

In the Neighborhood: *Match plants with the environments they need to grow*

Teaching Tip

Each In the Neighborhood *template includes at least one habitat that will be hard for students to locate.*

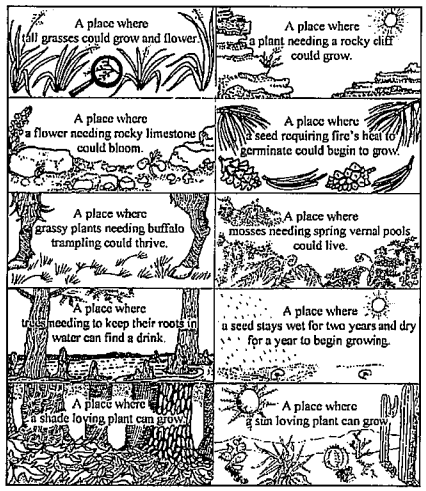
Any plant with very particular needs will not do well in human neighborhoods unless special steps are taken to create an appropriate habitat. Ask students to describe what steps people can take to create the hard-to-find habitats on their handouts.

Before Activity

Gather materials:

- ___ *In the Neighborhood* template, page 61
- ___ one-half class set of clipboards with paper and pencil
- ___ blank paper, 2 sheets for each pair of students

- Photocopy seven or eight sets of the *In the Neighborhood* templates, depending upon class size.



During Activity

1) Arrange students in pairs and give each pair an *In the Neighborhood* handout and a clipboard with paper and pencil.
2) Explain that student pairs will use their *In the Neighborhood* handouts to look for native plant habitats in the school's neighborhood. They can draw or describe the locations using blank paper on the clipboard.
3) Set up rules for walking in the school neighborhood before you begin. (Cross streets only with the group, stay out of yards, don't leave any trash, etc.)
4) After returning to the classroom, have students discuss their findings. How easy or difficult was it to find a place with rocky limestone? A place for tall grasses? A place with a rocky cliff? A place where tree roots can be in the water?

Native vs. Non-native Plants

Non-native plants come from outside the local plant communities and have not been a part of the give and take of adaptation to the area over time. People often grow these outsider plants because of a hardiness and tolerance that makes them successful. These seeds often germinate quicker, or the seedlings need less resources initially or are more efficient at getting those resources than are native plant seeds.

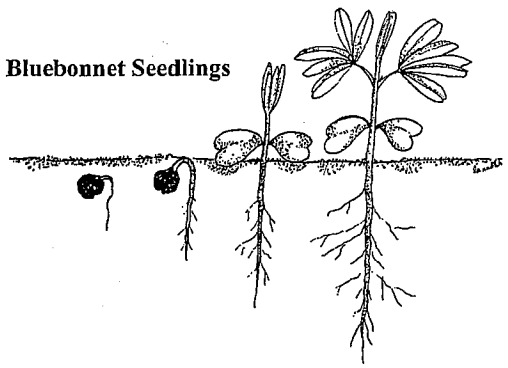
ACTIVITY 5.7

Seed Race: *Observe the success rates of native seedlings vs. non-native seedlings*

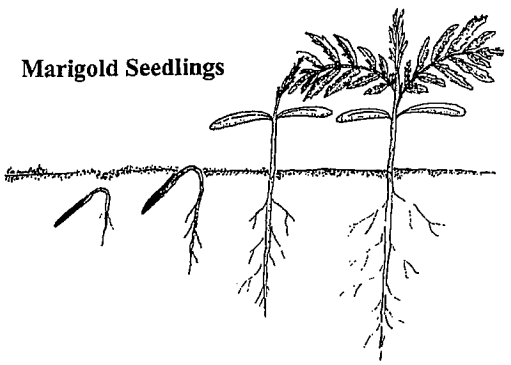
Before Activity

Gather materials:

- __ 3-inch pot of potting soil
- __ bluebonnet seeds
- __ marigold seeds
- __ *Seed Race* template, page 62
- Make one photocopy of the *Seed Race* template to post for the class.



Bluebonnet Seedlings



Marigold Seedlings

During Activity

1) Tell students they are going to see a race for survival between a native plant species (bluebonnets) and a non-native species (marigolds).
2) Wet the soil in the 3-inch pot. Scatter an equal number of bluebonnet and marigold seeds on top of the damp soil, lightly cover with more soil, and water gently.
3) Put the pot in a sunny location and water regularly.
4) Have students observe the pot daily; measure and record the progress of the seedlings. Tell them to use the *Seed Race* pictures to identify the growing plants.
5) Have students observe the plants for one month and write their measurements in a table. At the end of that period, have them compare the size and numbers of each type of plant. Which species had the best success rate? What conclusions can they draw from these results?

Appendix 1: Booklist

Aaseng, Nathan. 1996. *Meat-Eating Plants.* (Weird and Wacky Science). Enslow Publishers, Inc.

Amery, Heather. 1994. *Discover Hidden Worlds: Nature.* London, England: Reed International Books Limited (Hamlyn Children's Books).

Burnett, Frances Hodgson. 1911. *The Secret Garden.* New York: Harper & Row (Harper Collins).

Cole, JoAnna. 1997. *The Magic School Bus Gets Planted: A Book About Photosynthesis.* Scholastic Trade.

Dorros, Arthur. 1997. *A Tree Is Growing.* Scholastic Trade.

Dow, Leslie. 1997. *Incredible Plants.* Time Life.

Eyewitness Visual Dictionaries. 1992. *The Visual Dictionary of Plants.* New York: Houghton Mifflin (Dorling Kindersley, Inc.)

Heller, Ruth. 1999 reissue. *The Reason for a Flower.* Puffin.

Johnson, Sylvia A. 1992. *Roses Red, Violets Blue: Why Flowers Have Colors.* Lemer Publications Co.

Magley, Beverly. 1993. *Texas Wildflowers.* Helena, MT: Falcon Press.

Powledge, Fred. 1998. *Pharmacy in the Forest: How Medicines Are Found in the Native World.* Atheneum.

Ross, Bill. 1995. *Straight From the Bear's Mouth: The Story of Photosynthesis.* Atheneum.

Young, Allen M. 1996. *Lives Intertwined: Relationships Between Plants and Animals.* Franklin Watts, Inc.

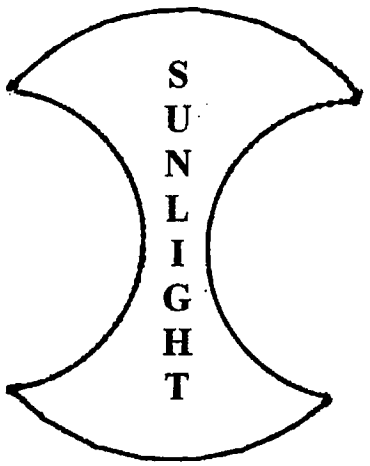
Appendix 2: 1.5 Photosynthesis Badges

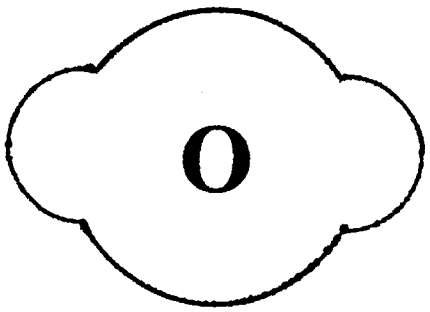
1.5 Photosynthesis Badges

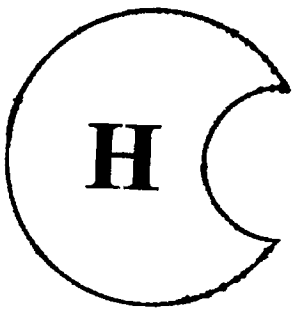
1.5 Photosynthesis Badges

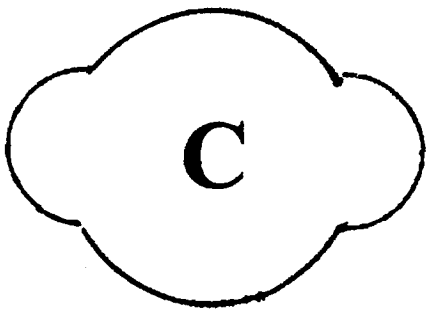
1.5 Photosynthesis Badges

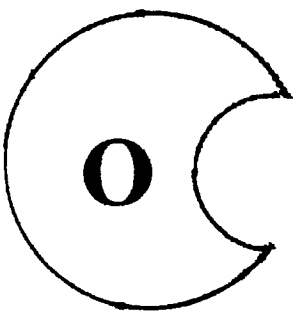
1.5 Photosynthesis Puzzle



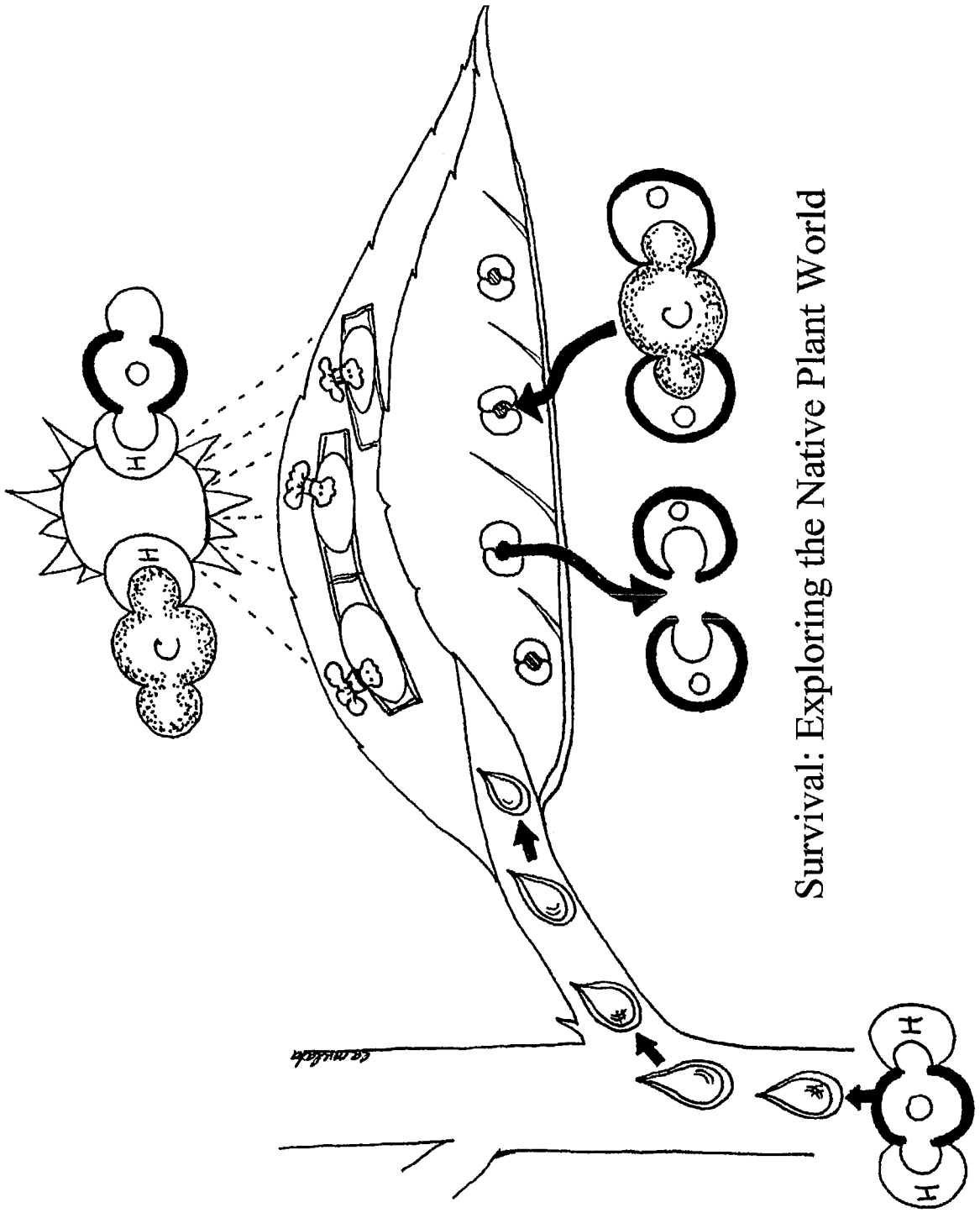








1.5 Photosynthesis Puzzle



2.1 Cohort Combos Information Sheets

Algae and Fungi

Algae and fungi combine to make a plant called lichen. Each partner plays their role in this match. The algae is a very simple plant that can make its own food, just like the algae does in ponds. Algae must stay wet to stay alive. Fungi cannot make its own food, but is equipped to live in places that get hot and dry, by absorbing water from the air. Together, the algae makes food for the fungi and the fungi provides a place for the algae, protecting it from the sun and drying out.

Agave and Mexican Long-Tongued Bat

The Mexican Long-Tongued Bat is the only pollinator for this particular type of agave. Late at night, the bat comes to open blooms and pushes its long snout deep into the flower. The stamens brush off pollen onto the bat's head as the bat collects nectar. The bat retrieves food from the agave flower and carries pollen between flowers to fertilize them.

Antelope Horn Milkweed and Monarch Butterfly

Monarch butterfly larvae feed on plants in the milkweed and dogbane families. Monarchs lay their eggs on milkweed leaves and when the eggs hatch, the small larvae use the plant for food. These plants contain a chemical that is toxic to vertebrates; the butterfly larvae are able to store this chemical. When a bird catches the butterfly and eats it, the milkweed chemicals cause the bird to get sick and throw up. The recovered bird avoids eating another Monarch butterfly and teaches its young to stay away.

Ball Moss and Tall Trees

Although it is called a moss, it really is an epiphyte, related to pineapples. The ball moss perches on shade tree branches using gripping type roots. It is not a parasite, because its roots do not penetrate the bark to take water or nutrients from the tree. Ball moss catches rainwater and nutrients from the air. The trees are usually not bothered by the ball moss, which settles on tree branches bare of leaves. Ball moss seeds are blown off the tall flower stalk to settle on nearby trees, wires, and other supports.

Bee and Bluebonnet

Bees are attracted to the bluebonnet's showy blue petals that are visible in the bees' ultraviolet light spectrum vision. When a bee's head enters the flower to draw up the nectar with a tube tongue, sticky pollen on the flower's hanging stamens is caught by the bee's hairy body. When the bee goes to the next flower, some of the pollen is left behind on the flower's pistil, where it will fertilize the ovules. Plants have no use for nectar, other then as an attractant for pollinators. The flower provides food for the bee, and the bee carries the pollen between blossoms to fertilize the flowers.

Blue Jay and Mistletoe

The blue jay eats the mistletoe berries. Inside each berry is a seed that is inedible, and the blue jay tries to spit it out. However, the seed is sticky, making it difficult to shake, so the bird scrapes it off on tree bark. This is where mistletoe needs to grow to survive. If the blue jay accidentally swallows the seed, it passes

through the bird and is left on a tree branch in bird droppings. Either way, the blue jay carries the beginnings of the plant to new homes, while enjoying a meal in the process.

Cardinal Flower and Hummingbird

The red flower attracts the hummingbird with lots of nectar that is almost all sugar. Because hummingbirds do not have a sense of smell, the cardinal flower does not need a strong scent. To feed, the hummingbird reaches down the long red tube of the flower with a long, thin beak. Pollen is brushed off the flower stamens onto the bird and carried to the next flower's pistil. The cardinal flower, in exchange for sharing nectar with the hummingbird, helps the flowers make seeds.

Cochineal and Prickly Pear Cactus

Cochineal are small insects that live on prickly pear cactus, hidden in white fuzz. The cactus spines could offer some protection for the cochineal from larger predators, along with the soft white down the insects hide in. Cochineal take nutrients from the cactus and seem to keep the cactus population in check. When cochineal insects are removed from the cactus, growth of the prickly pear increases.

Fly and Venus's-Flytrap

It is a short-lived partnership for the fly with the carnivorous plant. Of the 500 species of plants that depend on the bodies of insects to live and grow, most live in poor soil and cannot get their nutrients any other way. The variety of methods of capture by flesh-eating plants is very interesting. The Venus's-flytrap depends on a crawling bug to trigger the long hairs, which causes the leaf trap to snap shut and catch small insects for dinner.

Hackberry Tree and Mockingbird

The small, dainty berries become especially visible after leaves drop from the tree. These small fruits have a single seed surrounded by a sweet pulp that mockingbirds collect and eat. The mockingbird eats the tree's berries and passes the seeds through its stomach. The stomach juices help break the seed coat. The bird travels to a new spot before passing the waste containing the seeds. This is a great beginning for a brand new hackberry tree, since the seed is in a new sunny location a great distance away and has a startup of manure. Often, a line of hackberry trees marks a former fence line, where mockingbirds sat and sang.

Indian Paintbrush and Texas Bluebonnet

The Indian paintbrush's snapdragon family has many members that must depend on other plants to survive.

It has been noticed that Indian paintbrush flowers are not found blooming in the wild unless they are with certain other kinds of plants. In Central Texas, they are seen blooming with Texas bluebonnets.

Indian paintbrushes form a special kind of root as the plant gets bigger.

This root grows until it touches the root of a bluebonnet, and then it invades the bluebonnet. The Indian paintbrush's root, called a haustorium, is for the transport of water and minerals from the other plant. This special root can also take in the bitter-flavored compounds used by the other plant for insect defense.

Insect Galls and Live Oak Tree

Unusual lumps and bumps on plant twigs, leaves, and branches are formed by invading plants, fungi, or animals. These galls are usually from very small insects, such as aphids, lice, and little wasps, that have laid their eggs in the bark, stem, or leaf of a tree. The tree forms a scar around the eggs with each differ-

ent kind of animal, causing a different shape and color of gall. The plant attempts to isolate the insect or infection in a swollen bump, which makes a fine home to keep the insects safe while they grow up.

Live Oak Tree and Mistletoe

The live oak tree is a home for mistletoe. Mistletoe roots enter the tree and take the water and nutrients the plant needs. Mistletoe depends totally on the tree, and if it becomes well developed, it can kill the tree. Although many chemicals have been tried on mistletoe to eliminate it, few are effective. Tree doctors will cut off infected limbs to protect the tree.

Mycorrhizae and Pink Evening Primrose

The mycorrhizal fungi that live in the soil help this primrose's seed begin sprouting. The network of small, white mycorrhizal threads weaving through the soil wrap around the roots of the primrose. These threads can bring a greater amount of nutrition from the soil to the roots of the plant. As a kind of tip for good service, the pink evening primrose passes back some of the sugars it has made. Pink evening primrose seeds have been found to have a better chance of sprouting if the seeds are first treated with a mycorrhizal fungi.

Passionflower Vine and Fragrant Sumac

The small tree of sumac is one of the many kinds of support for vines that grow in Central Texas. Vines grow up trees, fences, bushes, and houses because the plant is reaching for more light. If there is too much vine growing on a tree or shrub, the coverage keeps the tree from getting enough light to make the food it needs.

Red Admiral Butterfly and Texas Lantana

Lantana blossoms are visited often by butterflies that come for the nectar. The flower has a nice flat landing platform and a deep tube shape for the butterfly's long tongue. Butterflies, in collecting the nectar, also accidentally carry off pollen. It is left at the next blossom, where it fertilizes the ovule or egg of the lantana, and a seed is formed.

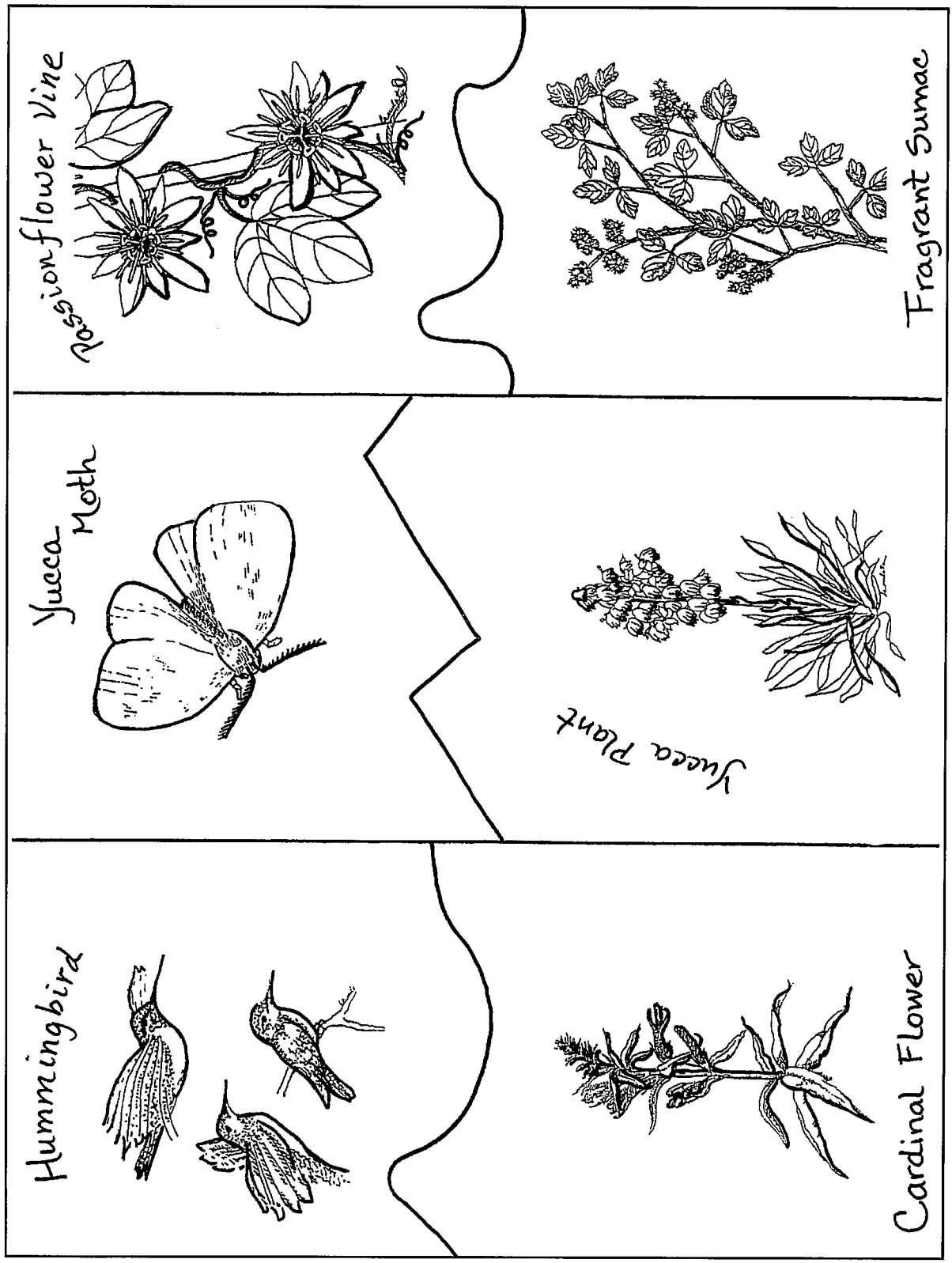
Yucca Plant and Yucca Moth

The yucca is fertilized only by this special moth. The moth climbs in and gathers pollen under her chin. She carries the pollen to another yucca flower and, after depositing the pollen ball, breaks into one of three chambers of the ovary of the plant and lays her eggs. Her developing larvae feed on one of the ovules, or developing seeds, but leaves the other two chambers with ovules alone. Pollen fertilizes the other two ovules, which become mature seeds.

Squirrel and Pecan Tree

The squirrel uses the tree for shelter and food. When the squirrel buries nuts for storage, it uses its sense of smell to locate them. Often, pecans are forgotten and left in the ground until spring. Because the squirrel plants each nut separately, like a farmer planting seeds, the pecan nut will have a better chance of sprouting and growing into a big tree in a new location, away from its parent plant.

2.1 Cohort Combos Puzzle



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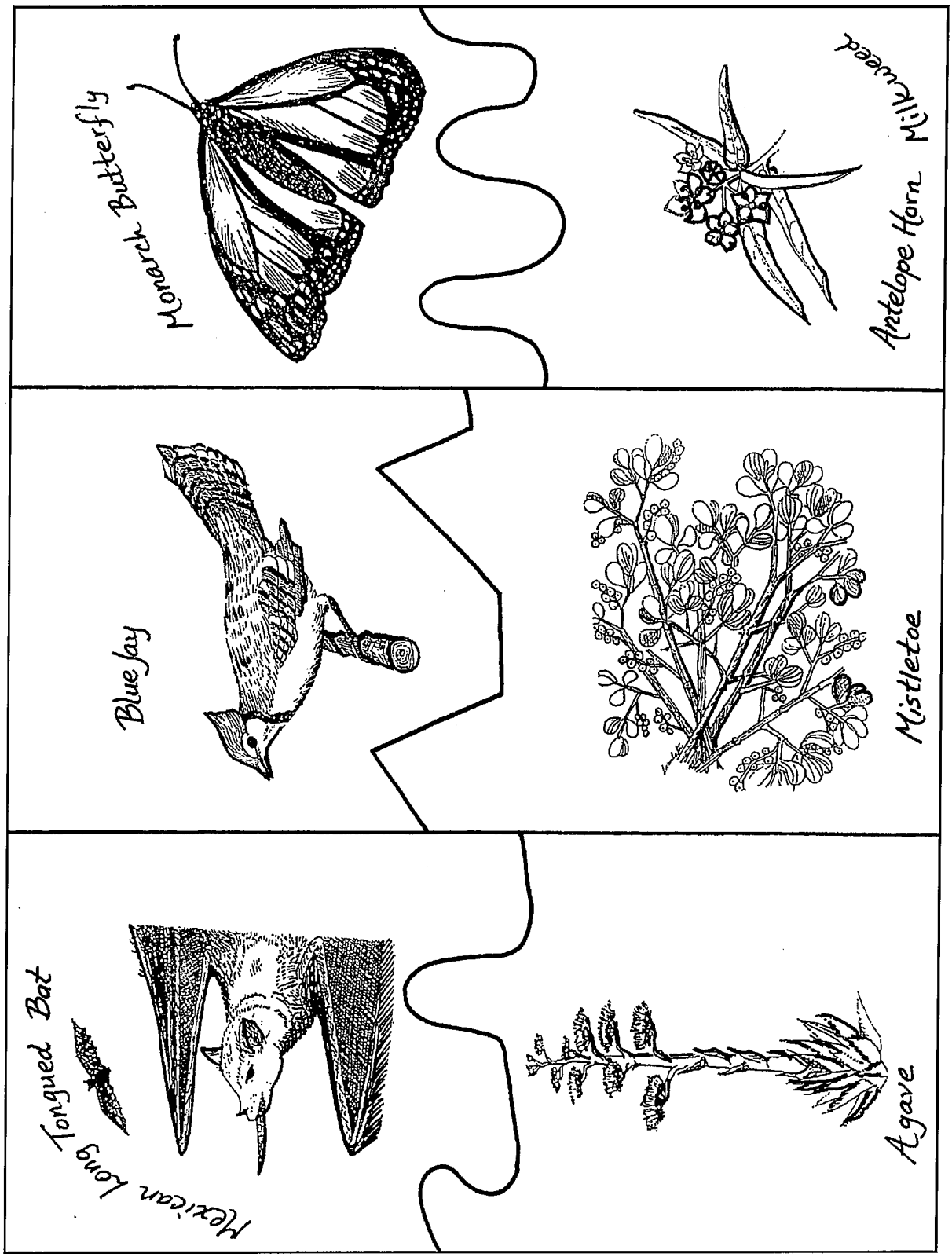

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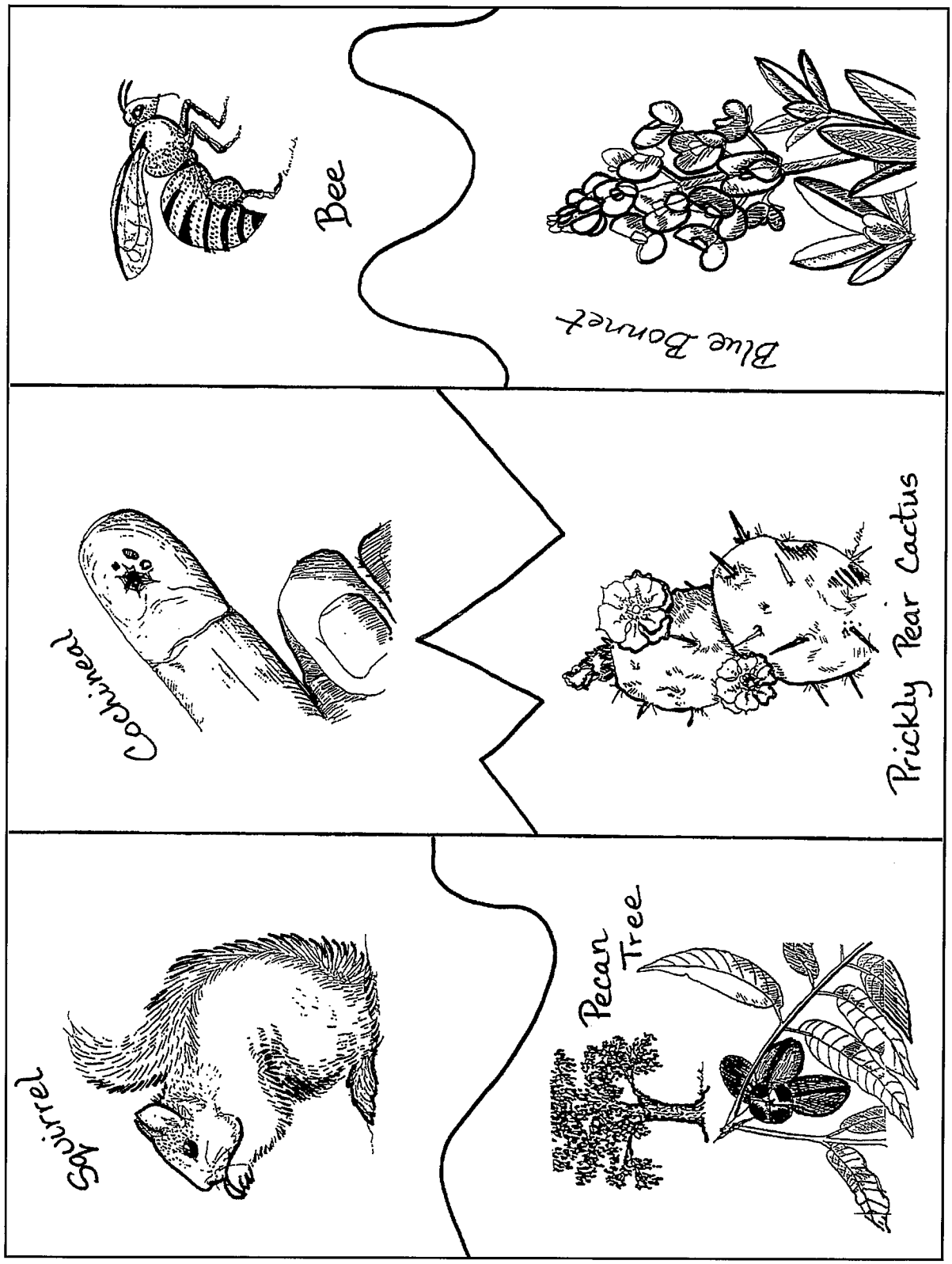

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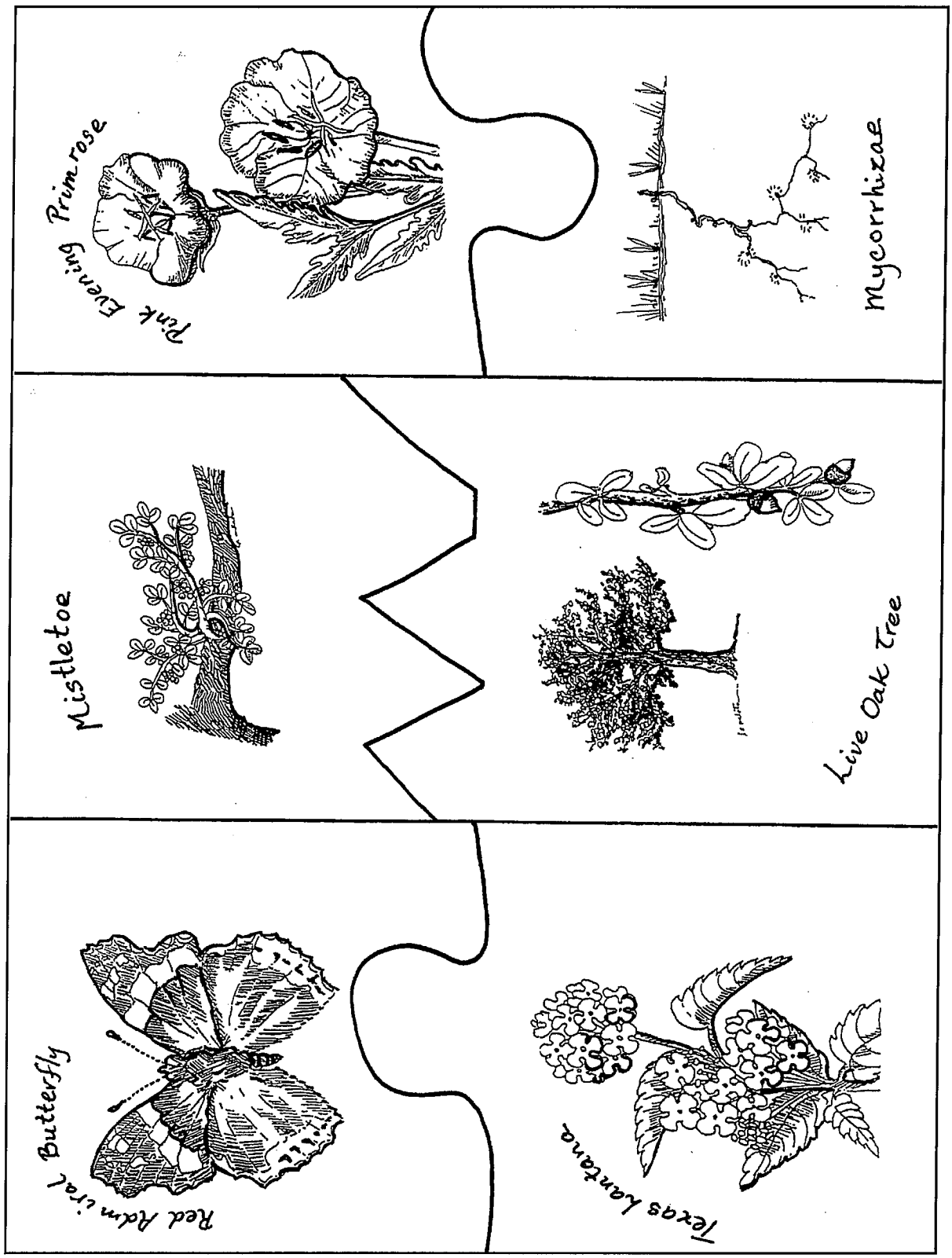

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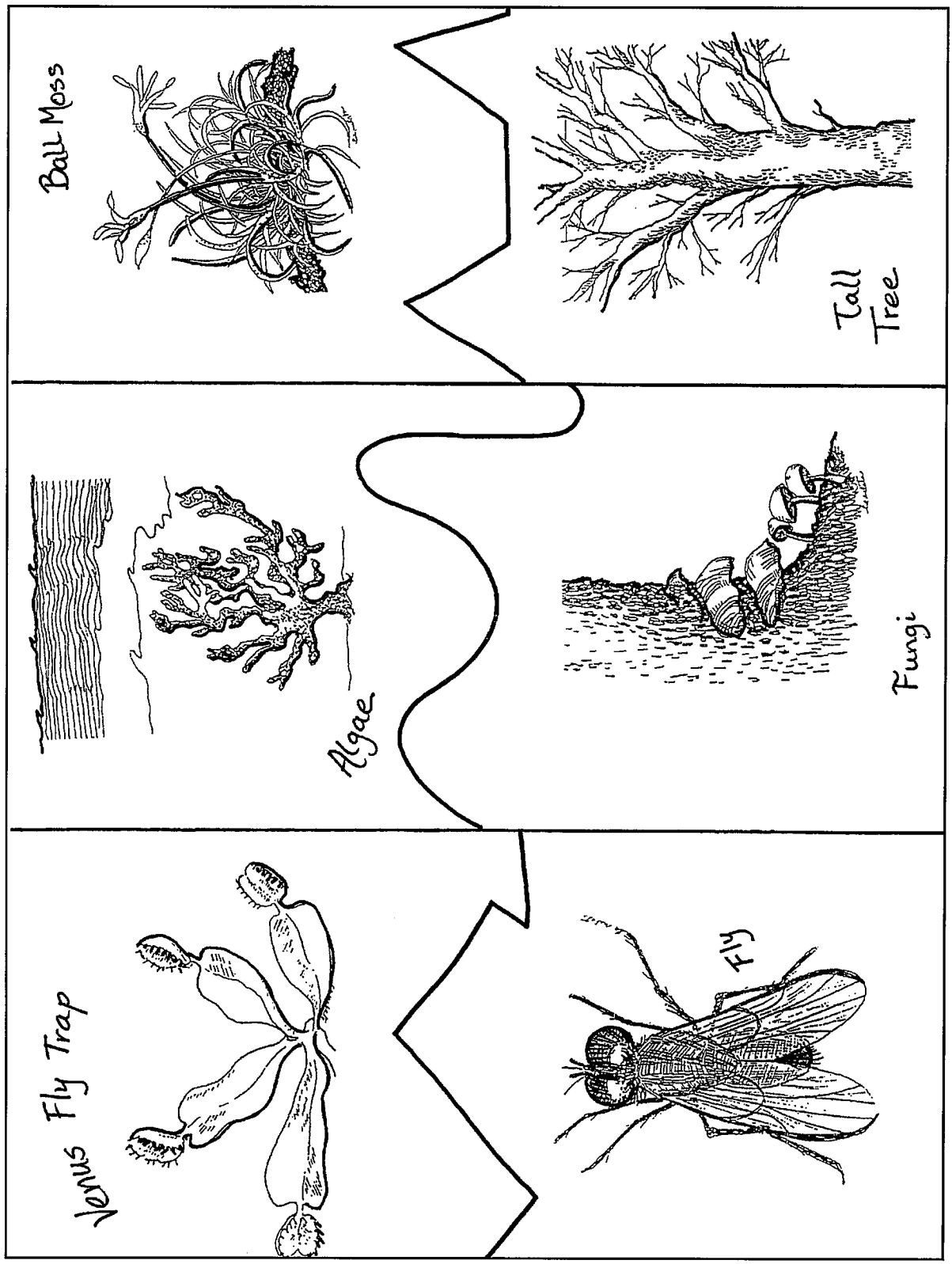
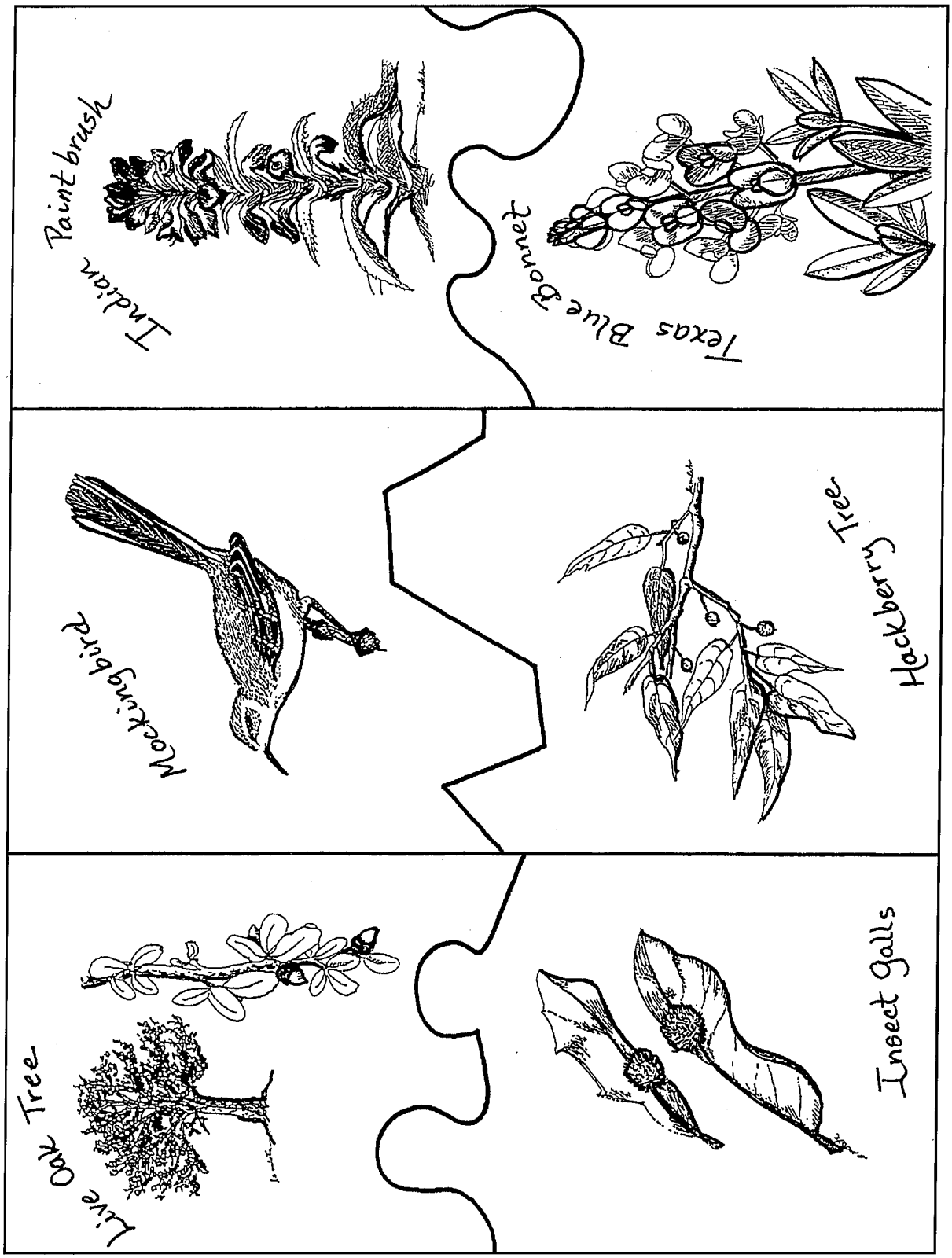


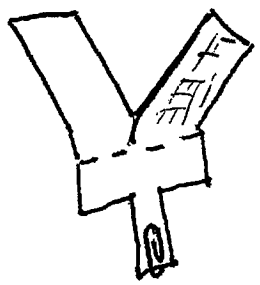
2.1 Cohort Combos Puzzle

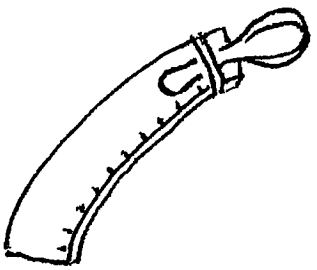


2.3 Flung, Flown, or Ferried?

Compare the distances of seeds traveling from plant power, and seeds depending on air currents and animal rides to get around.

Make a catapult with a plastic spoon, rubber band, and plastic ruler and use it to measure the distance a cotton ball or ping-pong ball can be thrown.



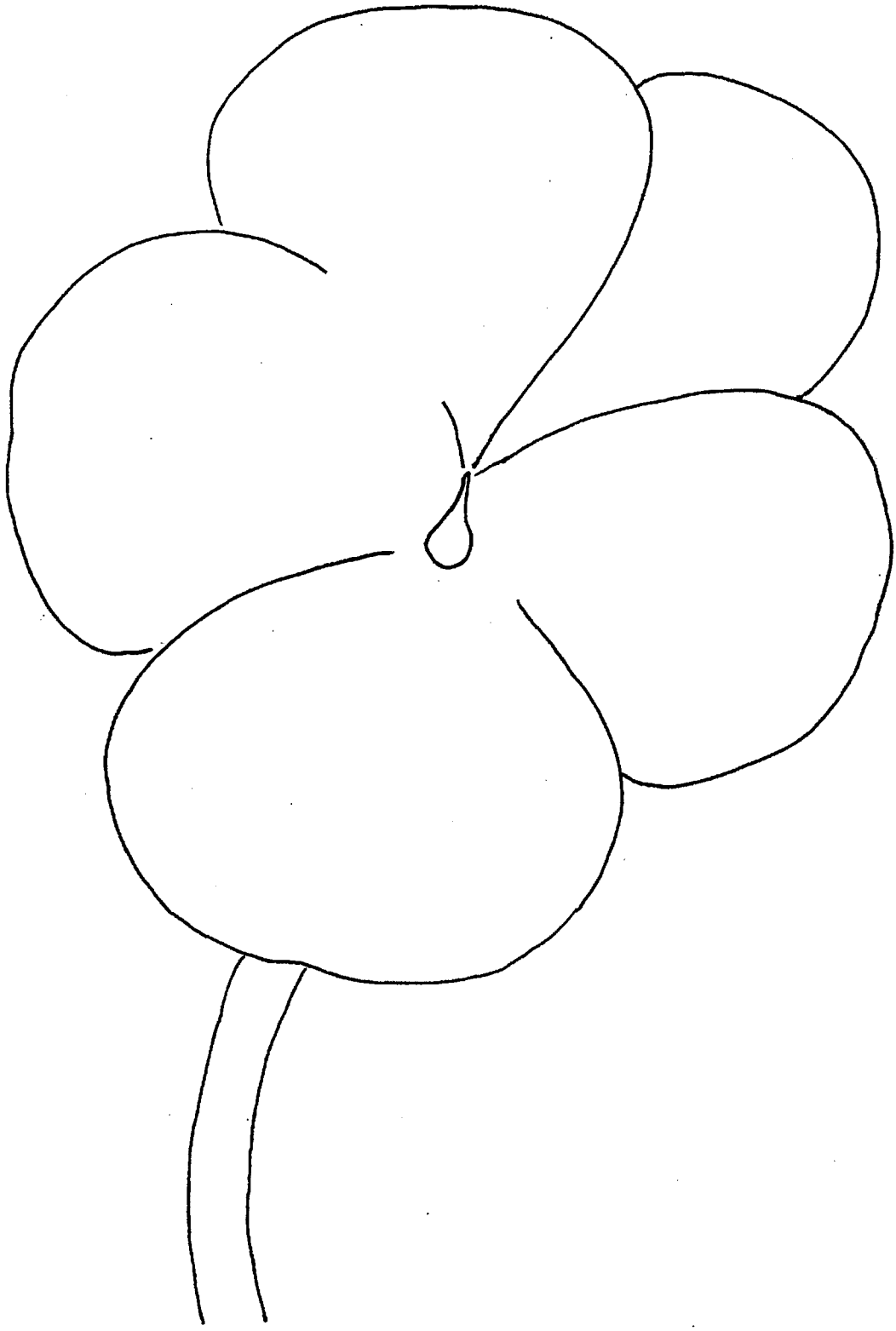


Make a whirligig or paper copter and measure the distance a paper clip is carried.

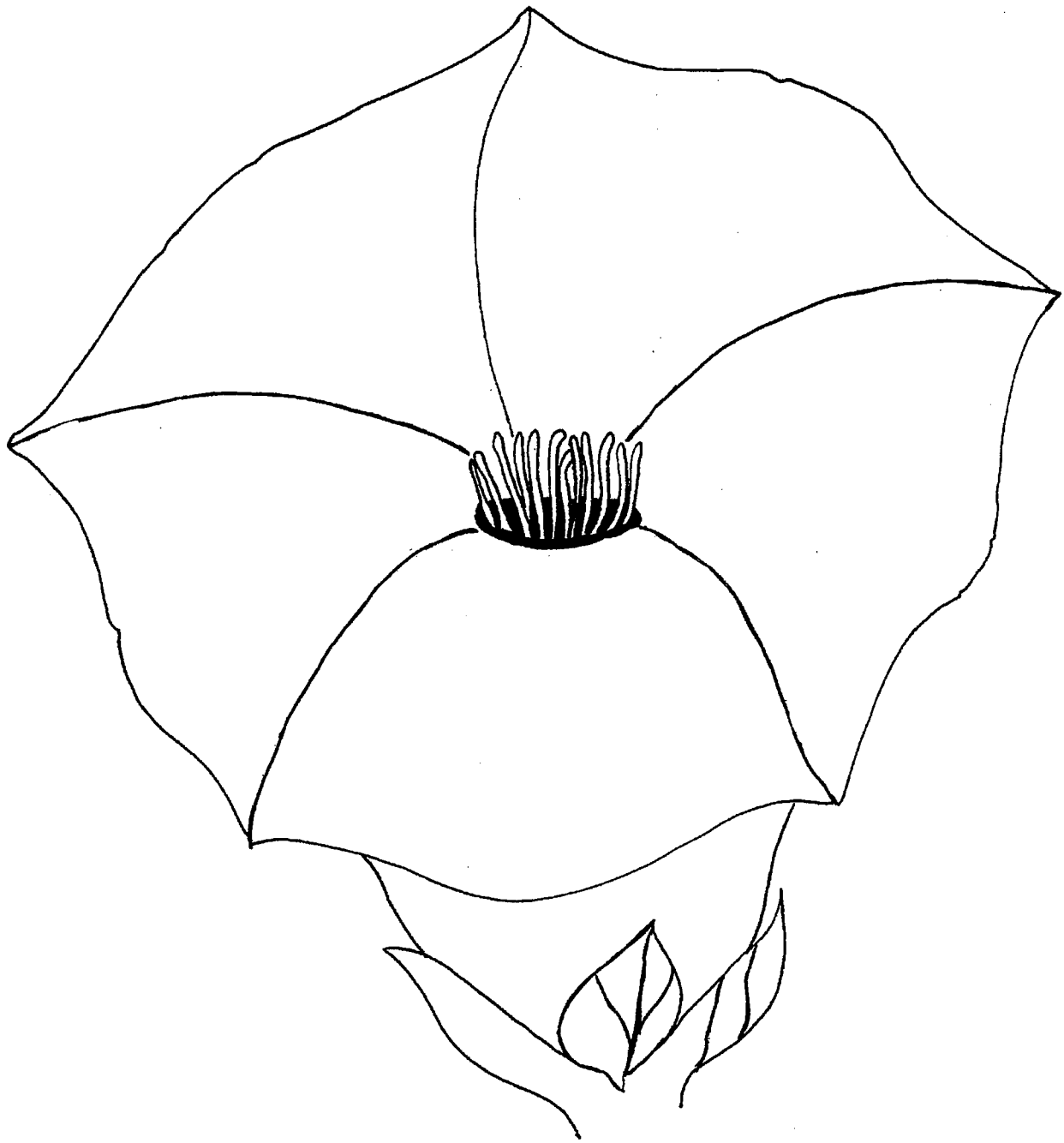
Distance for catapulted "seed"	Distance for air-lifted "seed"

Black bears travel 76 miles, deer mice move 65 feet, some birds can fly hundreds of miles each day. When seeds travel in the fur or guts of moving mammals and birds, how much farther can they go?

3.5 Flower Patterns



3.5 Flower Patterns



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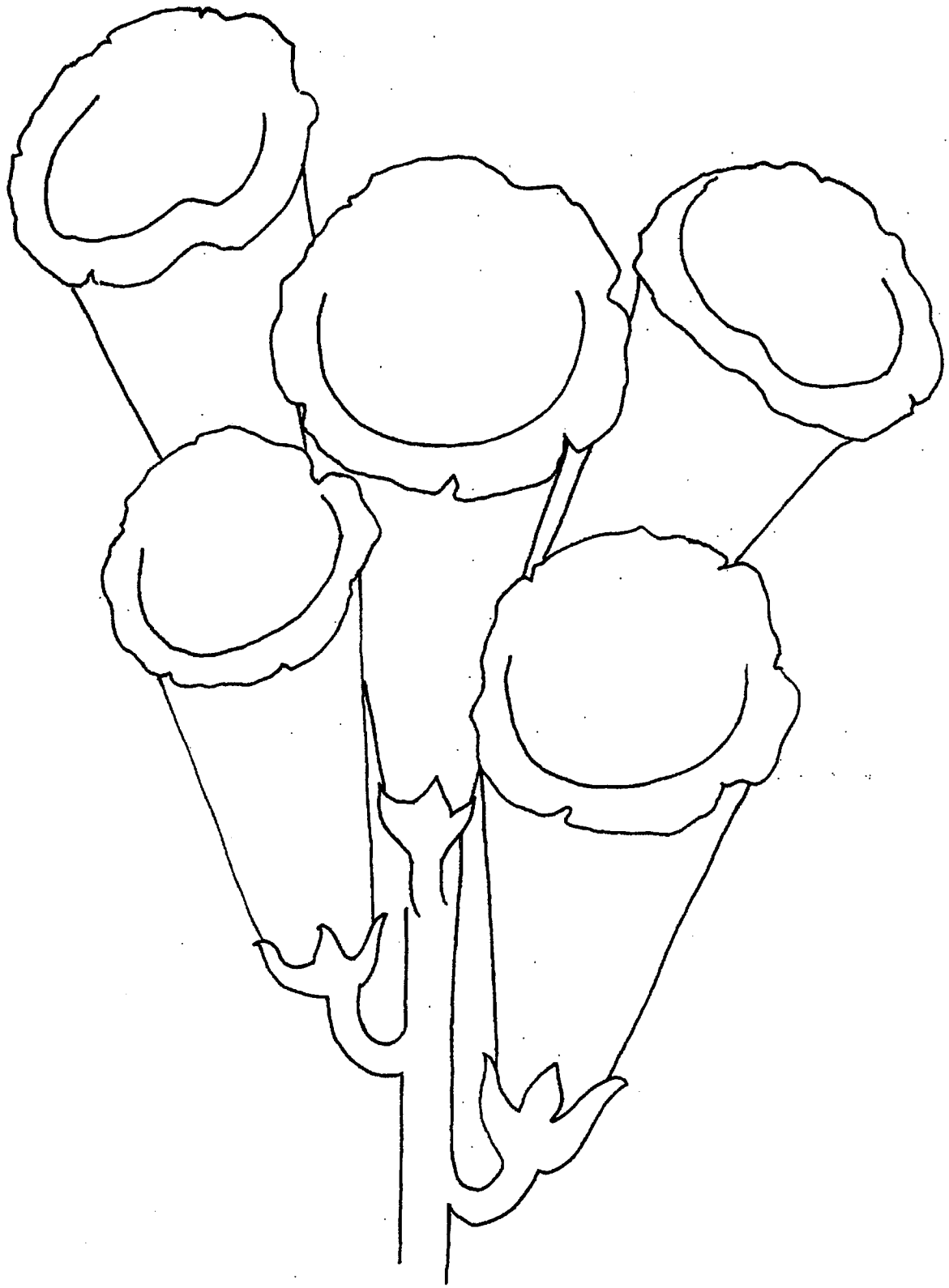

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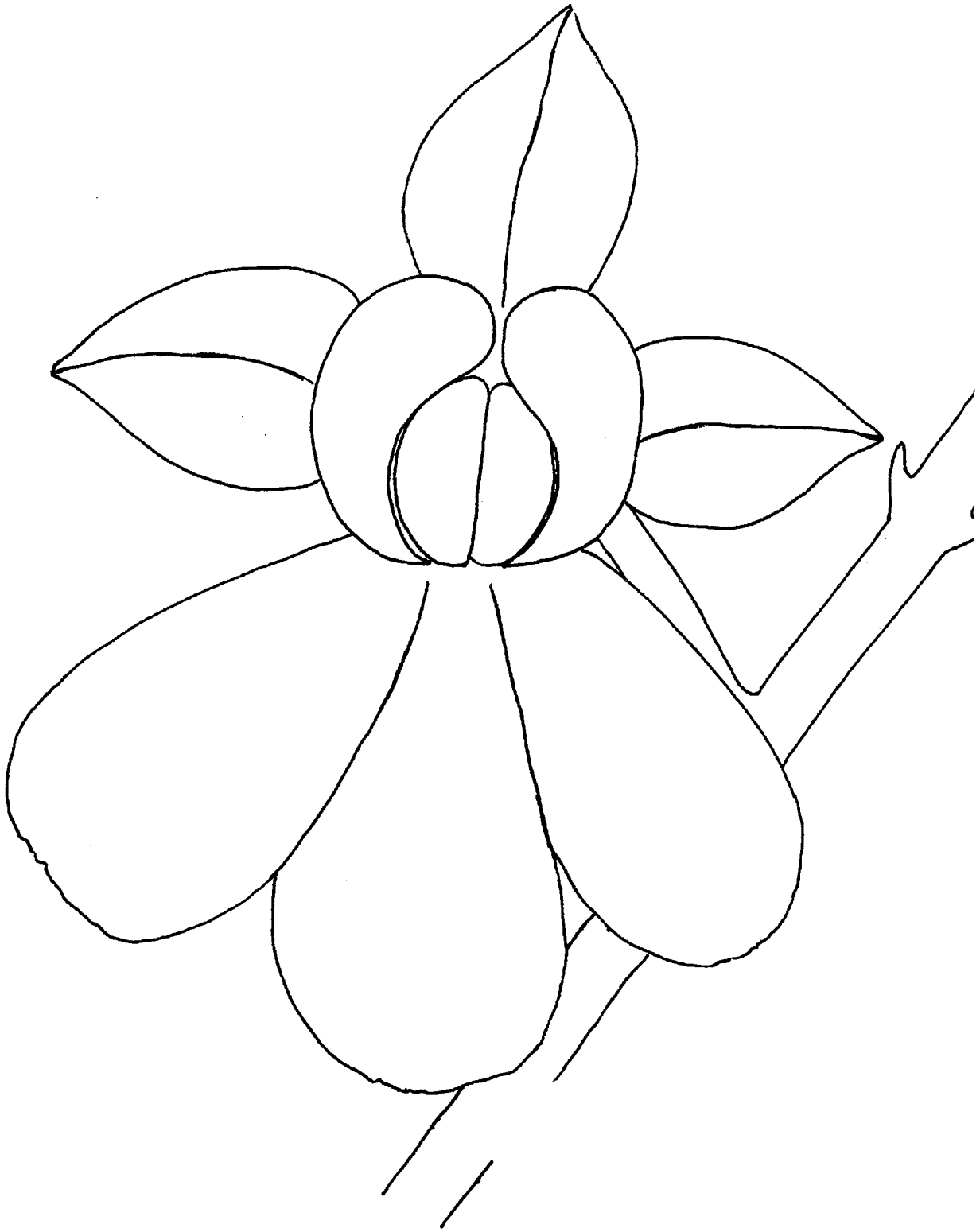
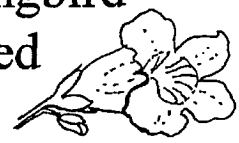


3.6 Pollinator and Flower Survey Sheet

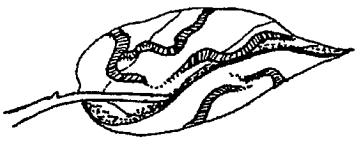
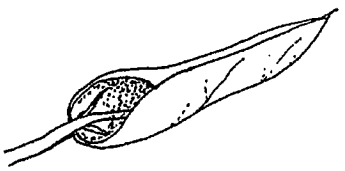
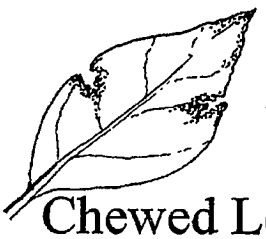
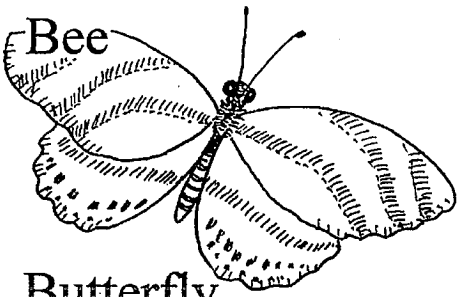
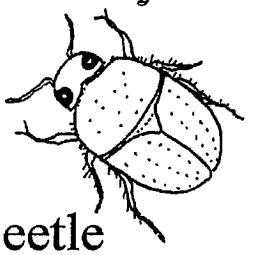
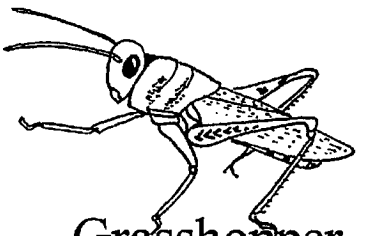
Bee Pollinated Flower

Butterfly Pollinated Flower

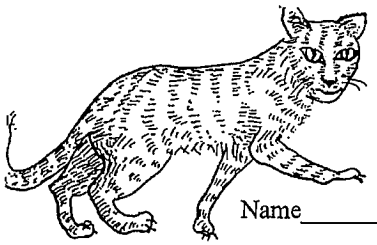
Hummingbird Pollinated Flower



3.7 Insect Evidence Survey Sheet

Evidence	Location	Insects
 Leaf Tunnels		Fly
 Wrapped Leaf		Bee
 Chewed Leaf		 Butterfly
Leaf with Galls		 Beetle
Foam Home		 Grasshopper

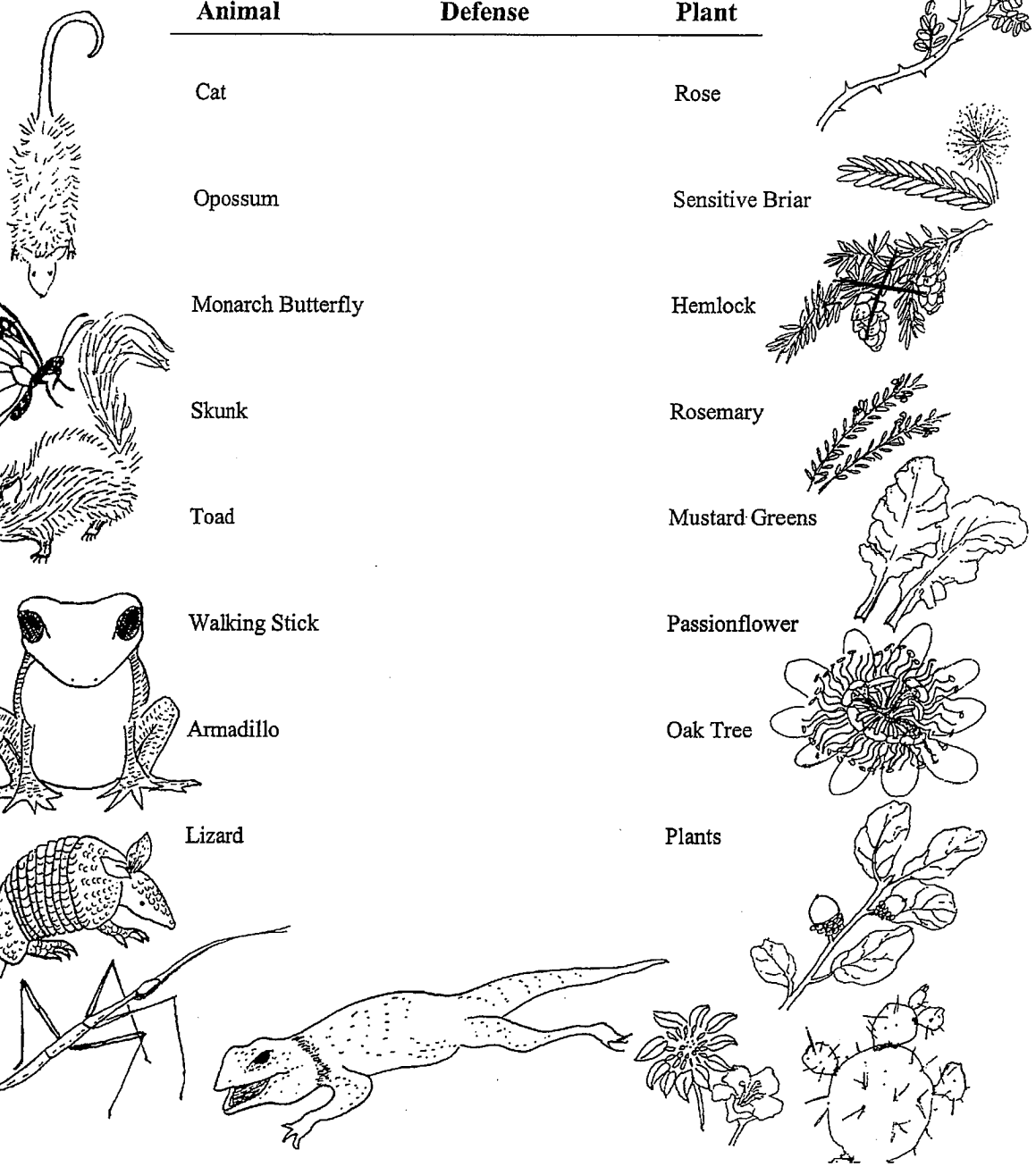
4.1 Defense, Defense



Name_____ Date_____

What methods of defense might these animals and plants have in common?

Animal	Defense	Plant
Cat		Rose
Opossum		Sensitive Briar
Monarch Butterfly		Hemlock
Skunk		Rosemary
Toad		Mustard Greens
Walking Stick		Passionflower
Armadillo		Oak Tree
Lizard		Plants



4.3 Siren of Smell Nametags

5.1 Pick-a-Plant

Four flowering plants live in a park along the Gulf Coast. They are called Jewels, Flox, Elbejay, and Marquet. They all grow approximately one foot tall. Changes are made at the park, and the weather also changes. Some of these changes help the plants and some harm the plants. Look at the box below to see what kind of environments these plants prefer, and then answer the following questions.

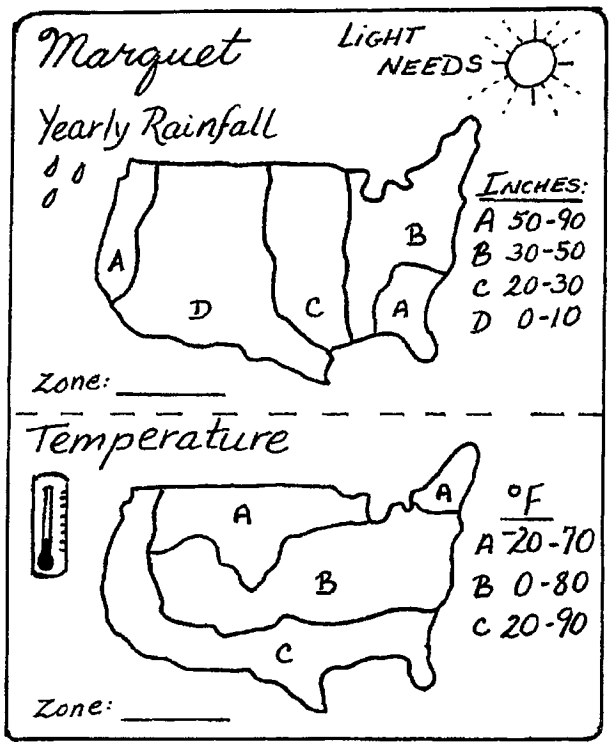
	Jewels	**Flox**	**Elbejay**	**Marquet**
Best Temperature	80°F	80°F	80°F	80°F
Rainfall	32 in/yr	32 in/yr	12 in/yr	6 in/yr
Sunlight	Full shade	Full sun	Some sun	Some sun
Coldest	32°F	32°F	17°F	0°F
Hottest	99°F	110°F	85°F	100°F

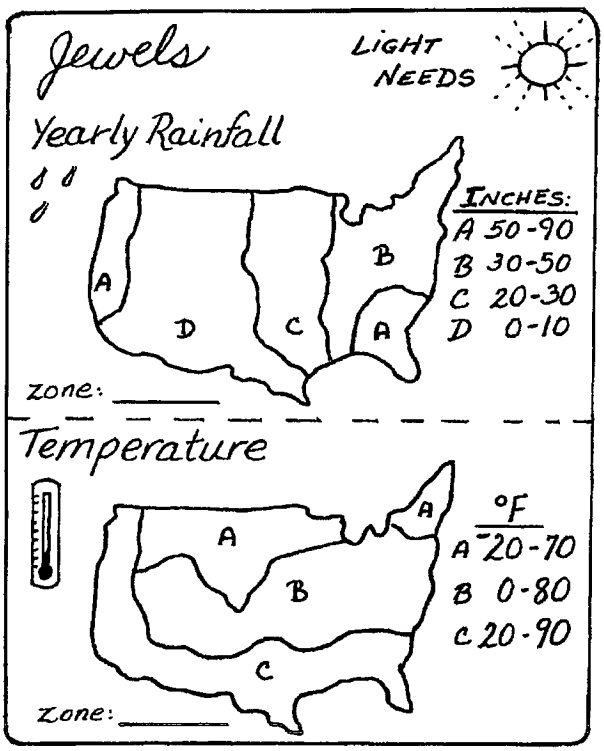
1. There is a winter storm and the temperature goes down to 27°F. Which plants might die?

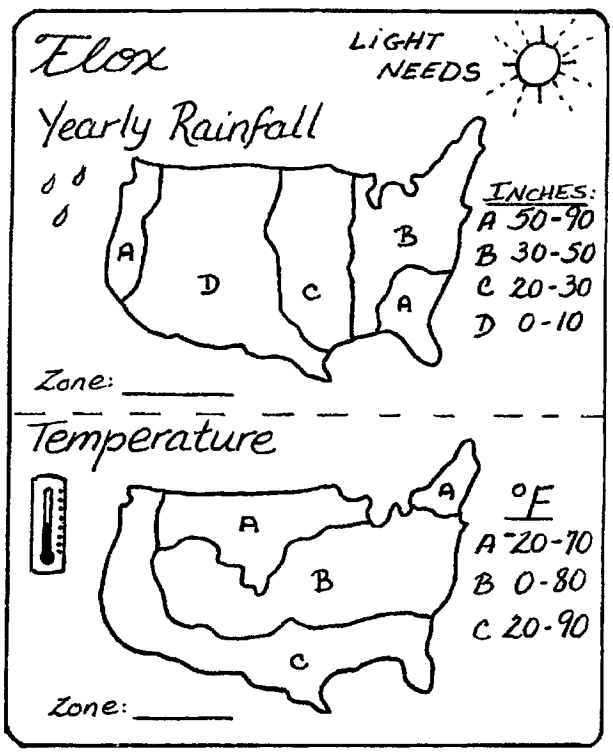
2. All the pine trees shading the park are cut down. Which plants will do better? Worse? The same?

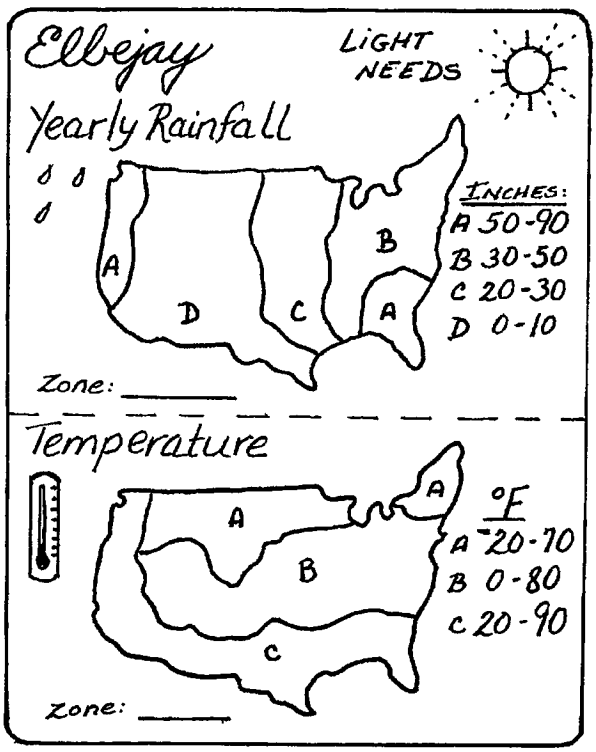
3. There is a drought, or lack of rain, for two years, and only one of the four plants survives. Which plant would it most likely be?

5.1 Pick-a-Plant Seed Packets

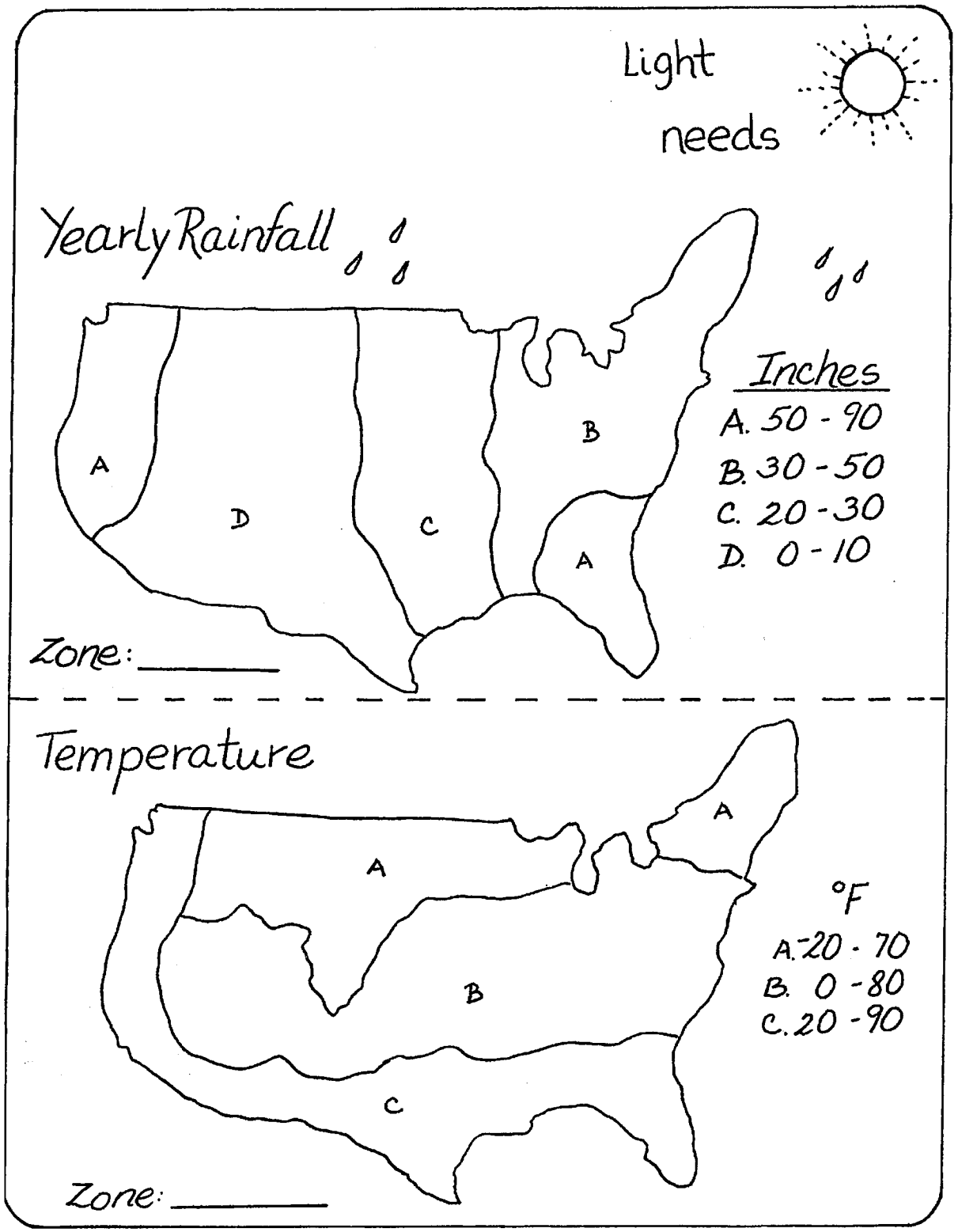








5.1 Pick-a-Plant Overhead

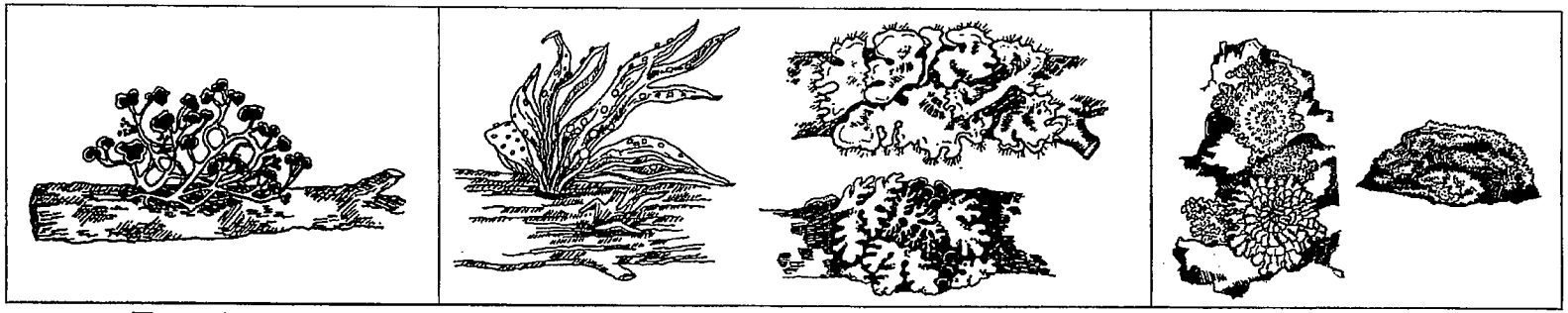


Name_____

Date_____

Survival in the Native Plant World

Lichen Survey



Type A
Fruticose

Types B
Foliose

Type C
Crustose

Clean Air Only

Polluted Air Tolerant

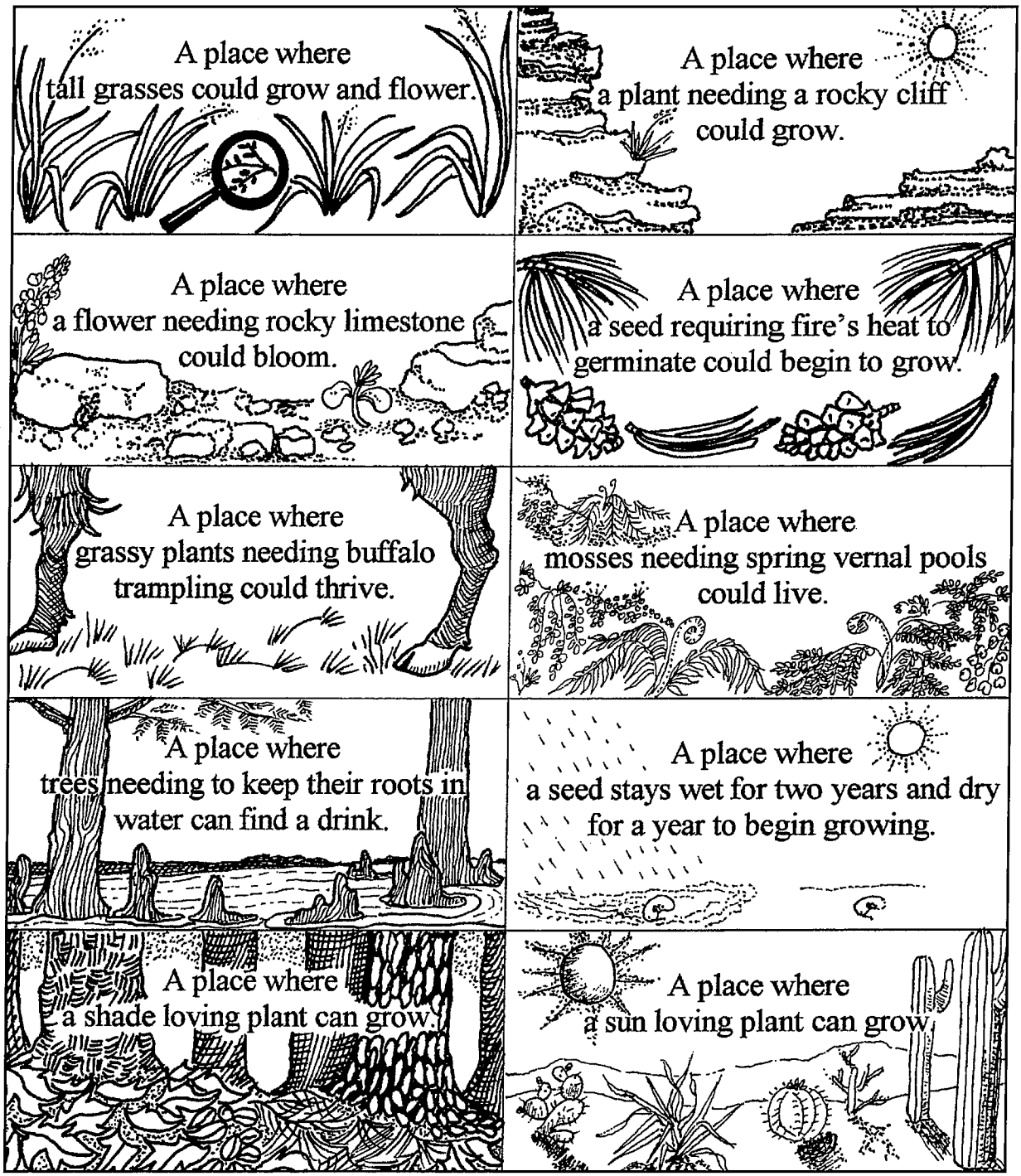
Circle the types of lichens found.

Urban trees Type A. Type B. Type C. No Lichens

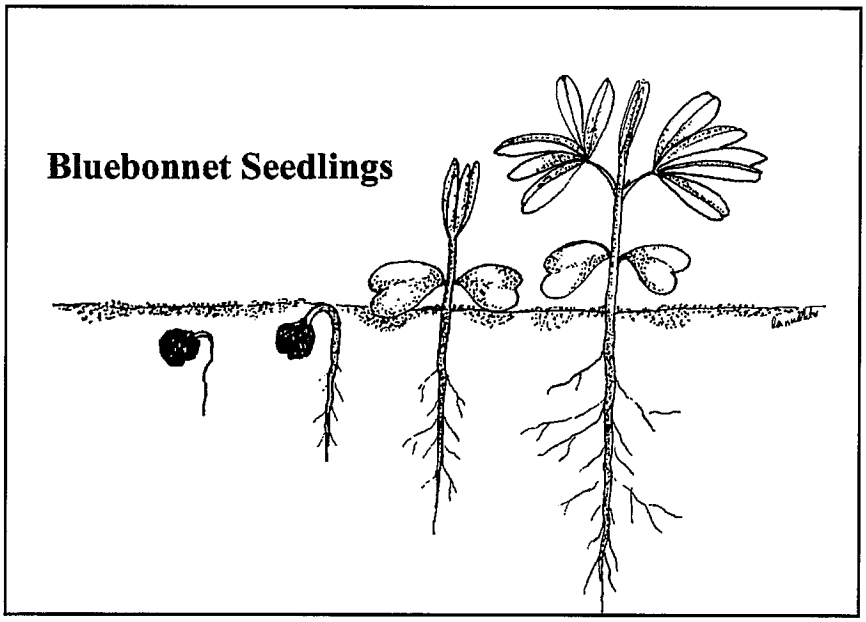
Rural trees Type A. Type B. Type C. No Lichens

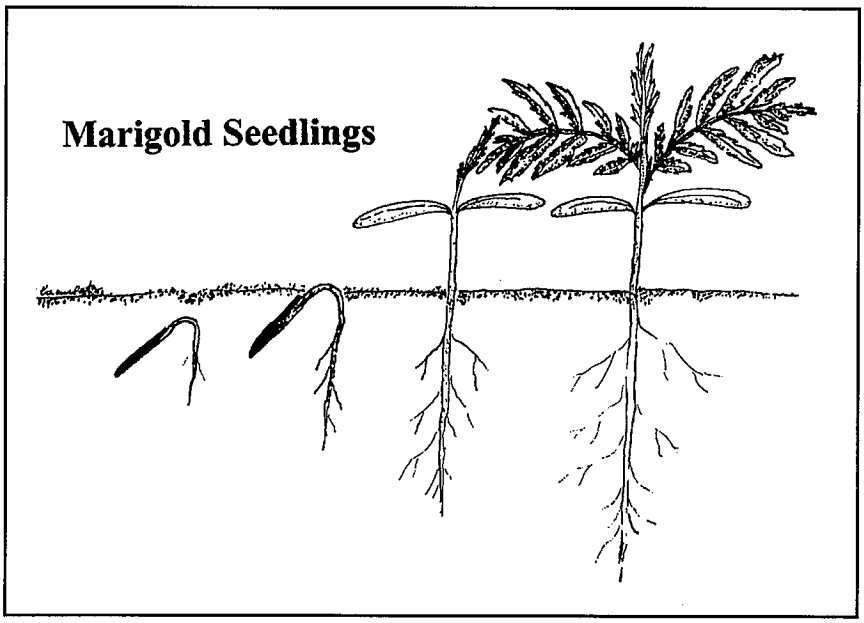
5.6 In the Neighborhood

Each card describes a native plant habitat.
Can you find these habitats in your neighborhood?



5.7 Seed Race





Appendix 3: Texas Essential Knowledge and Skills

Lesson 1 **Plants make their own food to survive.**

Activity 1.1 Suitcase for Survival: *Explore the needs of living things.*
TEKS: Science 3(1A), 3(5A), 3(8), 3(9A), 4(1A); Social Studies(Geography) 3.4B

Activity 1.2 Breathing Plants: *Discover how plants breathe through their leaves.*
TEKS Science 3(1A), 3(2B-D), 3(3A), 3(5A), 3(8), 4(1A), 4(2B-D), 4(3A), 4(5A)

Activity 1.3 Going Up!: *Observe the process of capillary action.*
TEKS: Science 3(1A), 3(2B-D), 3(3A, C), 3(4A), 3(5A), 3(8), 4(1A), 4(2B-D), 4(3A, C), 4(4A); English Language Arts and Reading 3.3C

Activity 1.4 Pulling the Water Chain: *Experiment with capillary action in the stems of plants.*
TEKS: Science 3(1), 3(2A-E), 3(3A, C), 3(5A), 3(8), 4(1), 4(2A-E), 4(3A,C)

Activity 1.5 Food Factory: *Simulate photosynthesis in a role-playing game.*
TEKS: Science 3(1A), 3(3C), 3(8), 4(1A), 4(3C) Math 3(3A); 4(3A)

Lesson 2 **Plants have a variety of relationships with other plant types and animals that affect their survival.**

Activity 2.1 Cohort Combos: *Research and present information about plant cohorts.*
TEKS: Science 3(1), 3(3B), 3(8D), 3(9A, B) 3(10A), 4(1), 4(3B), 4(5A), 4(8A, B); English Language Arts and Reading 3.3C

Activity 2.2 The "*Wander*" of Pollen: *Explore how insects and animals carry pollen.*
TEKS: Science 3(1), 3(2B-D), 3(3C), 3(5A), 3(6A), 3(9A), 4(1), 4(2B-D), 4(3C), 4(8A, B), 4(9A)

Activity 2.3 Flung, Flown, or Ferried?: *Compare how far seeds travel using different dispersal methods.*
TEKS: Science 3(1), 3(2A-E), 3(3C), 3(9A), 3(10A), 4(1), 4(2A-E), 4(3C), 4(8A, B), 4(9A); English Language Arts and Reading 3.3C; Fine Arts 3.2B

Lesson 3 **Plant reproduction is necessary for future survival.**

Activity 3.1 The Reason for a Flower: *Read a book about pollinators and seed types.*
TEKS: Science 3(1A-E), 3(3C); English Language Arts and Reading 3.1A-F; 4.1A,C

Activity 3.2 Flower Dust: *Explore the characteristics of different native plant pollens.*
TEKS: Science 3(1), 3(2B), 3(4A), 3(5A), 3(9A), 4(1), 4(2B), 4(4A), 4(8A), 4(9A); Fine Arts 3.1B, 4.1B

Activity 3.3 The Perfect Fit: *Observe pollinators at work.*
TEKS: Science 3(1), 3(2B-D), 3(3C), 3(8A), 3(9A), 3(10A, B), 4(1), 4(2B-D), 4(3C), 4(8A, B); English Language Arts and Reading 3.3C

Activity 3.4 Seed Sort: *Collect and categorize seeds according to dispersal method.*
TEKS: Science 3(1), 3(2B-D), 3(9A, B), 3(10A), 4(1), 4(2B-D), 4(8A, B); English Language Arts and Reading 3.3C

Activity 3.5 This Way to the Nectar Café: *Explore a variety of nectar guides.*
TEKS: Science 3(1), 3(3C), 3(9A), 4(1), 4(3C), 4(8A, B)

Activity 3.6 The Birds and the Bees: *Identify possible pollinators for various flowers.*
TEKS: Science 3(1), 3(2B), 3(4A), 3(5A), 3(8A-D), 3(9A, B), 3(10A, B), 4(1), 4(2B), 4(4A), 4(5A), 4(8A, B)

Activity 3.7 The Bugs and the Seeds: *Identify evidence of insects and collect seeds.*
TEKS: Science 3(1), 3(2B), 3(4A), 3(5A), 3(8A-D), 3(9A, B), 3(10A, B), 4(1), 4(2B), 4(4A), 4(5A), 4(8A, B)

Lesson 4 **Plants use different means of protection to survive.**

Activity 4.1 Defense, Defense: *Identify similar methods of defense among animals and plants.*
TEKS: Science 3(1), 3(3B), 3(9A), 3(10A, B), 4(1), 4(3B), 4(8A, B), 4(9A, B)

Activity 4.2 Plant Warriors: *Invent a plant with an effective method of defense.*
TEKS: Science 3(1), 3(3C), 3(9A, B), 3(10A), 4(1), 4(4 B, C), 4(8A, B), 4(9A, B); Fine Arts 3.2A-C, 4.2B-C

Activity 4.3 Siren of Smell: *Explore how plants use scent as a defense method.*
TEKS: Science 3(1), 3(3C), 3(5A), 3(8A, B), 3(10A, B), 4(1), 4(3C), 4(5A, B), 4(8A, B); English Language Arts and Reading 3.3C

Lesson 5 **Changes in the environment may affect plant survival.**

Activity 5.1 Pick-a-Plant: *Explore how different plants tolerate different growing conditions.*
TEKS: Science 3(1), 3(3C), 3(8A, C), 3(9A), 3(10A), 4(1), 4(3C), 4(8A, B), 4(9A); Math 3.3A, 4.3A

Activity 5.2 Plants in Place: *Observe plants growing in succession stages.*
TEKS: Science 3(1), 3(2B, D), 3(3C), 3(8B), 3(9A, B), 3(11A, B), 4(1), 4(2B-D), 4(3C), 4(8A, B), 4(10A), 4(11A, C); Math 3.3A, 4.3A, 3.7B, 4.12, 4.13C, 4.14D

Activity 5.3 Lichen Survival: *Compare lichen growth in low and high pollution areas.*
TEKS: Science 3(1), 3(2B-E), 3(3B), 3(4A), 3(8A, C), 3(9A, B), 3(10A), 3(11A), 4(1), 4(2B-E), 4(3B), 4(4A), 4(8A), 4(8A, B), 4(10A); Social Studies Geography 4.9C; Math 3.3A, 4.3A, 3.11A, 3.13, 3, 14A-C, 4.15A, 4.16B; English Language Arts and Reading 3.3C, 3.4A-B, 4.5F

Activity 5.4 Watered in Pollution: *Measure the effects of air pollution on leaf growth.*
TEKS: Science 3(1), 3(2B-E), 3(4A), 3(8C), 3(11A), 4(1), 4(2B-E), 4(4A), 4(8A, B), 4(10A), 4(11A, C); Math 3.3A, 4.3A, 3.7B, 14A-C, 4.13C, 4.14D

Activity 5.5 Acid Rain: *Observe the effects of acidic water on plant survival.*
TEKS: Science 3(1), 3(2B-E), 3(8C), 3(11A), 4(1), 4(2B-E), 4(8A, B), 4(10A); Math 3.3A, 4.3A, 3.7B, 14A-C, 4.11B, 4.13C, 4.14D, 4.15A, 4.16B; English Language Arts and Reading 3.3C, 3.4A-B, 4.5F

Activity 5.6 In the Neighborhood: *Match plants with the environments they need to grow.*
TEKS: Science 3(1), 3(2B-D), 3(8A-C), 3(9A, B), 3(11A, B), 4(1), 4(2B-D), 4(11C); Social Studies (Geography) 3.4C, 4.9C; English Language Arts and Reading 3.3C, 3.4A-B

Activity 5.7 Seed Race: *Observe the success rates of native seedlings vs. non-native seedlings.*
TEKS: Science 3(1), 3(2B-E), 3(4A), 3(8C), 3(11A), 4(1), 4(2B-E), 4(4A), 4(8A, B), 4(10A), 4(11A, C); Math 3.7B, 3.11A, 3.13, 3.14A-C, 4.12, 4.15A, 4.16B