Exploring the Native Plant World

A Life Science Curriculum

5th–6th Grade

Adaptations in the Native Plant World

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Contents

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 sen-sitive 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

Adaptations in the Native Plant World

In nature there are neither rewards or punishments—there are consequences.
—Robert G. Ingersoll, *Some Reasons Why* (1881)

In this unit of *Exploring the Native Plant World,* students study the basic units of genetic inheritance and how passing genetic material in populations plays a part in the close fit between organisms and their ecosystems.

Plants pass on their traits through seeds, and the idea of useful variations that make a plant more fit for its ecosystem is illustrated with the Pea Patch Game. Once students see how natural selection might affect a plant population's traits, the actual passage of these traits from parent to offspring is examined with the Pea Plant Gene Shuffle. This activity shows students that genes are discreet packages of information and not simply a blending of the genetic code.

Plant communities are adapted to their locations—both the smaller specific microhabitats and the larger global distributions. Climate, topography, soil composition and chemistry, and geology are just a few of the many factors that play an important role in the distribution and composition of plants and plant communities.

Within plant communities, plant species have developed a wide array of adaptations that enable them to survive in their habitats. These adaptations are explored through outdoor activities.

Humans have affected the environment, causing changes to plant communities and the animals that depend on those communities. Plant genetics are impacted when large populations are eliminated. Human choices and their results are explored in the last section of this curriculum.

Unit Overview

Suggested time: Three to four weeks

Objectives

Before your field trip, students will learn:

- Plants pass on traits to their offspring through genes.
- Plant communities are adapted to an area's climate.
- Plant species must cope in harsh environments.

During your field trip, students will learn:

- Plant structures and strategies help plants survive in their habitats.

After your field trip, students will learn:

- Human communities affect plant communities.

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

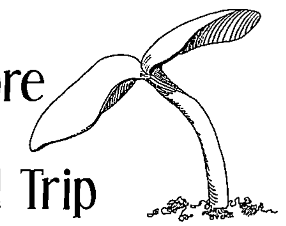
Concepts

- The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns.
- Human activities have changed the Earth's land, and some of these changes have decreased the capacity of the environment to support some life forms.
- Plants have a great variety of structures that contribute to their being able to make food and reproduce.
- For offspring to resemble their parents, there must be a reliable way to transfer information from one generation to the next.
- Plants typically have half of their genes coming from each parent.
- In all environments, plants compete with one another for resources. Individual plants with certain traits are more likely than others to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species.
- Tables and graphs can show how values of one quantity are related to values of another.
- The graphic display of numbers makes a pattern that can be used to make predictions about the phenomena being graphed.

Skills

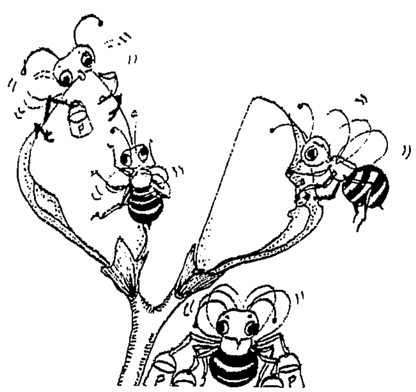
- Manipulating laboratory materials.
- Acquiring data through the senses.
- Classifying, ordering, and sequencing data.
- Communicating data and information in appropriate forms.
- Measuring using relationships to standards.
- Drawing logical inferences.
- Predicting outcomes and forming generalized statements.
- Relating objects and events to other objects and events.
- Applying applied terms based on observation.
- Identifying and manipulating the conditions of an experiment.

Before Your Field Trip

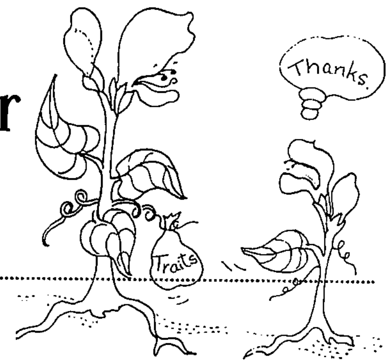


To prepare for your field trip, your class will:

- *model changes in plant populations caused by pollination patterns*
- *explore how characteristics are passed in genes from parents to offspring*
- *draw conclusions about genetic characteristics*
- *recognize the ways plant species are adapted to the world's four basic habitats*
- *identify precipitation patterns in different habitats*
- *observe four physical processes of the water cycle*
- *use historical data, current trends, and folklore to forecast the weather*
- *observe the revival of a dormant plant*
- *conduct experiments to compare the ability of plants and their seeds to cope with extreme conditions*
- *measure the effects of water loss in succulent leaves*
- *compare transpiration levels among plants adapted to different habitats.*



Lesson 1: Plants pass traits to their offspring through genes



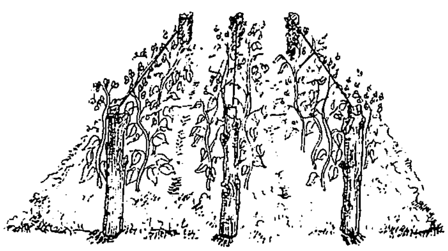
ACTIVITY 1.1

Pea Patch Game: *Model changes in plant populations caused by patterns of pollination*

Before Activity

Gather materials:

__ *Pea Patch Game Directions* template, page 37



__ *Pea Patch Field* template, page 38

__ *Pea Patch Data Table* template, page 39

__ approximately 300 white beads (buttons, poker chips, plastic or paper circles may also be used)

__ approximately 300 red beads

__ 12 cups or bowls

- Make six photocopies of the *Pea Patch Game Directions* template, *Pea Patch Field* template, and *Data Table* template (one copy for each team).
- Count out 50 red and 50 white beads for each team into cups or bowls.

During Activity

1) Explain to students that pollinators play a role in natural selection. When a bee visits a pea patch and pollinates more of a certain color flower, natural selection will change the color of the pea plant population over time.
2) Divide class into groups of five. Give each group a *Pea Patch Game Directions* handout, a *Pea Patch Field* handout, a *Data Table* handout, and two containers of beads (one red, one white).
3) Review the *Pea Patch Game Directions* with students. Explain that they will be *modeling* how a plant population changes as it responds to pollination patterns over several growing seasons. Guide students through Years 1 and 2.
4) When student groups have recorded ten years of data, ask them to graph the changes in flower populations over time. During Year 1 the white flowers made up 50 percent of the pea patch population. How did that percentage change during the following years?
5) Discuss characteristics that might help a plant survive the following environmental changes:
   - complete loss of honeybee population
   - freezing weather early each fall
   - freezing weather late each spring
   - visitors picking all the prettiest flowers.

The Difference Between Individuals and Populations

In his book *The Diversity of Life*, famous ant researcher and biologist E. O. Wilson makes the distinction between individuals changing and populations evolving.

Evolution occurs over time; thus individuals that change to fit their environment are actually adapting, not evolving. To illustrate evolution, Wilson uses the example of a population of butterflies with two inherited color phases. If, over time, the population goes from 40 percent blue individuals to 60 precent blue butterflies, it is due to evolution.

This means that *individual* blue butterflies have a better chance to survive and go on to reproduce more blue offspring. Over time, the entire *population* of butterflies will gradually become more and more blue until blue butterflies are the dominant members.

Survival Characteristics

Slight variations in a plant's genetic makeup often produce characteristics that help it survive during periods of environmental change. For example, a plant species that is pollinated by honeybees could face extinction if the honeybee population is completely wiped out. However, if butterflies can also pollinate the flowers, the plants will continue to survive.

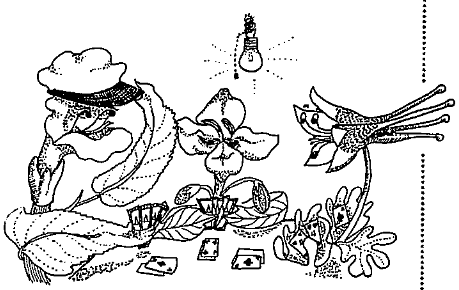
Leaves with tiny hairs that trap heat or water, thick cuticles to prevent water loss, flowers that bloom after the last chance of a freeze, or the ability to produce lots of heat prior to blooming are just some of the inherited traits or characteristics that allow plants to survive weather extremes long enough to successfully reproduce.

Modeling

Botanists will often set up a test situation to determine what happens to plants living under different conditions (i.e., temperature, soil type or composition, water availability, and light). They will manipulate these variables to see how the plants react. These "models" often provide botanists with information on: how to make the seeds germinate, what kinds of pollinators work best with a particular species of plant, and how to work with threatened and endangered species.

ACTIVITY 1.2

Pea Plant Gene Shuffle: *Explore how characteristics are passed in genes from parents to offspring*



Before Activity

Gather materials:

__ *Pea Plant Pollen* template, page 40

__ *Pea Plant Eggs* template, page 41

__ *Directions for Making Pea Plant Cards*, page 42

__ *Pea Plant Cards* templates, pages 43-44

__ *Pea Plant Gene Shuffle* template, page 45

__ 3 envelopes

__ red transparencies (enough to make 50 red "R" squares)

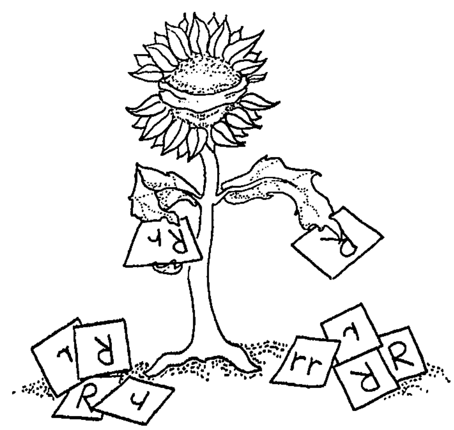
__ clear transparencies (enough to make 50 red "r" squares)

__ overhead projector

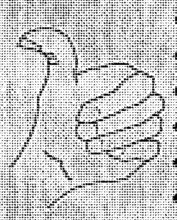
- Mark the three envelopes: "Pea Plant Eggs/Female Genes," "Pea Plant Pollen/Male Genes," and "New Seed Genes."
- Photocopy *Pea Plant Eggs* template (R squares) on a red transparency. Cut out the squares and put them in the envelope marked "Pea Plant Eggs/Female Genes."
- Photocopy *Pea Plant Pollen* template (r squares) on a clear transparency. Cut out the squares and put them in the envelope marked "Pea Plant Pollen/Male Genes."
- On cardstock, photocopy a class set of the *Pea Plant Cards* and follow the *Directions for Making Pea Plant Cards*.
- Make an overhead transparency of the *Pea Plant Gene Shuffle* template.

During Activity

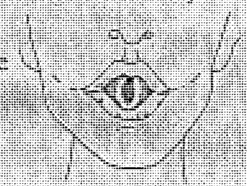
1) Begin this activity with a discussion about some of the students' inherited traits, such as eye color, hair color, and other obvious features. Then tell students about less obvious characteristics that actually are controlled by a *single* set of genes (see sidebar). Ask students if they have any of these characteristics. Does anyone in their family? Many family members, or only one?
2) Pass around the envelopes labeled "Pea Plant Eggs/Female Genes" and "Pea Plant Pollen/Male Genes." Have each student to take one red square and one clear square. The squares represent the flower color information that the male and female plants give to their offspring.
3) Have students hold both color information squares (red and clear) together. The color they see—red—means the flowers of all the offspring will be red. If students argue that combining red and white produces *pink*, explain that genes combine according



Characteristics Controlled by a Single Set of Genes



- direction of the whorl of hair on the back of the head
- presence of hair on the first knuckle of fingers
- backward bending thumb (known as "hitchhiker's thumb")
- leg on top when sitting cross-legged
- ability to roll tongue downward into a tube
- ability to taste certain bitter chemicals such as lemon juice



to rules that differ from those involved in mixing pigments. Point out the capital "R" on the red squares and the lower case "r" on the clear squares. Explain that the "R" genes are *dominant* and the "r" genes are *recessive.* You only need one dominant gene to be expressed while you need two recessive genes in order for that characteristic to be expressed. For example Rr=a red flower and rr= a white flower. Use the *Pea Plant Gene Shuffle* overhead transparency to illustrate the patterns of dominant and recessive genes.

4) Collect all the gene squares in the envelope marked "New Seed Genes." Tell the students the envelope now contains *all* the genetic information from the past season's red-flowered pea plants. Ask students to guess/predict what color the new pea plant flowers will be.
5) Have each student take two squares from the "New Seed Genes" envelope without looking and once again hold their squares together. What color do they see—red or white (clear)?
6) On the chalkboard or overhead, list the number of students whose genetic information produced red flowers and the number whose genetic information produced white flowers. Mendelian genetics predicts that the class will have three red flowers out of every four.
7) Put the different combinations possible on the board and list the number of students with each combination:

   R + R = red flowers. Two dominant (red) genes result in red flowers.

   R + r = red flowers. One dominant (red) gene overrides the recessive (clear) gene, resulting in red flowers.

   r + r = white flowers. Two recessive (clear) genes result in white flowers.
8) In a large population of red flowered and white flowered pea plants, the odds (statistical probability) favor these ratios: This is sometimes represented with a Punnett Square:
   - ¼ RR or 25% Red (RR)
   - ½ Rr or 50% Red (Rr)
   - ¼ rr or 25% White (rr)

	R	r
R	RR	Rr
r	Rr	rr

Ask students how close the class results came to this ratio.

Teaching Tip

Some students will predict that all the flowers will again be red, since all the "parent" flowers were red. Others may assume that half will be red and half will be white, since the number of red and clear squares is equal. Invite students to explain the rationale for their hypotheses. Later revisit the predictions and ask students to evaluate the strengths and weaknesses in their rationales.

Teaching Tip

To reinforce the concept of statistical probability in genetics, you may want once again to put all the red and clear squares into the "New Seed Genes" envelope and have students repeat the last few steps in this activity. Are the results different this time? In what way?

Mendel's Law

The basic principles of genetics were discovered by Gregor Mendel, a studious monk who tended a garden at an Austrian monastery in the mid-1800s. Gifted with a lively curiosity and sharp observational skills, Mendel conducted breeding experiments and kept careful records. His conclusion: Heredity factors come in two packages containing genes, one package from each parent.

From his experiments, Mendel deduced that genes are bundles of instructions—much like a modern-day computer program—that determine the characteristics of plants, animals, and people. Using this information, he described three principles: 1) Principle of Segregation, 2) Law of Dominance, and 3) Principle of Independent Assortment.

Principle of Segregation

According to Mendel's principle of segregation, gene pairs determine hereditary traits with each parent contributing half of the gene pair. Different forms of the same gene are called *alleles*. For example, the gene for pea pod color may have alleles for green, red, or yellow pods.

Law of Dominance

The genetic makeup of an organism is called its *genotype* and the outward expression of that genotype is its *phenotype*. A gene that is expressed in the phenotype of an organism is said to be *dominant*. A gene that is concealed, or not expressed, in the phenotype is said to be *recessive*. For example, a plant with green pods crossed with a plant with yellow pods produces offspring with yellow pods. The gene for yellow pods is said to be dominant, while the gene for green pods is recessive.

Principle of Independent Assortment

According to this principle, the alleles of one gene separate independently from the alleles of another gene. For example, the alleles for pea pod color separate independently of the alleles for pea flower color, so that the allele for the green color pod could be on a plant with red flowers or white flowers.

ACTIVITY 1.3

Tying It Together:

Draw conclusions about genetic characteristics

Before Activity

Gather materials:

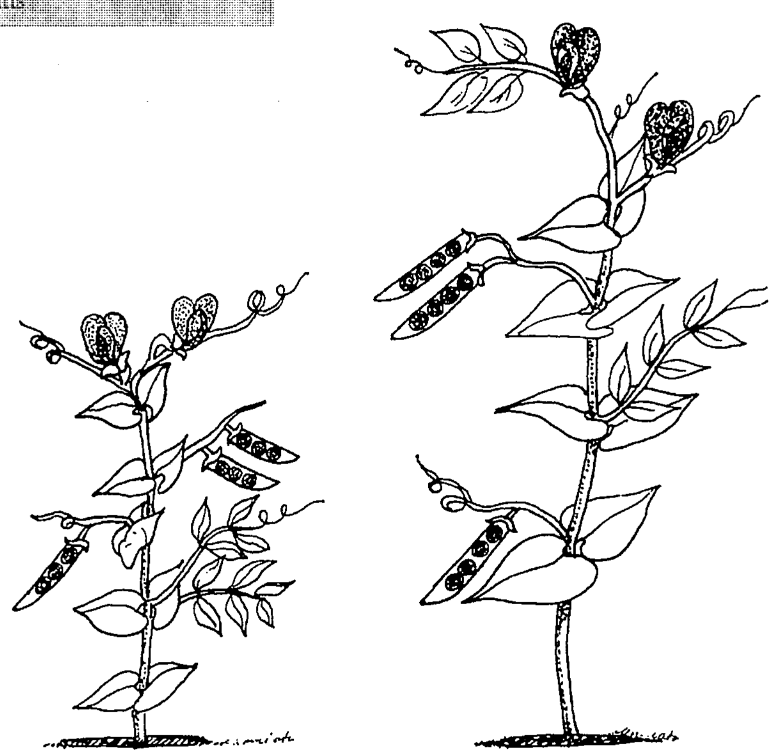
- __ *Family Ties Worksheet* template, page 46
- __ *Pea Plant Cards* from Activity 1.2
- __ *Genetic Letter Codes* template, page 47
- __ colored pens, pencils, or markers (red, green, and yellow)
- __ tape or glue

- Photocopy a class set of the *Family Ties Worksheet* template.
- Make a photocopy of the *Genetic Letter Codes* template. Cut out each genetic letter code combination.

Genetic Color Codes Key	
RR = red flowers	YY = yellow peas
LL = long stems	Rr = red flowers
Yy = yellow peas	Ll = long stems
rr = white flowers	yy = green peas
ll = short stems	

During Activity

1) Hand out the *Family Ties Worksheet.* Have students answer the first two questions.
2) Next hand out the *Pea Plant Cards,* one to each student. Have students use their cards to answer question #3 on the handout.
3) After students complete their worksheets, have them look for a partner with a *Pea Plant Card* that, crossed with their own, will produce seeds for an offspring plant with red flowers. Then have students try other combinations: Can *everyone* find a partner to produce seeds for an offspring plant with yellow peas? How about seeds for an offspring plant with red flowers, yellow peas, and a short stem?



Send in the Clones

There are two ways plants can reproduce: *sexually* and *asexually*. During sexual reproduction, genetic information from both parents combine to produce offspring with a genetic makeup different from each of the parents. This is a good thing because new genetic combinations may allow the offspring to compete and survive in an ever-changing environment long enough to reproduce.

When a plant reproduces asexually, it in effect creates a copy, or clone, of itself. No new genetic combinations are produced, and the offspring are genetically identical to their parent and their siblings. This may be okay for a while, especially if things in the environment don't change too drastically or suddenly. However, if the environment *does* change and the cloned plants don't have the genetic information necessary to cope with or survive that change, they may die before successfully reproducing. If the environment continues to change, cloned plants may eventually die out completely.

Darwin's Theory of Evolution

Charles Darwin's theory of evolution is based on four principles:

1. Organisms change over time, and those living today are different from those that lived in the past. Many organisms that once lived are now extinct.
2. All organisms are derived from common ancestors. Over time, populations split into different species, which are related through a common ancestor.
3. Change is slow and gradual, taking place over long periods of time.
4. The mechanism of evolutionary change is *natural selection*.

The Process of Natural Selection

Darwin and his colleague, Alfred Wallace, proposed the concept of natural selection in 1858. According to this concept, not all individuals in a particular population may survive and reproduce equally well. Small genetic differences can give certain individuals an advantage over other individuals in the population. This is known as *genetic fitness*.

Darwin's idea of natural selection depended on certain things to be true:

- Many species produce huge numbers of offspring to ensure continuation of the species.
- Species struggle or compete for existence. All seeds, spores, and other reproductive cells compete for available space and resources.
- The genes for survival are passed from generation to generation. Genes that don't help a species survive are gradually eliminated.
- Individuals of a particular species that are adapted to survive and cope with a changing environment will live long enough to successfully reproduce. Individuals that are not as well adapted may not live long enough to reproduce and will be eliminated from the population.

Lesson 2:
Plant communities are adapted to an area's climate

Environment and Natural Selection

Environment is the most important influence in natural selection. When the environment favors a particular trait as having survival value, more of the individuals with that trait survive and have offspring. Environmental factors include topography, soil, and climate. Humans can be an environmental factor influencing natural selection as well.

Case in Point A

A classic example of how the environment can affect natural selection involves the natural populations of the peppered moth (*Bison betularia*) in England. During the mid-nineteenth century, most of the moths in non-industrialized areas were light in color. As the country became more and more industrialized, buildings and trees became dark with factory smoke and soot. A later survey of the moth population revealed that most of the moths were dark.

Researchers found that the darker moths were better able to hide against the soot-covered trees and buildings, thus avoiding being eaten by predators. The uneaten dark moths went on to successfully reproduce dark offspring, which also survived to reproduce. In the industrialized areas, natural selection favored the dark-colored moths and worked against the light-colored ones.

In areas where no industrialization had taken place, natural selection favored light-colored moths and worked against the dark-colored ones.

Case in Point B—Clinal Variation

Another example of the environment affecting the natural selection in plant species is found in clines. A cline is a gradual change in the phenotypic or genetic composition of populations in relation to the environment. In the 1940s-1950s, Clausen, Keck, and Hiesey studied the yarrow plant (*Achillea lanulosa*) that grows in the Sierra Nevada mountains. As elevation increases, the same species of yarrow plants appear shorter and have different growth forms (i.e., number of flowers).

Of course, you say, there is a non-genetic explanation: the environment limits plant growth, increasing altitude, decreasing temperature, perhaps other resources, such as nutrients and water are also limiting. In order to determine whether these differences were actual genetic adaptations, the researchers collected seeds from various altitudes and grew them at the same altitude. They found that the plants from the shorter, higher altitude seeds were still shorter when grown at sea level, and the taller plants were stil tall when grown in different elevations. This showed that a genetic change had occurred within the same species due to adaptations to differences in climate.

ACTIVITY 2.1

Habitat World: *Recognize the ways plant species are adapted to the world's four basic habitats*

Before Activity

Gather materials

- __ *World Habitat Maps* template, pages 48-49 (both Eastern and Western hemispheres)
- __ *Spinner* template, page 50
- __ *Plant and Animal Habitat Cards* templates, pages 51-52
- __ photographs showing desert, grassland, forest, and rainforest habitats from around the world
- __ *Children's World Atlas*
- __ wall map of the world
- __ transparency sheets
- __ colored permanent markers (red, yellow, green, and blue)
- __ thumbtack (with plastic head)
- __ cardboard
- __ glue
- __ masking tape

- In the *Children's World Atlas,* locate different versions of the world map that use color legends to show population, economy, climate, rainfall, topography, or political boundaries.
- Assemble the *Spinner*:

  Photocopy the *Spinner* template on heavy cardstock. Cut out both the arrow and circle of *Spinner.* Laminate and trim.

  Cut out a piece of cardboard the same size as the circle. Glue the circle on top of the cardboard. Match up hole on center of circle with hole in arrow. Stick the thumbtack through that hole into the cardboard. Flick the *Spinner* with your finger to make sure it turns freely.
- Photocopy the *Plant and Animal Habitat Cards* templates on cardstock and cut out the cards.
- Photocopy four transparencies of the *World Habitat Map* template. Use markers to color a different climate/eco-region on each of the transparencies (follow the color key).

World Habitat Map Color Key

- Deserts – red
- Grasslands – yellow
- Temperate forests – green
- Tropical rainforests – blue

During Activity

1) Ask students to look at the wall map of the world. What do the colors stand for? Show the world population map in the atlas and ask what the different colors might represent. Show other versions of the world map in the atlas that illustrates economy, climate, and rainfall.
2) Stack the four colored transparencies on the overhead projector—showing a complete world map with distinctly colored habitats/eco-regions—and invite students to guess what the map represents. Explain that it represents habitats, a unique assemblage of plants and animals largely determined by climate.
3) Write the words "desert," "grassland," "forest," and "tropical rainforest" on the chalkboard. Point to different colors on the map and have the class identify the corresponding habitat type.
4) Remove all transparencies from the overhead projector except for the one colored blue (tropical rainforest). Show students the photograph(s) of

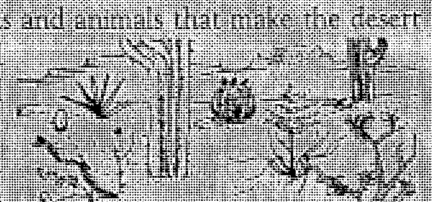
tropical rainforest habitats. Invite students to share what they know about tropical rainforest habitats—from pictures, television shows, and movies they have seen; from books they have read; or even from places they have been.

5) Repeat Step 4 for the remaining habitats—grassland, forest, and desert.
6) Divide the class into five teams and give each team animals and their habitat cards.
7) Explain the game: You will turn the spinner and announce the habitat where it points. Students then must check their cards to see if they have an animal or plant from that habitat. Those with the appropriate cards must quickly raise their hands and tell the name of the continent on which their plant grows. The first student to raise his/her hand may take the card to the world map, tell the class about the plant or animal, and then use masking tape to carefully attach the card in the correct location on the map. The first team to run out of animals and their habitat cards "wins" the game.
8) When the game is over, identify types of plants that live in each of the habitats around the world. Encourage students to point out similarities and differences among the plants that live in these habitats on different continents.
9) Invite students to share any conclusions they have reached regarding animals that live in the different habitats and their relationships with the plants there.

Habitat Homes

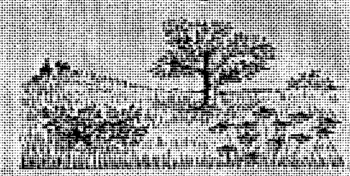
Every major continent has deserts, grasslands, temperate forests, and tropical rainforests, and these habitats can be distinguished by the plants and animals that live there.

Deserts are areas of warming air and little rainfall, and most deserts have less than 10 inches of rain a year. Plants and animals that make the desert their home are specially adapted to deal with high temperatures and limited water resources.



Many desert plants are annuals that flower and set seed during rainy periods when water is readily available. Desert-dwelling perennials tend to be succulents adapted for water storage. Others drop their leaves during the dry seasons, have small, water-conserving leaves, or bear modified leaves (such as cactus spines) to prevent water loss. Some desert species have extensive root systems that help trap large amounts of water during the infrequent rains.

Desert animals are also specially adapted to cope with the harsh climate. Many are nocturnal, coming out during the cool desert nights to get water, forage for food, and mate. Some have waterproof skins, while others rest in the shade during the hottest part of the day to conserve water.



Grasslands are transitional areas between deserts and forests. Generally found in the interiors of continents, they are characterized by rolling to flat terrain, hot-cold seasons, periodic droughts, and fires.

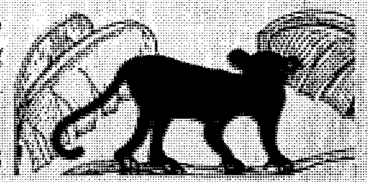
The dominant plant species are bunch or sod-forming grasses mixed with legumes and annuals. Periodic fires destroy tree seedlings, clear out brush and trash, return nutrients to the soil, and break dormancy in seeds.

Grasslands support small seed-eating rodents and large herbivores such as bison.

Temperate forests once covered most of eastern North America. Today only scattered patches of the original forest remain. Occurring in areas with a warm, mild-growing season followed by a colder period, deciduous (leaf shedding) trees are the dominant plant species. Four layers of vegetation characterize deciduous forests:

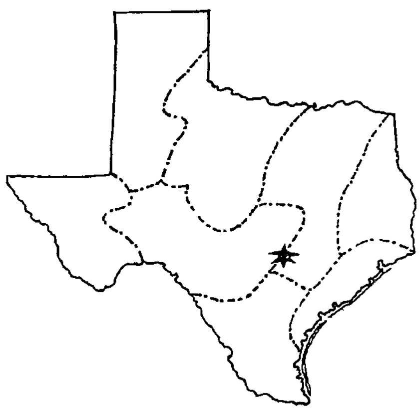
- A continuous canopy, dominated by one or two species of trees.
- A shrub layer populated by species that resemble trees but branch at or close to the ground.
- A field layer made up of grasses and other non-woody plants that bloom early in the spring before the trees leaf out and cut off the sunlight.
- A ground layer consisting of mosses and liverworts as well as leaf litter.

Small mammals such as chipmunks, voles, squirrels, raccoons, opossums, and mice feed on nuts, fruits, mushrooms, and insects. Larger mammals—including wolves, bobcats, foxes, and mountain lions—feed on the smaller mammals.



Tropical rainforests receive between 78 and 157 inches of rain every year. As a result, there are more species of plants and animals in a tropical rainforest than in all the rest of the habitats of the world combined. The critical factor for rainforest plants is light, and competition for this resource is fierce. Trees forming the canopy are usually slender, branching only near the crown, which is high up and small due to crowding. Root systems are shallow, and trunks often end in thick buttresses that provide support and anchorage. Large, leathery, dark green leaves capture the filtered sunlight, and flowers are inconspicuous and green or white in color. A variety of plants including ferns, orchids, mosses, and bromeliads are epiphytic (grow on other plants) and capture water from the humid air.

The canopy is home to a wide diversity of insects, birds, and mammals that make the treetops their home.



Activity Extension: Visit My Habitat

Divide the class into eight groups (two groups for each habitat). Have each group create a travel poster (text and pictures) advertising the unique attractions of their habitat.

Activity Extension: Where Was That Again? *Reinforcing Habitat Knowledge*

Materials: *World Habitat Maps* templates, pages 48-49, one for each student, colored pencils, Play-Doh, globe

1) Hand out the *World Habitat Map* worksheet to each student.
2) Provide colored pencils or crayons, at least 4 colors for each child, and ask them to fill in forests, grasslands, tropical rainforests, and deserts with a different color. Remind them that every map has a title and a key or legend, and ask them to add those to their map. Keep the overhead map transparencies turned on while the students are working on their maps.
3) After all the maps are finished, divide the class into 4 or more groups and invite each group to use a small amount of Play-Doh to cover a particular habitat in a certain continent on the globe.
4) Pass the globe around until the four types of habitats (forest, grassland, deserts, and tropical rainforest) are identified with Play-Doh relief.

ACTIVITY 2.2

The Water Cycle and Weather: *Observe four physical processes of the water cycle*

Before Activity

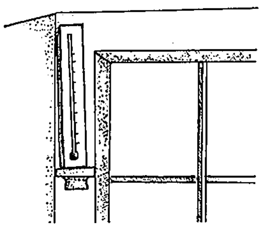
Gather materials:

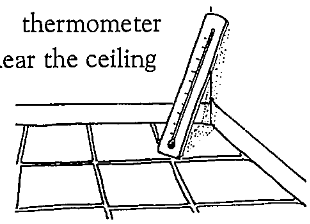
- __ 2 thermometers
- __ coffee maker
- __ empty 1.5 liter water bottle
- __ funnel
- __ pitcher
- __ safety matches
- __ saucer
- __ ice pack

- Test the thermometers to make sure they are calibrated with each other.
- Fill the coffee pot with water and turn on the coffee maker just before beginning the activity.

During Activity

1) Precipitation (rain, snow, hail, etc.), an important part of habitats, is a result of physical processes known as the *water cycle*. In this activity, students will learn about four physical laws that affect the weather.
2) Show students the two thermometers and ask them to think of a way to prove that hot air rises. Have students help you find suitable locations and place the thermometers there. (Make sure a thermometer is placed near the ceiling and away from any air vents.)

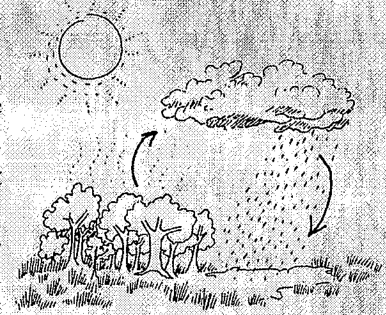




Teaching Tip

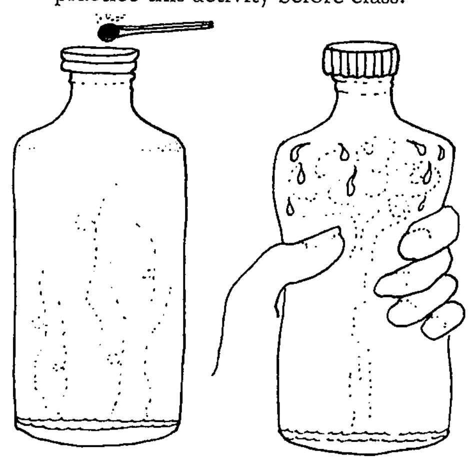
To verify for students that the different temperatures are not due to miscalibration of the thermometers, you may want to repeat this part of the activity after switching the thermometers. You may also want to try repeating the experiment in one or several other locations, such as the hall, the library, or the gym. This will reinforce the concept of reproducibility in the scientific method.

The Water Cycle



Water changes forms—gas, liquid, solid—as it moves through a predictable cycle. Heated surfaces of oceans, ponds, puddles, and ice release water vapor that rises in the air and condenses into clouds. When these clouds are saturated, the vapor precipitates out as rain into oceans, rivers, lakes, ponds, and puddles. Some of this water may freeze. As ice, snow, and sleet melt, water runs to fill low places and later evaporates into the air for another cycle.

3) Wait at least five minutes before comparing the temperatures registered on the thermometers. Ask students why the temperatures are different.
4) Tell students they have just seen evidence of one physical process that causes weather: *Hot air rises.*
5) Put the coffee maker on to heat the water. When the water in the coffeepot is steaming, take the lid off and ask students what they see. Ask students to explain what steam is (the gas form of H_2O). Why is it *rising*? What would happen if the coffee maker was left on for a long time? Where would all the water go?
6) Tell students they have just seen evidence of another physical process that causes weather: *Warmed water turns to gas and rises.*
7) Next, pour approximately two cups of hot water from the coffee pot into a pitcher. Add enough cold water to cool the water temperature from "hot" to "very warm." Using the funnel, pour the warm water into the water bottle until it is about one-fourth full. Then screw on the lid.
8) Hold up the bottle to show students the water vapor that has fogged the sides of the bottle. Is this a cloud? No, clouds are more than just water vapor; in a cloud, particles of water gather around other small particles of dust or dirt.
9) Tell students you are going to make a cloud inside the bottle. Light a match, blow it out, quickly unscrew the bottle lid, put the smoking match in the neck of the bottle for a moment, and then quickly reseal the bottle. DO practice this activity before class.

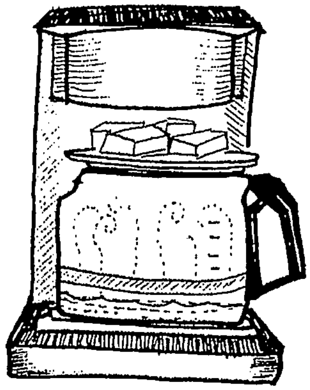


10) Swirl the vapor off the sides of the bottle and then, holding it up so students can see, squeeze the sides of the bottle. The change in pressure causes the water to condense very quickly and form a visible cloud at the top of the bottle. Ask the students what is happening.
11) Tell students they have just seen evidence of another physical action that is involved in weather: *Water vapor will gather around small particles to form clouds.*
12) Next, take the coffee pot from the coffee maker and set it in a safe location

where all students can see it. Remove the lid and put a saucer in its place. Then lay the ice pack on the saucer.

13) After a moment, show the students how the steam has cooled into water by holding the saucer up and letting water drip off the sides.

14) Tell students they have just seen evidence of another physical process that causes weather: *Cold causes water vapor to become rain.*



ACTIVITY 2.3

The Climate Connection:
Identify precipitation patterns in different habitats

Before Activity

Gather materials:

- __ *World Habitat Maps* templates, pages 48-49
- __ *World Climate Worksheet* template, page 53
- __ *World Habitat Map* transparencies created for Activity 2.1
- __ *Mapping Habitats* (use *World Habitat Maps* from Activity 2.1 in Appendix)
- __ wall map of the world
- __ colored pencils or crayons

- Photocopy a class set of the *World Habitat Maps* template. (Eastern and Western hemisphere maps need to be reduced and retraced without patterns but keep lines dividing habitats and legend and squares.)
- Photocopy a class set of the *World Climate Worksheet* template.

During Activity

1) Display the stack of colored *World Habitat Map* transparencies on the overhead projector (see Activity 2.1). Prompt students to make observations about where the various habitats are in relation to each other. What patterns can students find? Have students use a topographical map to look for features—such as mountains, plateaus, and major lakes and rivers—that are not apparent on the transparencies.

2) Encourage students to reflect on the connection between climate and topography (the physical features of a place or region). For example, point out that blue areas are near the equator and also near large bodies of water. On the other hand, some yellow areas also are near the equator but not as close to water. What inferences can the students make?

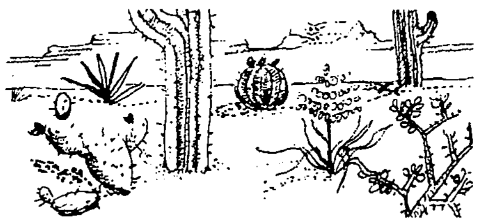
3) Point out the desert habitats on the map. Ask students why a desert would form in the middle of a large continent. (Clouds filled with water picked

Habitat and Climate

Climate is defined as the *typical temperature, precipitation (rain, snow, etc.), and wind of a particular region.*

Climate determines the plant types that will grow in any particular area. Large amounts of rain falling on continents near the equator nurture tropical rainforests. Temperate forests arise in the temperate areas where there is enough rain, while the grasslands begin where rainfall diminishes. Those places in the world receiving little rain each year are deserts, regardless of temperature and altitude. For example, Antarctica is considered a desert!

up from the oceans cannot travel that far.) Why would a desert form near a continental coast? (There is a rain shadow where tall mountains prevent rain clouds from moving inland.) This is a good example of how topography affects climate.



4) Give students the *World Habitat Map* handouts. Have them use colored pencils or crayons to fill in the four types of habitat—tropical rainforests, grasslands, forests, and deserts—each with a different color. Tell students to add a title and a key or legend to their maps.
5) Using their colored *World Habitat* maps and the classroom wall map, have students work in groups to locate the cities on the *World Climate Worksheet* and complete the exercise. Ask students if the amount of rainfall correlates to the different types of habitats, and what kinds of vegetation would they expect to find near the cities. Ask the students to create their own set of icons to delineate the different levels of rainfall in each city.

Activity Extension: Changing Climate

Provide students with Internet access and reference materials documenting climate and weather of your school's location. (Check U.S. Geological Survey at www.usgs.org and National Climatic Data Center at www.ncdc.noaa.gov.).

Divide the class into groups by time period—in decade increments. Tell each group to gather information about annual temperatures (average highs and lows) and precipitation for each year during their assigned time period. Have each group create two line graphs showing both kinds of data. Make the increments so the graphs can be attached for continuous data.

Have the groups display their graphs in chronological order and, beginning with the oldest time period, have each group summarize/explain the information in their graph. When all groups have shared their findings, invite the class to discuss any trends or changes they can see over time.

ACTIVITY 2.4

Weather Kids: *Use historical data, current trends, and folklore to forecast the weather*

Before Activity

Gather materials:

- __ *Predicting Weather* template, page 54
- __ *Forecasting Folklore* template, page 55
- __ *Old Farmer's Almanac* for the year
- __ daily weather data for last year (check the *Farmer's Almanac*, Internet, local TV channel, Weather Service, U.S. Geological Survey website)
- __ overhead projector (optional)

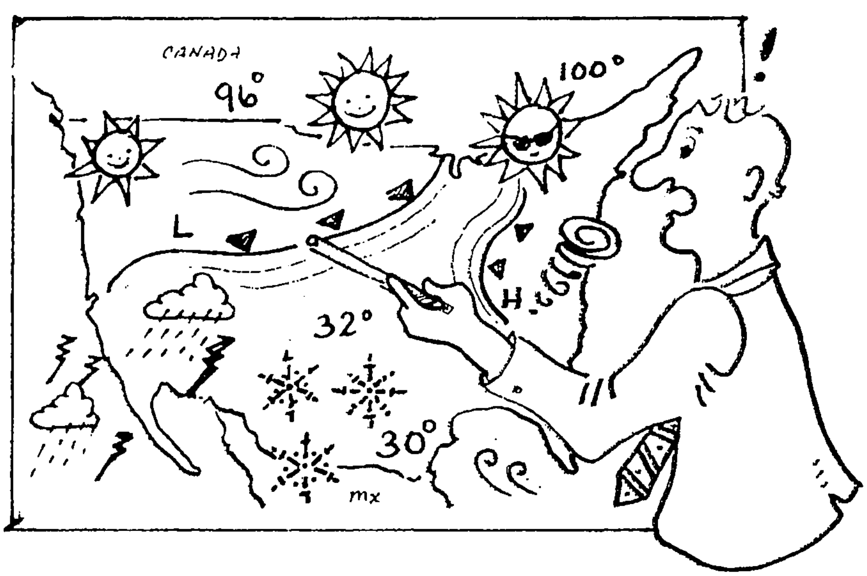
- Photocopy a class set of the *Forecasting Folklore* template to give to students, or make a transparency to display on the overhead projector.
- Photocopy a class set of the *Predicting Weather* template to give to students, or make a transparency to display on the overhead projector.

During Activity

1) Weather over a long period of time is what determines climate. Maintain a month-long diary of the weather conditions in your town on a class calendar. At the end of the month, compare the daily weather recorded on the class calendar to the forecast in the almanac.
2) Invite the students to devise their own secret formula to forecast the next month's weather. They can choose to use:
   - last year's data,
   - some of the methods meteorologists use today,
   - or weather folklore.
3) Recognize those students who accurately predict each day's weather as the official Class Meteorologists.

Activity Extension: Meet the Meteorologist

Arrange for a local TV meteorologist to visit your class. Ask him or her to discuss the geographical and climatological features that affect the weather in Central Texas, as well as the methods he or she uses to predict the weather.



Teaching Tip

Weather predictions vary—sometimes dramatically—depending upon the methods used and the judgment of the meteorologist. Bring in the weather section of your local newspaper each day to see the data for yesterday as well as the predictions for today and tomorrow. Have students track the newspaper meteorologist's accuracy.

You may also want to have students record the predictions of one or more local TV meteorologists every evening. Compare their predictions with those in the newspaper to see which is most accurate.

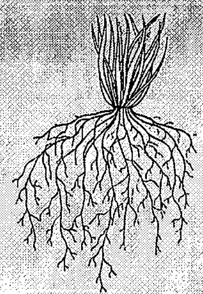
The Internet is a rich source of weather data. Visit www.aws.com/kxan/sitelist.asp to get current data from the Live WeatherNet Real-Time Sites. Locate the site closest to your school (your school may even be a part of the WeatherNet) and have students check each day to see the current regional conditions.

Lesson 3:
Plant species must cope in harsh environments

Surviving the Dry Days

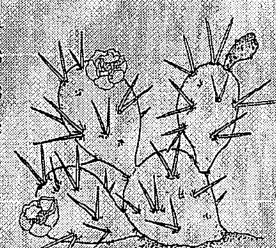
Plants have adapted to the amount of rainfall in their area and have developed a variety of mechanisms to survive periods of low moisture. Three of those mechanisms that are often observed in plants are *evasion*, *avoidance*, and *conservation*.

Through *evasion*, plants escape dealing with the problem of drought altogether. Many **annual** wildflowers and desert plants live out their entire lives—from seed to flower—during the rainy season, never having to cope with the lack of water. Some of those plants live only a few days, germinating when the rains begin, then growing rapidly, flowering, and setting seed. The seeds remain dormant until the next rainy season. Other plants, such as spring-blooming annual wildflowers, live their lives from fall to spring, going to seed by summer. Their seed remains dormant until the fall rains come.



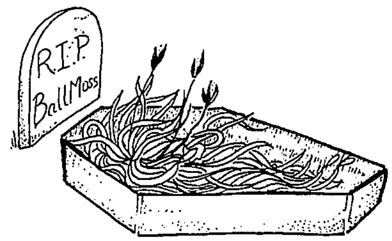
Perennial plants that experience all kinds of weather have developed the *avoidance* method to survive drought. What they are avoiding is not drought in the environment but drought in their internal tissues. These plants are able to maintain high water content in their cells despite the scarcity of water. Desert rains are torrential and soak in or run off the land very quickly. Cacti, succulents, and other desert plants have very long taproots or large fibrous root mats to collect water and expandable leaves and stems to store it for use during dry times. Other plants have the ability to increase water uptake by extending root growth when soil moisture decreases.

Conserving water is probably the most common way plants tolerate drought. The physical properties of leaves help plants do this. Hairy and waxy leaves help plants conserve water by preventing excessive water loss through transpiration, the natural evaporation of water into the atmosphere through the leaves. Hair on leaf surfaces conserves water by shading the surfaces and increasing humidity around them. Waxy substances protect leaves from drying out. And many desert plants have decreased transpiration rates by drastically decreasing leaf size—or eliminating leaves altogether. Cactus spines are considered extremely evolved leaves!



ACTIVITY 3.1

Plant Hiatus:
Observe the revival of a dormant plant



Before Activity

Gather materials:

___ ball moss or Spanish moss (found in trees) or carpet moss (found in damp woodlands)

___ clear glass bowl

- Place moss in a sunny window and allow it to dry out and turn brown (this should take approximately 2–3 weeks).

During Activity

1) Show students the brown moss and ask if they believe the plant is dead or alive. Why? How can they test their hypothesis?
2) Fill the bowl with water and submerge the moss. It should turn green over several hours.
3) Invite students to hypothesize about what happened to the moss. Was it really dead to begin with? If not, what state was it in? Why would it be beneficial for a plant such as moss to reduce functions until water is available?
4) Depending on the climate and environment, plant adaptations often must deal with large water loss, gale force winds, limited sunlight or water, high levels of salt, and hot or frigid temperatures. Explain that some plant species survive extreme conditions like drought by entering a period of dormancy. Ask students what other conditions might cause certain plant species to become dormant.

ACTIVITY 3.2

Cold Consequences: *Evaluate the parts of plants most vulnerable to freezing weather*

Before Activity

Gather materials:

___ Plant parts presented by:

- Lettuce (leaf)
- Broccoli (stem and flower)
- Blossoms (cultivated wildflowers)
- Potato (tuber root)
- Pepper (fruit)

During Activity

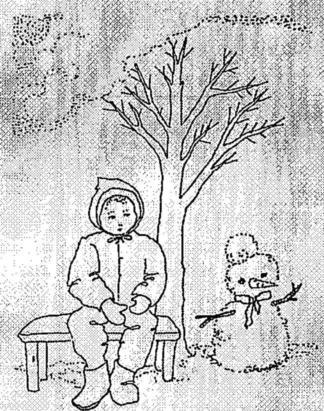
1) Ask the students what happens to plants in freezing weather.
2) Show them the different vegetables and ask them to identify the parts of the plants they represent.
3) Have the students brainstorm and list different signs of frost damage.
4) Ask them to predict what would happen to each plant part after a night in the freezer.

5) Freeze plant parts and bring to class for inspection. Be sure to cut open to aid observations. An unfrozen specimen would help for comparisons.

6) Ask the students to list the most and least vulnerable plant parts to freezing. What strategies could a plant use to avoid damage?

Surviving the Cold Days of Winter

To cope with the harsh conditions of winter, hardwood trees in Northeastern forests enter a period of *dormancy*. Several environmental factors trigger dormancy. The primary environmental trigger is day length. As winter approaches, days become shorter and nights become longer. It is actually the length of the night that influences dormancy. Long, uninterrupted nights stimulate dormancy and trees begin to slow their growth, eventually stopping altogether.



Decreasing temperatures also play a role in stimulating dormancy. Cool temperatures are needed for trees to enter true dormancy, and it is the combination of short days and cooler temperatures that actually causes dormancy.

The stems and trunks of these trees are protected from the low temperatures, and the sap that can freeze drops down out of the woody parts as weather gets colder. In fact, in very cold climates, tree trunks will sometimes freeze solid, producing frost cracks. This is usually not fatal to the tree since the tissue that freezes and cracks (xylem) is dead tissue.

Temperate woody plants also use two other mechanisms to avoid freezing to death: *supercooling* and *intracellular dehydration*.

Many species of trees and shrubs found in the temperate forest have the ability to suppress ice crystal formation in their cells, even at temperatures far below 0°F. Species such as oaks, elms, and maples exhibit this supercooling ability.

Other species living in regions where the temperatures can drop below -40°F do not depend on a supercooling mechanism to survive the harsh winters. Instead, species such as dogwood, paper birch, and willow prevent water from freezing within their cells using a mechanism called intracellular dehydration. When temperatures begin to drop toward -40°F, water moves out of the cells and freezes in the areas between the cells where no damage can occur. As the water leaves the cells, solutes (such as sugars) become concentrated in the cells and lower the cells' freezing point. This works in the same way that antifreeze protects a car's radiator.

To survive the cold weather during dormancy, trees will also get rid of the plant parts vulnerable to freeze damage and strong winds—in other words, they drop their leaves. Losing surface area by shedding leaves reduces the impact of high winds, which can cause large quantities of water to transpire from the leaf surfaces.

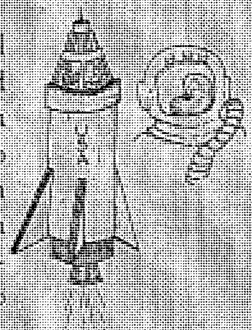
ACTIVITY 3.3

Safety in Seeds:

Conduct experiments to compare the ability of plants and their seeds to cope with extreme conditions

Seed Survival

Seeds are small survival packages that are adapted to withstand environmental extremes while waiting for conditions that favor germination. This *dormancy* can last several days to many years.



Seeds of species that grow in areas with seasonal temperature variation almost always require a period of cold prior to germination. This *cold stratification* breaks the seed's dormancy and allows germination to occur. Some species need to dry out before they can germinate. This type of dormancy prevents them from germinating while they are still in the moist fruit. Others require light to germinate while still others need to be in the dark.

Seeds of wetland plants can remain dormant for 12 years or longer, until conditions of drying and extended submergence occur. There are lotus seeds collected over 100 years ago that were still able to germinate when removed from the dry herbarium cabinet shelves and wetted.

The primary benefit of dormancy is that seeds can wait around until the environment is just right to support the new seedling, thus enhancing the species' chances of surviving to reproduce.

Before Activity

Gather materials:

__ wildflower seeds (bluebonnet, Indian blanket, or Mexican hat)

__ 6 small pots

__ soil

__ thermometers

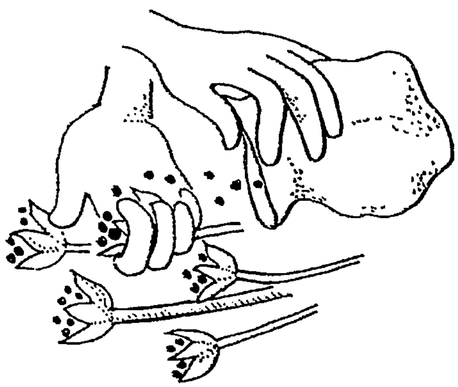
__ heat lamp

__ electric fan

__ cooler full of ice

__ medium-sized cardboard box

- Plant several wildflower seeds in each pot and allow approximately four weeks for them to germinate and grow to approximately 4 inches tall. Save the remainder of the seeds.
- Be prepared to provide students with access to other tools or appliances they may need for their experiments, such as a toaster oven or a freezer.



The Scientific Method

Through research new knowledge and concepts are gained and formed. The scientific method provides a logical and orderly framework to solve problems and answer questions. There are six easy steps to the scientific method:

1. Ask the question. You can't answer a question unless you see that one exists. Your question might be: Does the plant survive wet conditions better than its seeds? A well-planned experiment can answer this question.

2. Collect information about the question. Biologists build on the knowledge and work of other biologists. Before starting your experiment, research the question to see what information others may have found in their experiments and observations.

3. Form a hypothesis. A hypothesis is a kind of working answer to your question.

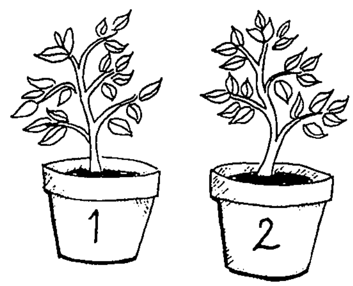
4. Experiment to test the hypothesis. Your experiment will either support or disprove your hypothesis. The experiment must test for only one factor or variable.

5. Observe and record data from the experiment. Everything about the experiment, from the way it was set up to the results, must be accurately recorded. Accurate records will allow other biologists to duplicate your experiment.

6. Draw conclusions. Data only has value when valid conclusions can be drawn from them. Valid conclusions must be based solely on the observations and results of the experiment.

During Activity

1) When the wildflower plants are 6 inches tall, tell the class they will design and conduct experiments to compare how well plants, compared to their seeds, cope with environmental extremes. Begin by discussing some of the extremes a plant and/or its seeds might be exposed to—cold, heat, flooding, drought, high winds, no light.
2) Divide the class into 6 groups and assign each group one of the extreme conditions the class discussed. Give each group a potted wildflower plant and several seeds. Tell them to follow the scientific method by developing a hypothesis and then designing an experiment to test it. Remind students that the only way to confirm a seed is still alive is to germinate it.



3) Help students set up the tools and/or small appliances they need to conduct their experiments. Remind them to follow the scientific method by carefully recording data from the experiment (temperatures, lengths of time, amounts of sunlight or water, wind speed, etc.) as well as the results.
4) When all the results have been discovered, have each group present their findings to the class. Discuss what conclusions they have drawn about the coping abilities of these plants and their seeds.

Teaching Tip

If time is short, purchase a 6-pack of bedding plants that have seed packets available.

Activity 3.4

Fill 'er Up: *Measure the effects of water loss in succulent leaves*

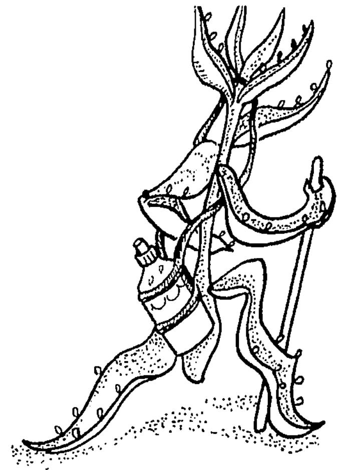
Before Activity

Gather materials:

- __ succulent plants (such as aloe, bryophyllum, jade, kalanchoe)
- __ graph paper
- __ toaster oven
- __ small food scale
- __ plastic knives
- __ magnifying lenses

During Activity

1) Show students the succulent plants. Tell students the class is going to learn more about how succulent leaves help plants survive.
2) Remove a leaf from a succulent plant, weigh it on the scale, and trace its outline on graph paper.
3) Place the leaf in a toaster oven at 200°F for six hours or put it in a sunny, dry place for several weeks.
4) Trace the leaf again on the graph paper. Count the number of square centimeters difference between the two outlines. Compare the dried leaf to a fresh leaf that fits into the diameter of the outline. Besides size, how do the leaves look different?
5) Next weigh the leaf. How has the weight changed from the first time? Ask students what has caused these changes in the leaf.
6) Give each student (or group of students) a succulent leaf, a plastic knife, and magnifiers. Tell them to dissect the leaf to find the water storage areas.



Water Storage

This tissue can be differentiated only under high magnification, but the students will find evidence of water storage throughout the leaf. Specialized tissue, called *parenchyma*, is designed to expand when the spaces between the cells fill up with water.

Activity 3.5

Made for Heat: *Compare transpiration levels among plants adapted to different habitats*

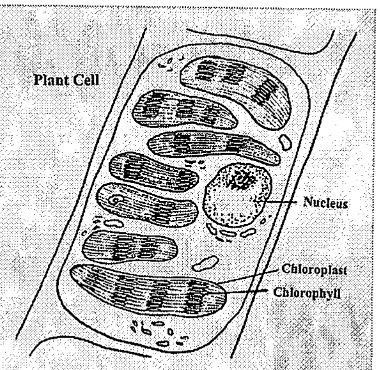
Before Activity

Gather materials:

- __ 1 small potted cactus with spines
- __ 1 small potted succulent, such as bryophyllum or aloe
- __ 1 small potted broad leaf plant, such as coleus or geranium
- __ 3 large sandwich baggies
- __ masking tape
- __ graduated cylinder or a medicine measuring vial

During Activity

1) Show the class the three different plants and have them discuss the differences among them. Ask students what kinds of habitats they think the plants are adapted for. Explain that you are going to conduct a small ex-



Transpiration

Transpiration is the loss of water vapor through stomata on leaf surfaces.

periment to see which plant is best adapted for a hot climate.

2 Water the soil of all three plants. Use a paper towel to cover the soil as a barrier, so any captured evaporation comes from the plant and not the soil.

3) Put a clear plastic baggie over each plant. As much as possible, prevent the baggie from touching the plant. Seal the baggie closed around the pot with masking tape.

4) Place all three plants in a sunny window in the morning.

5) In the afternoon, have students look at the amount of water collected in the plastic bags covering each plant. Ask them to identify which plants produced the most, middle, and least amounts of water. Where did the water come from? Have them measure the amount of water with a graduated cylinder or a medicine measuring vial.

6) Explain the process of transpiration. Ask students what differences might have affected the water loss in each plant. What habitats have the different plants adapted to?

Activity Extension: Leaves Let Loose

Look for two trees on your school grounds: one with large, thin leaves and one with thick, small leaves. Both trees should have morning sun exposure.

1. Early in the morning, put a large, clear plastic bag over a branch on each tree and tie it closed. Try to put the same number of leaves in each bag.
2. After several hours, check the bags.
3. Carefully remove both bags from the trees, making sure to retain all moisture. Shake the moisture off the sides and down into the bottom of the bags.
4. Cut a small hole in one bag and drain it into a graduated cylinder.
5. Record the amount of transpiration water. Repeat with the second bag.

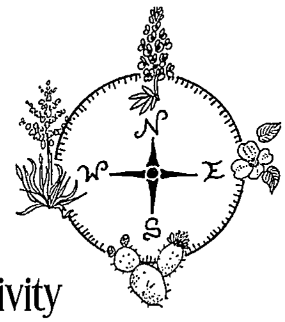
Which tree has lost less moisture? (The tree with the smaller leaves should lose less water from its smaller and thicker leaves.) Ask students what kind of climate the tree with smaller leaves has adapted to.

Tell students that plants often respond to lack of water or dry seasons by dropping leaves. This prevents a large loss of water through the leaf openings used for gas exchange. The fewer the number of leaves, the smaller the area of possible water loss. Ask the students to watch their neighborhood trees for heavy leaf shedding in the summer. Where do they think these landscape trees would be found naturally?

Lesson 4:
Plant structures and adaptations help plants survive in their habitats

ACTIVITY 4.1

Botany-by-Compass:
Search for specific plant adaptations



Before Activity

Gather materials:

- __ 6 sets of *Botany-by-Compass Direction Cards*, pages 56-58
- __ 6 compasses
- __ 6 hand lenses

- In order to create this game for your students, you will need to visit your field trip site in advance with a compass (not necessary if you are coming on a field trip to the Wildflower Center). Use the list of directions on the *Botany-by-Compas Direction Cards* from the Wildflower Center for ideas (pages 56-58).
- Produce *Botany-by-Compass Direction Cards* using example from the Wildflower Center (pages 56-58). Create clues to orient students around an outdoor area using compasses. Make sure that all teams will end at the same location. Cut and glue each clue onto an envelope that can fit inside a larger envelope. Complete a set that has at least four envelopes that fit inside each other in the order that the clues are presented.

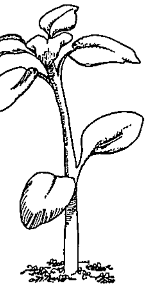
During Activity

1) Divide the class into six teams of students.
2) Show students how to use a compass:

   Hold the compass case level to allow the needle to swing freely in the case and hold it far enough away to avoid interference from metal objects, such as belt buckles.

   Stand so the compass is in front of you and you are facing the direction the needle is pointing.

   Align the red tip of the needle with N (north) within the double arrows. Straight in front of you is magnetic north (which is slightly below the North Pole). To your right is east, to your left is west, and to your back is south.
3) Hand out a compass to each team and allow time for each team member to find magnetic north.
4) Pass out a hand lens and instruction packet to each team. Each packet should contain five instruction cards, so have students alternate jobs for each card (reading the card, reading the compass, locating the directions on the grounds, using the hand lens, and answering the question).



During Your Field Trip

While on your field trip, your class will:

- *search for specific plant adaptations*
- *look for adaptations that help plants obtain more resources or avoid predation*
- *construct rainwater collectors and test their effectiveness*
- *locate and record micro-habitats that favor certain plant adaptations.*

Teaching Tip

To make optimal use of your time, assign students to teams before your field trip.

Teaching Tip

Send a chaperone to wait at the end point (far entrance of the Theme Gardens if you are at the Wildflower Center). All of the teams' final instructions will send them there.

When all teams have completed this activity, collect all instruction packets and compasses (but not the hand lenses). Then lead students to the Courtyard.

Teaching Tips for the Wildflower Center

- *If at the Wildflower Center, do this activity in the courtyard.*
- *Tell students the information they learn about plant structures will be their "ticket" into the Visitors Gallery, where they can look at exhibits.*
- *After reminding students of garden etiquette, the boundaries of this activity (the plantings in the Courtyard), and where the water fountain and bathrooms are located, have them begin their search.*
- *Stand at the door to the Visitors Gallery (or assign a chaperone). Ask students to report the types of plant parts they discovered. Collect the Plant Structure Search cards and hand lenses from them as they go into the gallery. Be prepared for students to lean over the Courtyard spring! Assign a chaperone to supervise that location.*
- *In the gallery encourage students to discover all the ways humans can take advantage of native plant adaptations. Tell them to listen to the talking lawn mower and view the video.*
- *Have students find answers to the following questions:*
  Would the sugar maple tree live in the Sonoran Desert? Why?
  What are three types of ecosystems in North America? Which one do you live in?
  In what environment are insect-eating plants found? Why do the plants need the insects?
- *When students have fully explored the Visitors Gallery, lead them downstairs to the classroom.*

ACTIVITY 4.2

Plant Structure Search:
Look for adaptations that help plants obtain more resources or avoid predation

Before Activity

Gather materials:

__ *Plant Structure Search List*, page 59

- If you are not coming to the Lady Bird Johnson Wildflower Center, create *Plant Structure* cards by laminating index cards from the *Plant Structure Search List*. You may want to add clues depending on the plant species at your field trip site.
- Make copies for each student pair.

During Activity

1) Give each student pair one *Plant Structure Search* card.
2) Have students read the cards and come up with specific things they will search for in the area.
3) Have students begin their search. After ten minutes, ask them to report the types of plant parts they discovered.

Stayin' Alive

Plants have evolved many ways to get the necessary nutrients, water, and sunlight, as well as ways to avoid being eaten.

Leaf Modifications

Plants that grow in the shade tend to have leaves that are thinner and have fewer hairs than those that grow in the direct light. Shade leaves also tend to be larger to increase the surface area available to capture the limited sunlight.

Desert plants may have thick, leathery leaves, succulent leaves, or no leaves at all. Their leaves may be covered in dense hairs, have a thick cuticle, or even an extra layer of cells (*hypodermis*) beneath the epidermis. These modifications help the plants store and conserve water and/or reduce water loss.

Other leaf modifications include tendrils, which help a plant climb and keep it anchored to a supporting structure; spines, which reduce water loss and also prevent animals from eating the plant; specialized leaves, called *bracts*, which attract pollinators; and the insect-trapping leaves of carnivorous plants.

Stem Modifications

The stems of some plants have become specialized over time. Horizontal, underground stems called *rhizomes* are often modified for storage, while their aboveground counterparts, *stolons*, are modified for reproduction. Johnson grass is an example of a plant that has a rhizome, while strawberries produce stolons.

Tubers are stems that have been modified for storage. Potatoes are good examples of tubers. *Corms*, such as gladiolus bulbs, are almost completely stem tissue and also store food. *Bulbs* are actually large buds with a small stem at the bottom surrounded by large fleshy leaves. Onions are a great example.

Root Modifications

In addition to their primary function of anchorage and water absorption, some roots are modified for special functions. Some roots are modified for food storage while others store water. *Pneumatophores* are roots that rise above the water surface and allow trees with their roots under water to "breathe." Cypress knees are an example of pneumatophores.

Aerial roots perform a number of different functions, including absorbing extra water (*velamane roots*), providing additional support (*prop roots*), and photosynthesis (*photosynthetic* roots of orchids).

ACTIVITY 4.3

Water Harvesting: *Construct rainwater collectors and test their effectiveness*

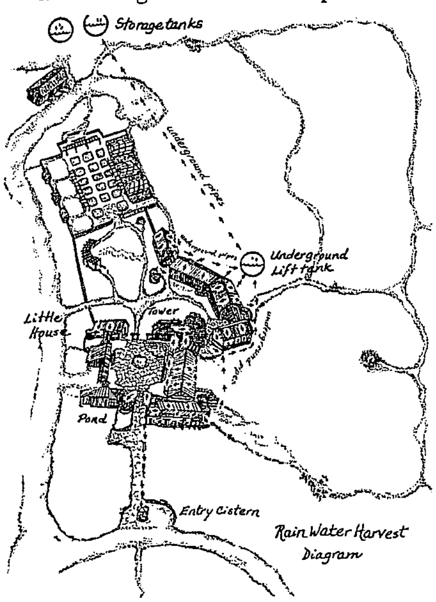
Before Activity

Gather materials:

- __ 6 aluminum baking pans
- __ 6 bags of equipment (including foil, transparency, cups, straws, craft sticks, clothes pins, modeling clay, and cistern cup)
- __ 6 pairs of scissors
- __ sprinkling water can
- __ measuring cup and graduated cylinder
- __ *Lady Bird Johnson Wildflower Center Rainwater Harvesting Map*, page 60

During Activity

1) Have students gather into their original six teams.
2) Review with students what they have learned about how plants have adapted to conserve water. (For example, cactus roots collect and hold water across a large area for reserves during dry times.) Point out that humans have taken cues from nature to solve their water supply problems. The Lady Bird Johnson Wildflower Center, for instance, gathers falling rain water across large areas of rooftops and holds

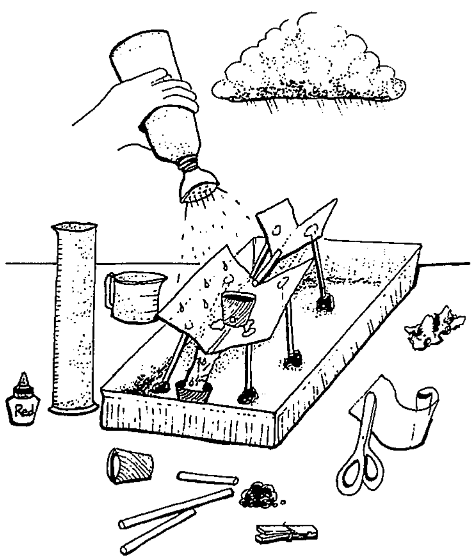


Teaching Tips for the Wildflower Center

- *Have students tidy up their work areas and put the scissors and other materials near the sink. Ask a chaperone to stay in the classroom to disassemble the rainwater collectors and pour out the water.*
- *Before leaving the classroom, decide which trail students will use for Activity 4.4 (Habitat Mapping)—either the Meadow Trail or the Forest Trail—and pick up the appropriate maps.*
- *Lead students to the trailhead of the Nature Trail, under the Breezeway. Encourage students to notice the overhead water troughs and roof collectors as they walk around the Wildflower Center during the rest of their visit.*

it in cisterns to use for irrigation during dry weather. (Make an overhead of the diagram on page 60 to show students the flow of rainwater collection at the Wildflower Center.)

3) Give each team a pan, a pair of scissors, and an equipment bag. Explain that each team will use the materials in the equipment bag to construct a rainwater collector for their baking pan (which represents a piece of land). Their challenge is to direct as much water as possible into the cistern cup (included in the equipment bag).
4) Allow 15 minutes for the teams to construct their water collectors. While students are working, measure one cup of water and pour it into the sprinkling can. Before using the sprinkling can in the activity, try it out to get a feel for how the water spreads out
5) Select one team's rainwater collector to be tested first. Simulate a rainstorm by sprinkling water evenly over the entire pan from several feet up. Have the



students estimate the amount of water collected in the cistern cup before pouring it into the graduated cylinder to measure.
6) Repeat the test for each team. After all the collectors have been tested, ask students to identify the features that made some collectors better than others.

ACTIVITY 4.4

Habitat Mapping: *Locate and record microhabitats that favor certain plant adaptations*

Before Activity

Gather materials:

__ clipboards

__ pencils

__ blank paper

__ 2 thermometers (only 2 thermometers are in the Wildflower Center backpacks; your school may be able to provide 6 thermometers or 1 per group).

__ 6 compasses

__ *Trail Map*, page 61

- Create a map of the trails you will follow during your field trip. Look at the Wildflower Center's map for examples of landmarks and the legend for student searches.

During Activity

1) Have students gather once again into their teams. Each student on a team must perform one of the following jobs:

   cartographer, who is the mapmaker recording information on the trail map

   botanist, who records identifiable plants

   entomologist, who records insects or evidence of insects

   zoologist, who records birds, mammals, and reptiles seen on the trail

   geologist, who records land forms and rock types

   climatologist, who records general weather conditions and microhabitat conditions

2) Give each team a compass and a trail map. Have students study the map key for items they will be looking for on the trail.
3) Explain that each team member will be responsible for recording different information during the trail walk, depending upon their job. Give every student a pencil, a clipboard, and (except for each team's cartographer, who records on the map) blank paper for recording information from the trail walk. Proceed on the trail.
4) At the appropriate location on the trail, ask climatologist students to place the two thermometers in the grassland and wooded habitats marked on the maps (each team's climatologist should read the thermometer for their group). Allow the students time to sit and add map details as they wait for each thermometer to register a stable temperature. Have them compare the temperatures of the two habitats.

Teaching Tips for the Wildflower Center

- *Be sure you picked up the trail maps for this activity in the classroom.*
- *Return to the classroom. Let the class take a bathroom/drinking fountain break. If there is time, allow the students to illustrate their maps.*
- *The habitat maps are yours to keep. Leave the Field Study Pack, clipboards, and other materials neatly in the classroom before returning to the School Group Picnic Area.*

After Your Field Trip

To follow up on your field trip, your class will:

- *explore the effects of human communities on plant communities*
- *invent a plant according to the rules for plant patenting.*

Lesson 5:

Human communities affect plant communities

ACTIVITY 5.1

Past Destruction: *Explore the effects of human communities on plant communities*

Before Activity

Gather materials:

__ an essay describing man's impact on plant communities. Some suggested essays include:

"Earth's Green Mantle," from *Silent Spring* by Rachel Carson

"The Lay of the Land" from *Noah's Garden* by Sara Stein

"The Loss of Diversity" by Paul R. Ehrlich from *Biodiversity*, edited by E.O. Wilson

- Photocopy a class set of the chapter.

During Activity

1) Give each student a copy of the essay to read.
2) Have students write a paragraph or two explaining what the changes were. Ask them to explain how man has broken nature's cycle of adaptation.
3) Is there a plant native to the local habitat that is considered a pest by land managers? Discuss with students the possible consequences if that particular plant species is eliminated. Examples: Mesquite, bastard cabbage, carizo cane, salt cord grass, cedar ashe trees, etc.

"No Return" of the Native

A regular sequence of events occurs to ensure that the most fit plant produces seeds for the next generation of plants. This system of natural selection has worked well with changing climates and environments when the changes have been localized or slow and measured.

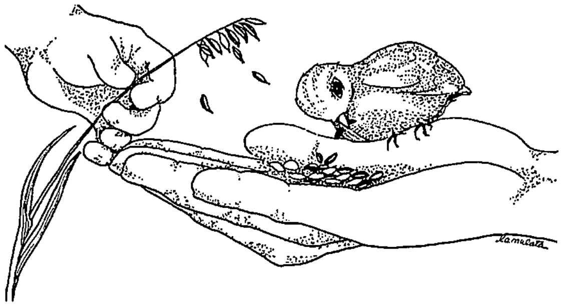
However, humans have caused large changes in the landscape during the last hundred years and natural selection cannot keep up with them.

For thousands of years, Central Texas was a savannah dominated by native grasses with pockets of oaks and junipers. It was partially maintained by Indians who set fires to promote useful plants and to aid in hunting. As ranching and agriculture began to grow and spread, natural fires were suppressed. As a result, woody trees and shrubs dominated Central Texas, and the grasslands slowly diminished. The grass species were unable to keep up with a continually changing environment and could not compete with the woody species, which were able to cope with the disturbances that ranching and farming created.

Activity Extension: Save the Species!

Get students involved!

- Arrange for a guest speaker from a university/college/nonprofit organization who can talk about plant conservation to speak to the class.
- Have students write letters to plant conservancy organizations to request information about their programs.



- Check out the Internet for web sites where students can learn about conservation programs and share their findings with the class.
- Start a small seed banking class project: Have students collect a few seeds from several native plants, then clean and store them. The Wildflower Center can provide information and help on setting up a seed banking program like this.

The Latrine Factor

Scientists have been affecting natural selection for many years in order to improve our food supply. They "unnaturally" select favorable traits from different plant populations—originally through breeding but now often through genetic manipulation—to make crops that better resist freezing or insect damage, as well as producing a larger yield (for example, more grain or larger fruit).

But long before scientists got involved, humans played a role in natural selection for the plant species they ate through a process called the "latrine factor." Here's how it worked:

Early people—gatherers and hunters—moved their camps to take advantage of foods in season. When they returned to earlier encampments, they found plants growing from the (undigested) seeds left in the latrine area. Since these seeds came from the largest and best plant food the people could collect, they produced bigger and better seeds and fruits—which were again collected, with the biggest and best fruits and seeds eaten first.

Over time, the plants growing in these fertilized areas changed enough until they became genetically different from the truly wild populations of their species. This is evolution.

Teaching Tip

The bag of colored squares represents all the existing plants of a rare plant species. Each square represents a plant and each color stands for a useful genetic trait in the plant population. When population numbers drop, some of these useful traits are lost.

ACTIVITY 5.2

Bottleneck: *Discover the impact of genetic diversity when large populations are eliminated*

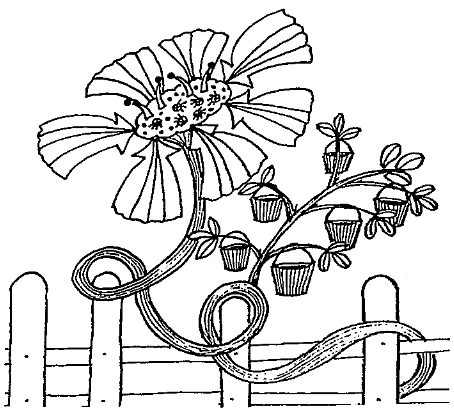
Before Activity

Gather Materials:

- __ 16 different colors of paper, 2 sheets each
- __ paper bag
- __ *Human Impact Cards* (see below)
- __ Scotch tape

During Activity

1) Separate the duplicate colored sheets into two different stacks of 16, reserve one stack for use later. Divide the stack of 16 into two piles of 8. Cut out five 2 x 2-inch squares from one stack of 8, and fifteen 2 x 2-inch squares from the other stack of 8. There will be a total of 160 squares.
2) Mix the 2 x 2-inch squares and put them into the paper bag.
3) Copy and cut out the *Human Impact Cards* (see next page). These cards describe different activities by people that negatively affect plant populations. Loss of habitat, loss of pollinators, overharvesting, climate change, and exotic species introduction are all brought about by human activities.
4) Introduce the idea of genetics. Every living thing has in each of the smallest of their cells a set of blueprints containing instructions for that entire organism. This is where the idea of cloning comes from.
5) Practice naming plants for traits they possess. Tell the children they can help invent a very rare plant, and they can help describe it. Does it have big or little flowers? Does it smell sweet or stinky? How tall does this plant grow, and what color are its blooms? Once the plant characteristics are decided upon, have the children help name the plant. The first part of the name is the genus, a Latin word that might describe the plant, such as big "punciceus." It was discovered by their principal, or other favorite adult, so the scientific name would include that person's name in the species slot. (As an example; if Mr. Berkman discovered the plant, it could have a scientific name *berkmanii.* The invented plant might be named *Puncicea berkmanii.*)



6) Show the class the reserved stack of 16 colored sheets. Each of these colors represents a special trait of the plant that might help it grow in a different place. Have the children name some characteristics and draw pictures to help identify the colors with these traits:

   Big leaves, small leaves, thorny stems, antifreeze, dark green leaves, light gray leaves, grows low to the ground, grows tall, catapults seeds, extra seeds, another color of petals, pointed leaves, fuzzy leaves, smell that attracts bugs, smell that repels bugs, big roots, a landing platform.

7) Hang the 16 colored sheets at the front of the room with tape.

8) Ask a student to read a *Human Impact Card*, and have other students remove the squares from the paper bag without looking. The students cannot select certain colors to remove.

9) When all the direction cards are read, and the squares removed, show how many plants are left in the population. To find out if there are any colors missing from the final population, hand out the remaining squares and have the children tape their squares on the matching color hanging sheet of paper. Remove those colors that had no squares left in the bag. If the plant population had help from humans and grew to 1 million plants next year, would those missing traits come back? What was lost in this bottleneck of low numbers?

Human Impact Cards

Road cuts through main population Remove 10 squares	New housing development Remove 20 squares
Pasture overgrazed Remove 10 squares	Junior High plant collection Remove 5 squares
Teacher picks a flower Remove 1 square	Climate warms up Remove one-half of all the squares
Goats pastured on 4 fields Remove 10 squares	Crop duster sprays for bugs, removes bees Remove 10 squares
Introduced butterfly larvae eats plants Remove 30 squares	Unusual flooding soaks ground, seeds rot Remove 10 squares

Plant Patents

With increased concern about world hunger and the other side effects of overpopulation, many plant biologists have turned their attention to developing new and more useful plant varieties. Many of these new varieties are issued a plant patent by the government. A *plant patent* is granted by the government to a person who has invented, discovered, or asexually reproduced a distinct and new variety of plant. The patent lasts 20 years and protects the inventor's rights to the plant. This means that no one else can grow or sell the plant without the approval of the original inventor. Examples of patented plants include the 1015 onion and maroon bluebonnets.

For more information on plant patents, visit www.uspto.gov.

"A Rose is a Rose"... or is it?

The classification system used to name plants can be traced back to the great Swedish botanist Carolus Linnaeus. In the late eighteenth century, Linnaeus devised the binomial system of nomenclature in which every plant is given a two-part name consisting of a genus name and species name.

While botanical names seem somewhat ancient and can sometimes be difficult to say, they are also very descriptive and say a lot about the plant. For example, *Lupinus texensis* is the botanical name for the Texas bluebonnet. *Lupinus* comes from the Latin word "*lupus*" which means "wolf." This is because early botanists observed that lupines grow in areas that typically have very poor soils. They thought that the plant was "eating" the nutrients out of the soil much like a wolf would eat sheep from a flock. The species *texensis* describes the place the plant was first identified or described from. Many other botanical names have similar origins.

The Naming of Plants

To help students grasp the concept of plants' scientific names, provide them with the scientific names of some familiar native plants and explain what the names mean. Then invite students to give the common names of the plants.

Castilleja indivisa (Indian paintbrush): The genus name honors the Spanish botanist Juan Castillejo; the species name *indivisa* means "undivided" and refers to the entire leaves.

Echinacea purpurea (Purple coneflower): *Echinacea* comes from the Greek word *echinos*, which means "hedgehog," and refers to the stiff, sharp-pointed chaff that sticks out of the flower head.

Aquilegia canadensis (Columbine): *Aquilegia* comes from the Latin for "eagle's claws" and *canadensis* is the place it was first identified or described.

Some common botanical terms:

Acaulis: stemmed
Bicolor: two-colored
Contortus: twisted
Digitatus: finger-shaped
Erectus: upright
Filiformis: thread-like
Glabrous: smooth
Hirsuite: hairy
Lyratus: lyre-shaped
Mulitflora: many-flowered
Nitens: shining
Odoratus: with an odor, smelly
Pumilis: dwarf, small
Quadrifolius: with four leaves
Reptans: creeping
Simplex: unbranched
Tomentosus: felty
Uniflorus: one-flowered
Vulgaris: common
Zebrinus: zebra-stripped

Natural Selection

Natural selection is the main engine of evolution—but not the only one. There are those variations that arise from neutral selection, in which the gene survives and endures in populations due to sheer chance, not by any benefit it conveys. This happens in times of catastrophe, when large portions of the population are lost mostly by chance and not by lack of survival abilities. Those individuals remaining create a founders effect, guaranteeing that a large percentage of the population offspring will contain their genes, whether of extra benefit or not. This bottleneck, with its reduced gene variability, is thought to be a likely location of punctuated equilibrium, the giant steps of evolution rather than the small, incremental changes.

Appendix 1: Booklist

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

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Appendix 2: 1.1 Pea Patch Game Directions

Adaptation and Plant Populations

A bee visits your field of flowers, looking for pollen to collect. Plant pollen sticks to the bee's knees and travels on the bee to the next flower it visits. In this fashion, the bee helps make certain that flowers are pollinated as part of the process that makes seeds and future plants.

Place 10 red pea plant beads on the pea patch field. Place 10 white pea plant beads on the pea patch field. The bee notices the white flowers first and visits most of them. The bee also visits the red flowers, but does not see them as well and visits them less often.

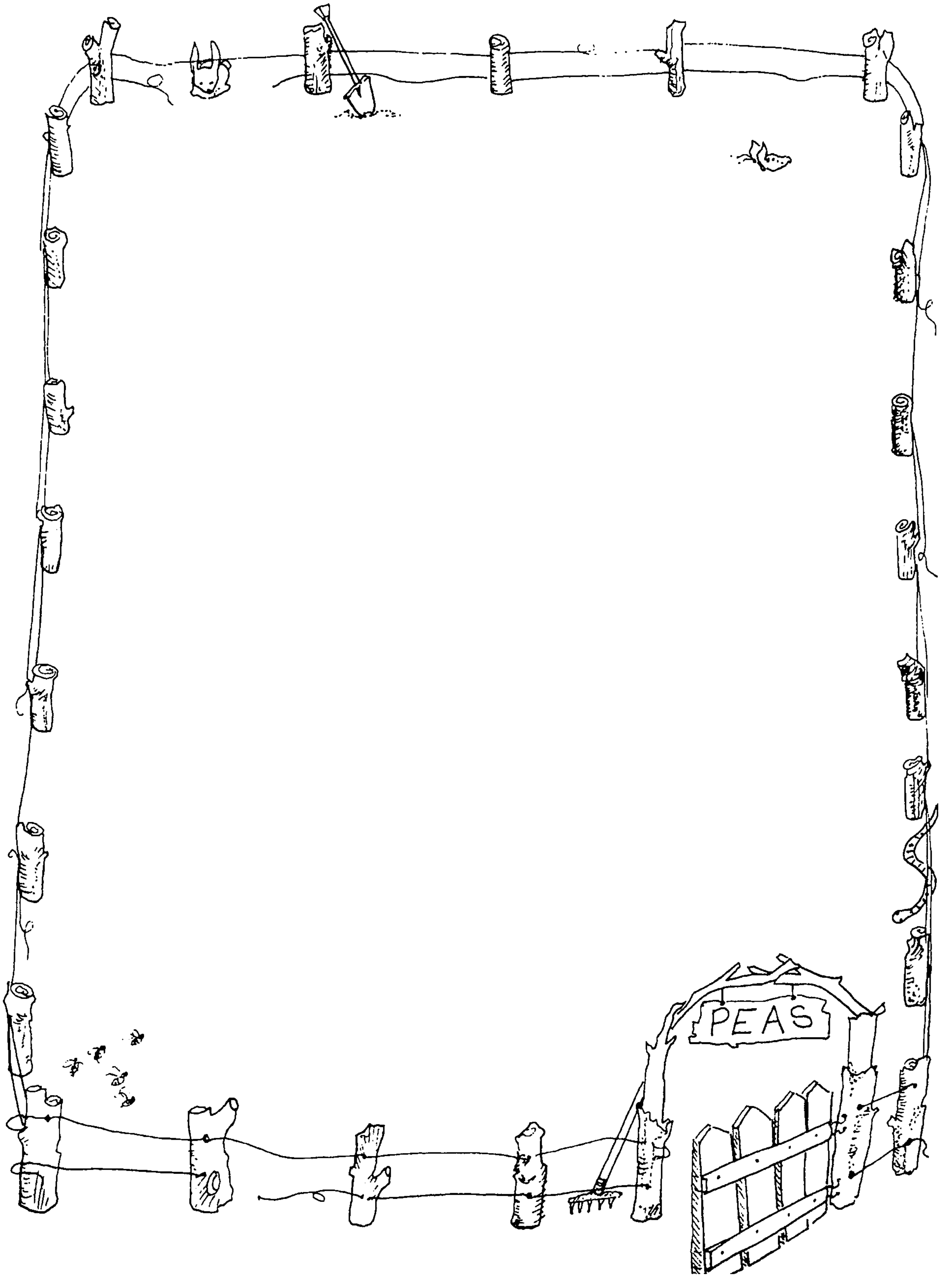
Record the number of flowers in Year 1 on the data table. In the first spring, the bee pollinates 8 white flowers. How many white flowers does the bee miss? Two white flowered plants go unpollinated. Twice as many red flowers are missed, so the bee misses 4 red flowers and pollinates 6 red flowers. Record the number of pollinated pea flowers.

The flowers produce seeds and die. Remove all the beads from the field during the winter season. Every plant that was pollinated produces two offspring, so for Year 2 return twice as many beads for each pollinated plant.

In the spring of Year 2, 16 white and 12 red-flowered plants grow. Of these flowers, the bees once again miss some of the white and twice as many of the red flowers. Four white flowers were missed, leaving 12 flowers visited by the bee, and 8 red flowers did not get visited by the bee, who pollinated just 4 red flowers. Year 2 will have 12 white flowers with 24 offspring, and 4 red flowers with 8 offspring.

Continue playing the game through 10 years of bee pollination, deciding how many white flowers are to be missed and how many are pollinated each season. Some seasons may have a surplus of bees because a winter is unusually warm or a farmer brings in a beehive, and some seasons will have fewer bees to do the pollination because of an increase of predators, such as skunks or severe weather. Record the number of red and white flowers each season, the number of flowers pollinated, and the number of offspring produced on the data table.

1.1 Pea Patch Field



1.1 Pea Patch Data Table

Year	White Flowers	Red Flowers	Pollinated White Flowers	Pollinated Red Flowers	White offspring	Red offspring
1	10	10	8	6	16	12
2	16	12	12	4	24	8
3						
4						
5						
6						
7						
8						
9						
10						

1.2 Pea Plant Pollen

r	r	r	r	r	r
r	r	r	r	r	r
r	r	r	r	r	r
r	r	r	r	r	r
r	r	r	r	r	r
r	r	r	r	r	r

1.2 Pea Plant Eggs

R	R	R	R	R	R
R	R	R	R	R	R
R	R	R	R	R	R
R	R	R	R	R	R
R	R	R	R	R	R
R	R	R	R	R	R

1.2 Directions for Making Pea Plant Cards

1. Make 1 photocopy of the short pea plants illustrations page on cardstock.
2. Make 3 photocopies of the tall pea plants illustrations page on cardstock.
3. Cut out each pea plant picture along the lines. Set aside one short and four long stemmed pea plant pictures. These are extra and will not be used.
4. Color the pea plant pictures as follows:

Long-stemmed pea pictures:	*Short-stemmed pea pictures:*
8 cards with red flower, yellow peas	4 cards with red flower, yellow pea
4 cards with red flower, green pea	2 cards with red flower, green pea
4 cards with white flower, yellow pea	2 cards with white flower, yellow pea
2 cards with white flower, green pea	1 card with white flower, green pea

5. Make 1 photocopy of the Genetic Letter Codes page.

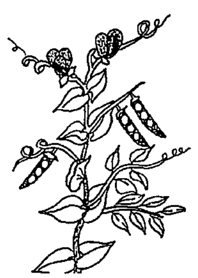
Genetic Letter Codes Key:

RR = red flowers	YY = yellow peas	LL = long stems
Rr = red flowers	Yy = yellow peas	Ll = long stems
Rr = white flowers	yy = green peas	ll = short stems

These genetic letter codes indicate plant characteristics such as flower color, pea color, and stem length. Capital letters (for example R, Y, and L) indicate dominant characteristics. These characteristics will be visibly expressed in the plant as red flowers, yellow peas, and long stems any time they are present. Recessive characteristics (for example r, y, and l) are visibly expressed in the plant only when two recessive genes are present. For example, rr, yy, and ll will be expressed as white flowers, green peas, and short stems.

6. Cut out each of the genetic letter codes together with its corresponding description of plant characteristics.
7. Match each genetic letter code and description with its appropriate colored pea plant picture.

For example, any ONE of the following genetic letter codes would match correctly to the following picture.



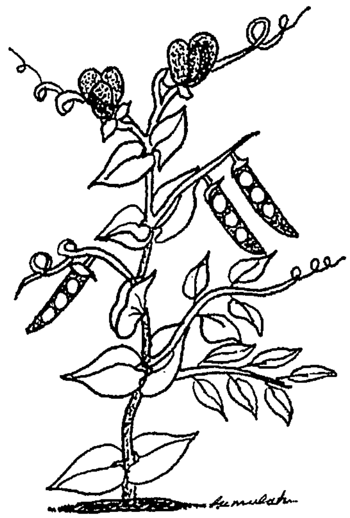
Red flower, short stem, yellow pea

RRYYll
RRYyll
RrYYll
RrYyll

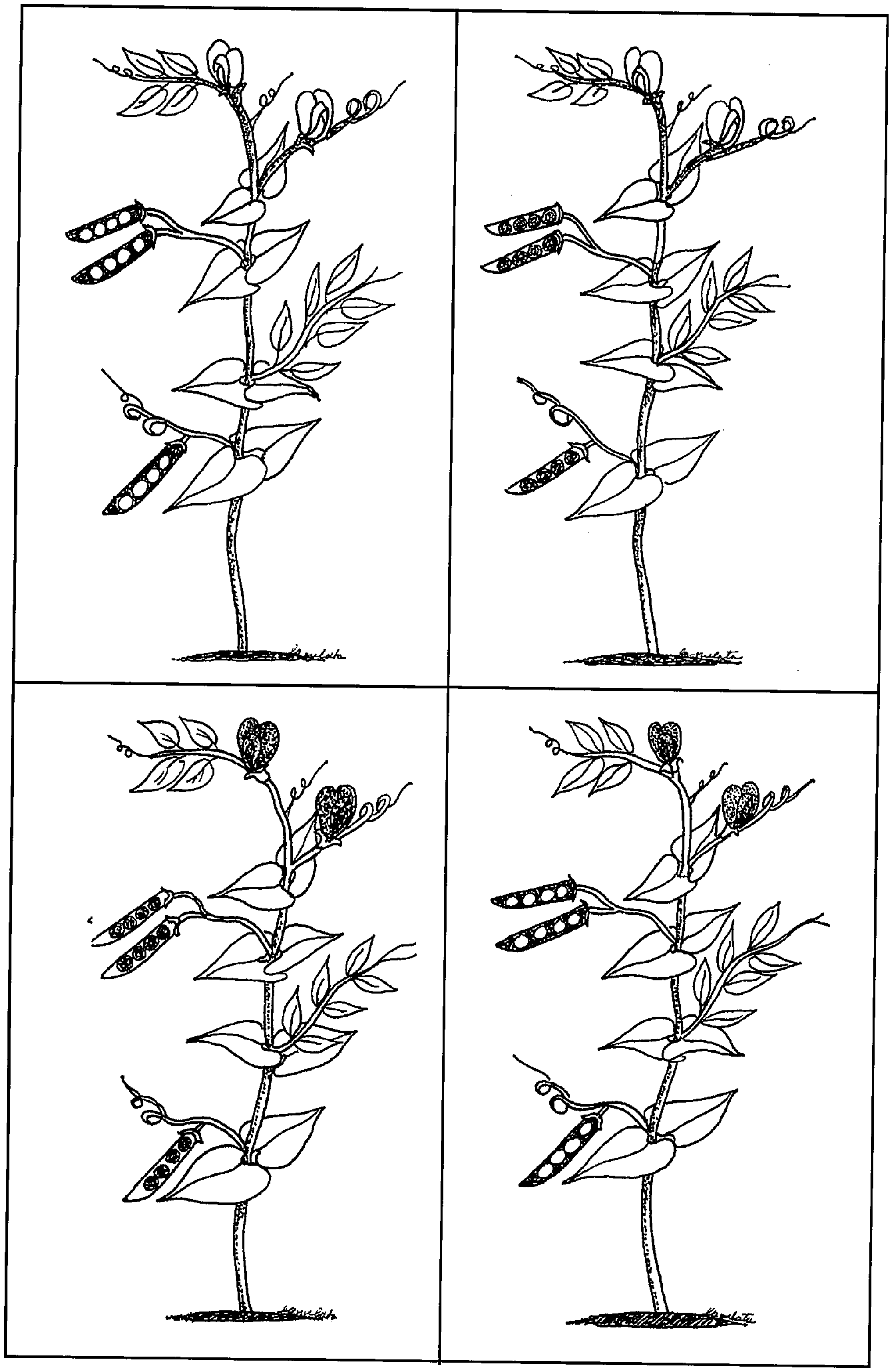
NOTE: Only one genetic letter code and characteristics set should be glued to each colored picture matching those characteristics.

8. Cards may be laminated for future use.

1.2 Pea Plant Cards



1.2 Pea Plant Cards



1.2 Pea Plant Gene Shuffle

Red Flower   White Flower

Red Flower + White Flower = Red Flower

Red Flowers
RR

Rr

White Flowers
rr

RR =

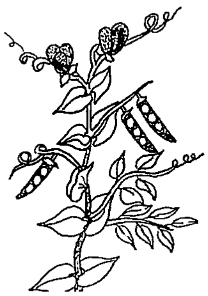
Rr =

rr =

1.3 Family Ties Worksheet

The pea plants studied by Gregor Mendel had a variety of colors and shapes. He studied flower color and seed color. Below are pictures of two pea plants with their descriptions and genes.

Red Flower (Rr)
Green Peas (yy)



Red Flower (Rr)
Yellow Peas (Yy)

RR and Rr = Red flower
rr = white flower

YY and Yy = yellow pea
yy = green pea

1. Which pea color needs two matching genes before it can be seen in the plant? ________________

   Is this the dominant or recessive pea color? ________________________________

2. These pea plants pollinated each other's flowers. The possible combination for the seeds are:

   RRYy ________________________ Rryy ________________________

   RrYy ________________________ RRyy ________________________

   rrYy ________________________ rryy ________________________

   Write the characteristics, or phenotypes, for each of the possible combinations.

3. Look at your pea plant card. What traits do you have? What traits do your seeds have?

PLANT PART	Plant Phenotype YES NO	Seed Phenotype YES NO
Flower	Red	Red . . . .
	White	White . . . .
Pea	Yellow	Yellow . . . .
	Green	Green . . . .
Size	Long stemmed	Long stemmed . . . .
	Short stemmed	Short stemmed . . . .

1.3 Genetic Letter Codes

RrYyLl
Red flower, Yellow pea, Long stem

RrYyLL
Red flower, Yellow pea, Long stem

RrYyll
Red flower, Yellow pea, short stem

RrYYLl
Red flower, Yellow pea, Long stem

RrYYLL
Red flower, Yellow pea, Long stem

RrYYll
Red flower, Yellow pea, short stem

RryyLl
Red flower, green pea, Long stem

RryyLL
Red flower, green pea, Long stem

Rryyll
Red flower, green pea, short stem

RRYyLl
Red flower, Yellow pea, Long stem

RRYyLL
Red flower, Yellow pea, Long stem

RRYyll
Red flower, Yellow pea, short stem

RRYYLl
Red flower, Yellow pea, Long stem

RRYYLL
Red flower, Yellow pea, Long stem

RRYYll
Red flower, Yellow pea, short stem

RRyyLl
Red flower, green pea, Long stem

RRyyLL
Red flower, green pea, Long stem

RRyyll
Red flower, green pea, short stem

rrYyLl
white flower, Yellow pea, Long stem

rrYyLL
white flower, Yellow pea, Long stem

rrYyll
white flower, Yellow pea, short stem

rrYYLl
white flower, Yellow pea, Long stem

rrYYLL
white flower, Yellow pea, Long stem

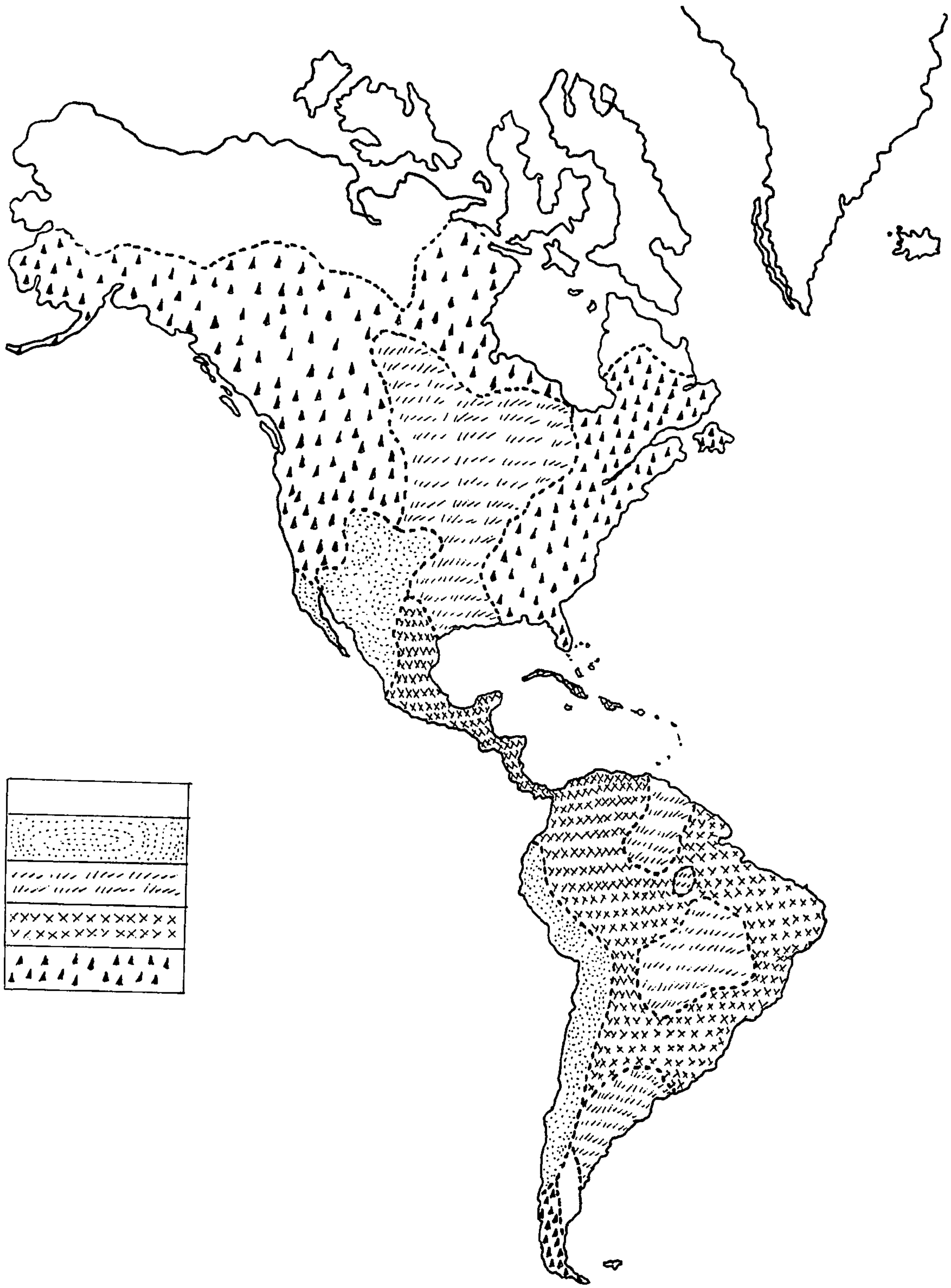
rrYYll
white flower, Yellow pea, short stem

rryyLl
white flower, green pea, Long stem

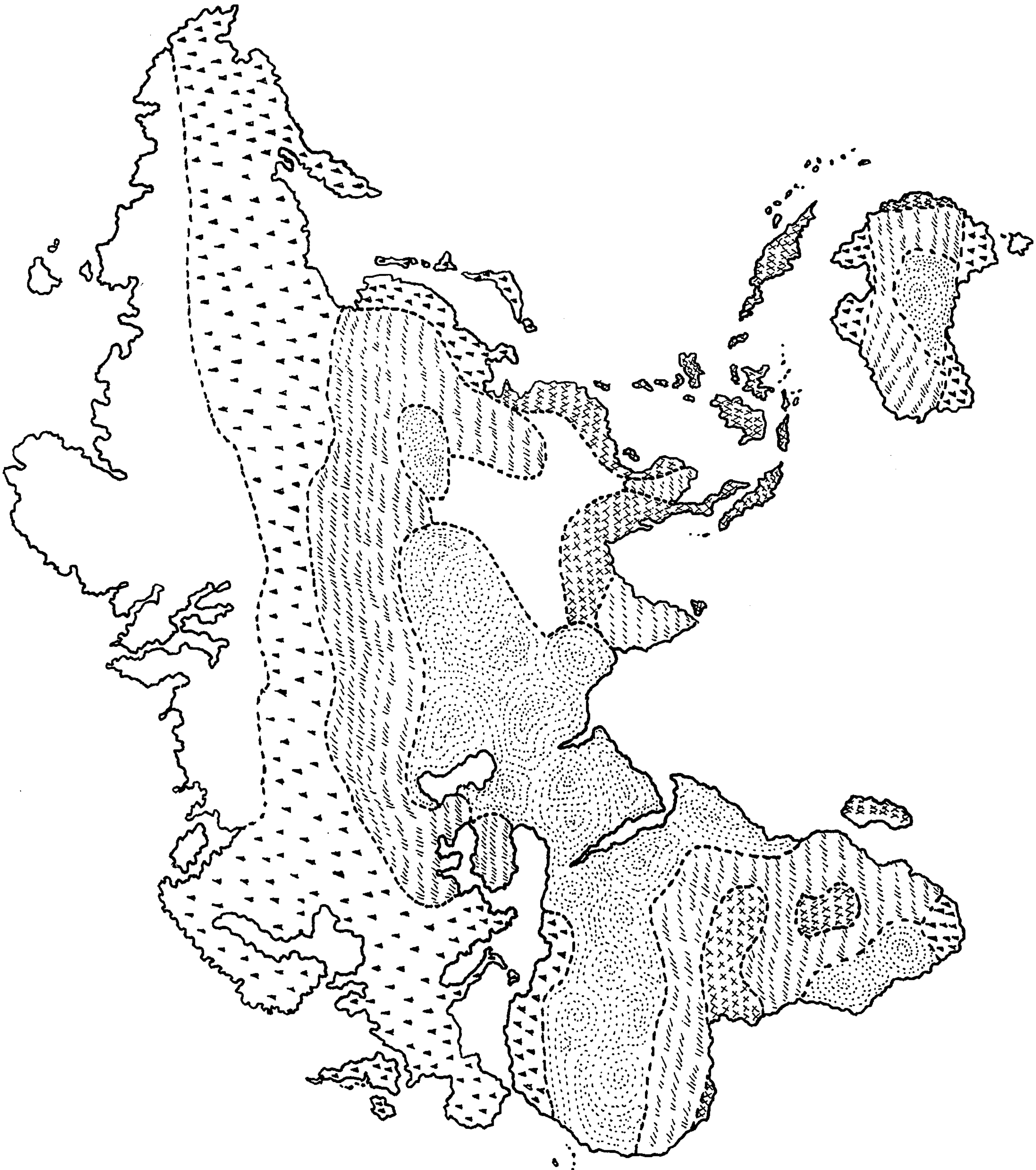
rryyLL
white flower, green pea, Long stem

rryyll
white flower, green pea, short stem

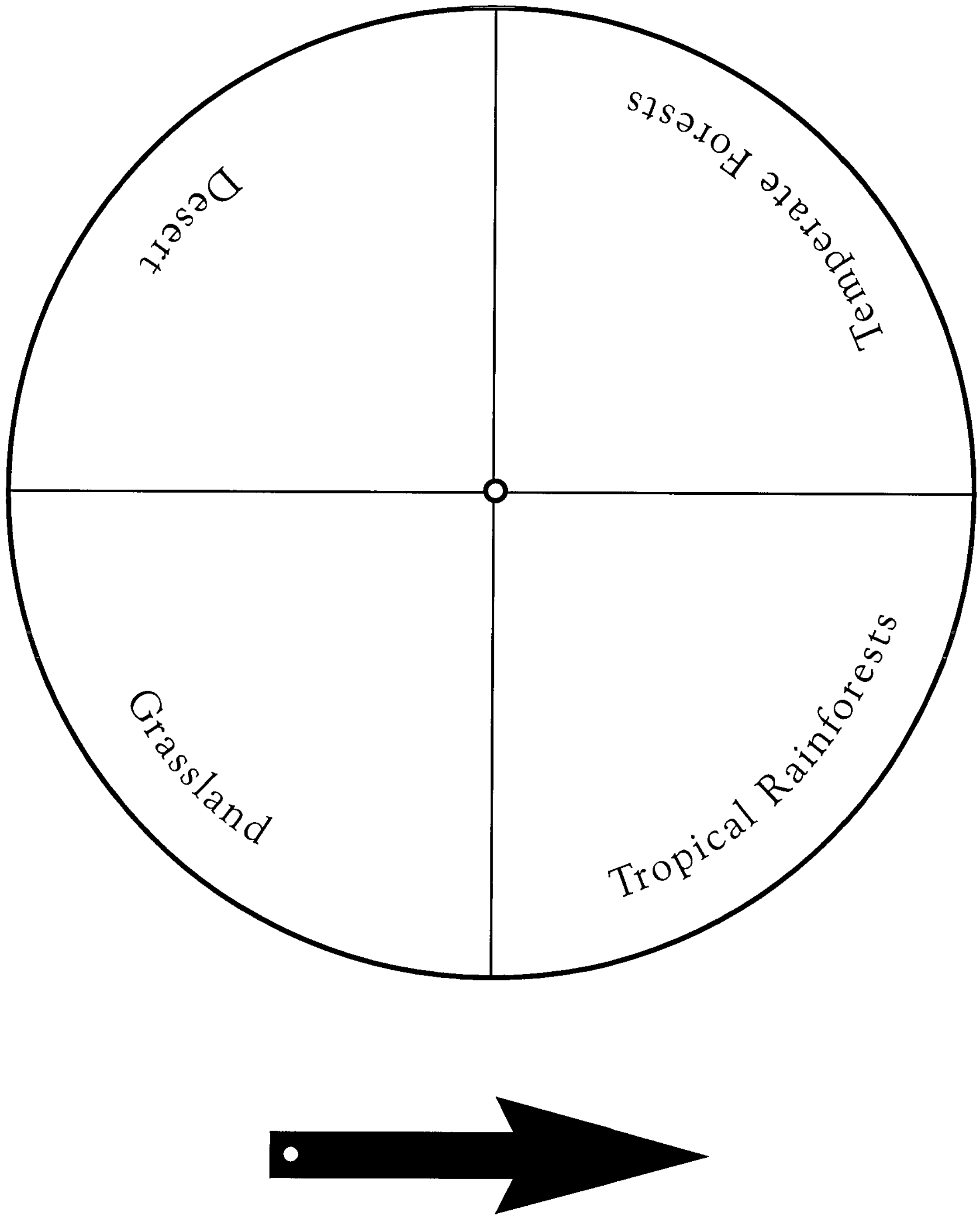
2.1 World Habitat Maps



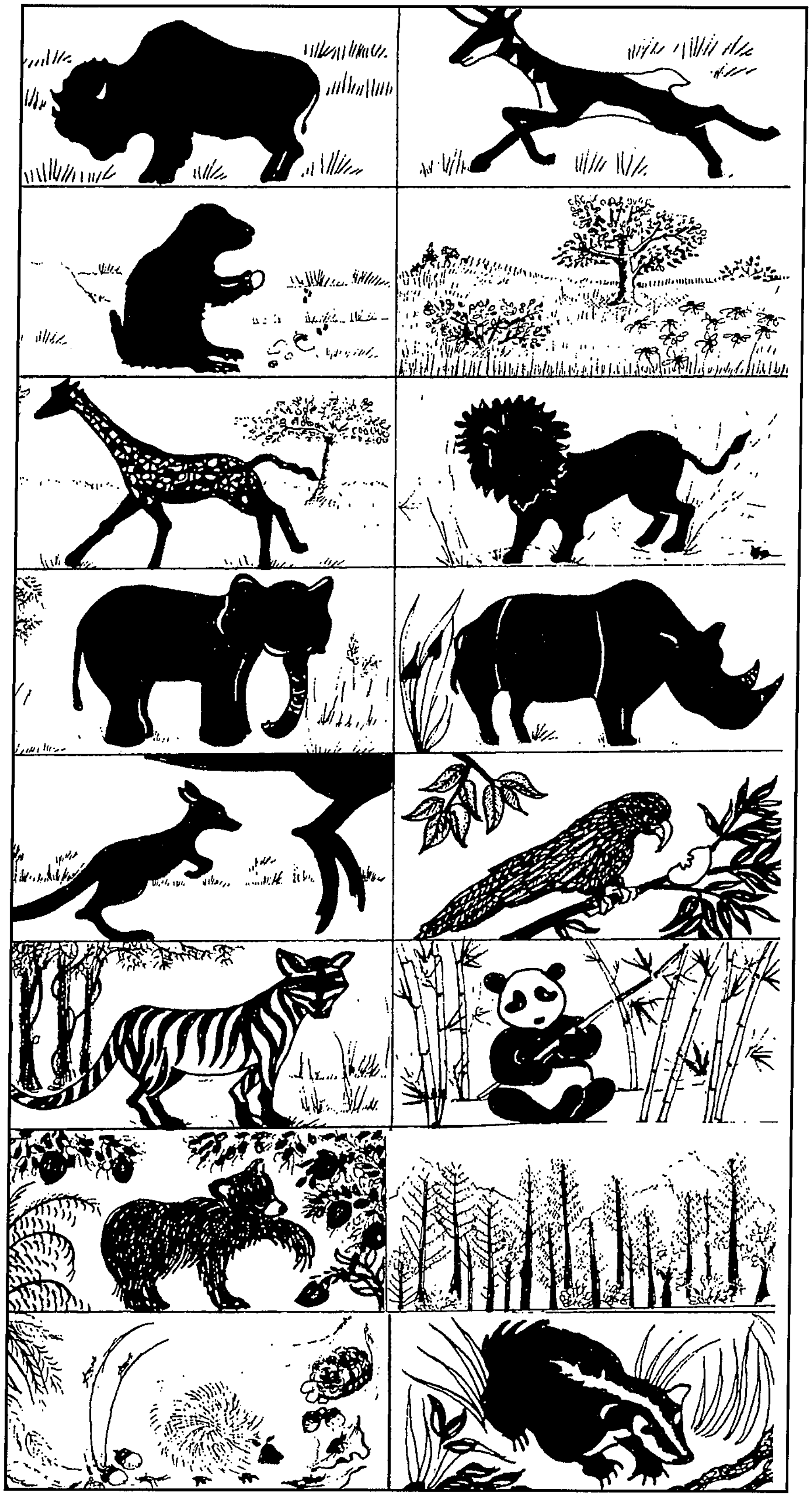
2.1 World Habitat Maps



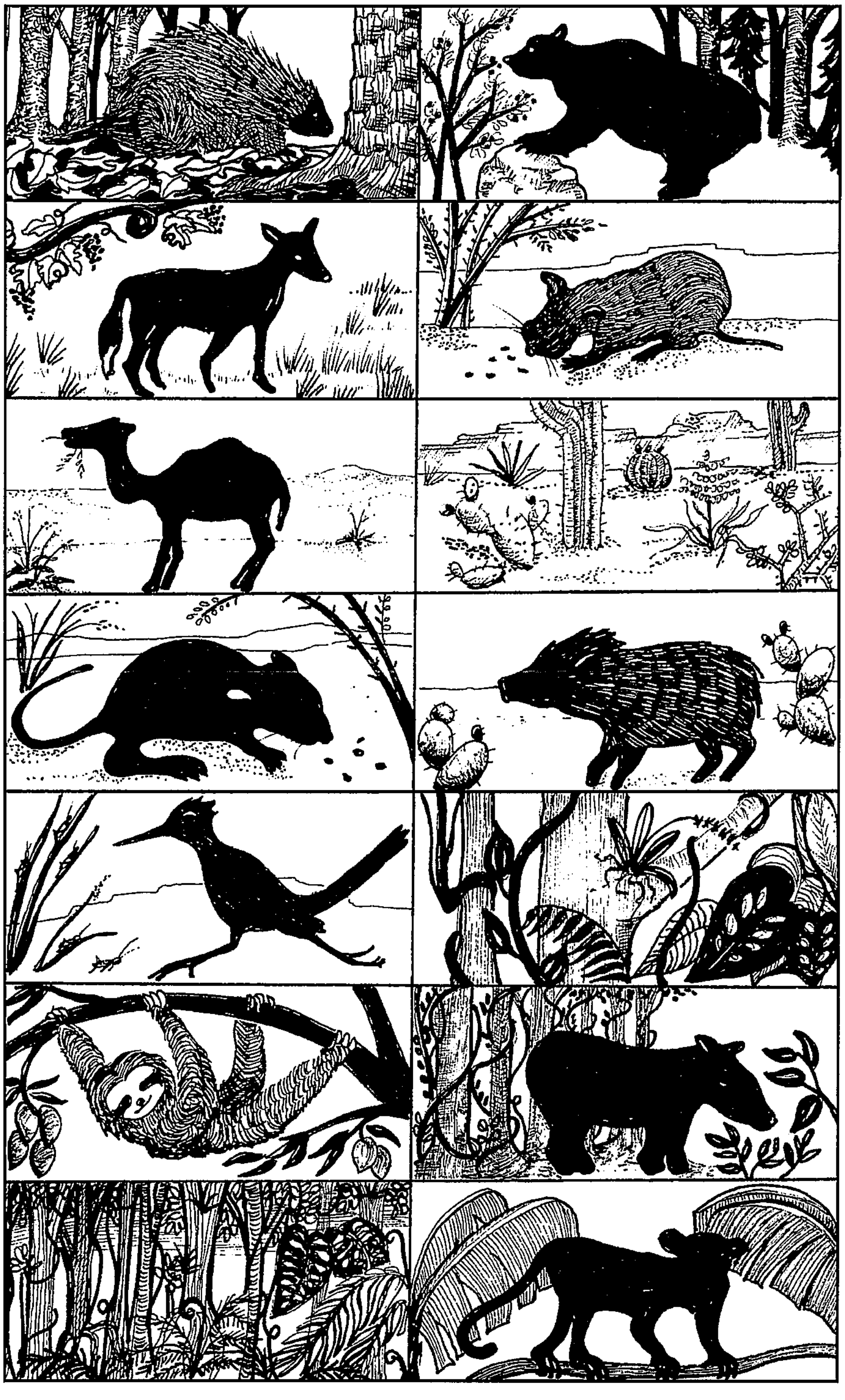
2.1 Spinner


Desert
Temperate Forests
Grassland
Tropical Rainforests

2.1 Plant and Animal Habitat Cards



2.1 Plant and Animal Habitat Cards



2.3 World Climate Worksheet

City and Country	Average yearly rainfall	Ranked
Lima, Peru	36mm	2
Brisbane, Australia	1092mm	
Bombay, India	2078mm	
Reginia, Canada	394mm	
Little Rock, Arkansas, USA	1236mm	
Perth, Australia	889mm	
Cairo, Egypt	25mm	1
Rochambeau, French Guyana	3744mm	
Montreal, Canada	971mm	
Phoenix, Arizona, USA	183mm	3
Athinai, Greece	402mm	
Ankara, Turkey	512mm	

1. Organize the data in a table with the rainfall in order of least to most.

2. Locate the cities on a class map first and then the approximate location on the *World Habitat Map*. List each city under its habitat type.

DESERT	FOREST	GRASSLAND	TROPICAL RAINFOREST

3. What are the lowest and highest amounts of rainfall, or the **rainfall ranges** in each habitat type?

4. How many average **inches** of rainfall does Phoenix, Arizona, receive each year? (Note: 1 inch of rain= 25.4 millimeters)

2.4 Predicting Weather Using Clouds and Wind

You will improve your accuracy by learning about the types of clouds and how the wind affects the weather with each kind. *There are only three basic cloud formations: cirrus, stratus, and cumulus.*

Cirrus, from Latin, meaning "curled." These are high ice clouds in an otherwise clear sky, from 20,000 to 40,000 feet. You see them as feathery "mares' tails," long curling clouds that are the tops of thunderheads off beyond the horizon.

With cirrus clouds overhead:

1) If the wind is anywhere from the northeast around through east to the south, you can expect rain in the next 24 hours.
2) If the wind is anywhere from the southwest around through west to the north, good weather will remain another 24 hours.

Stratus, from Latin meaning "spread out." These are low clouds, a uniformly gray overcast from near ground level up to about 8,500 feet. They always predict unpleasant weather.

With stratus clouds overhead:

1) If the wind is from the northeast around to the south, you can count on heavy rain in the next 24 hours.
2) If the wind direction is from any other direction, you can count on a continued overcast for the next 24 hours, with no rain or at the worst a slight drizzle.
3) If the cloud cover has a slightly billowing look, you have "strato-cumulus" clouds. This type of cloud allows you to predict immediate rain.

Cumulus, from Latin meaning "heap." These are low clouds at 1000–2000 feet, the heaped-up fluffy white clouds scattered in a blue sky.

With cumulus clouds overhead, it never rains, unless:

1) The wind shifts to the east, or
2) the clouds build up into towering black clouds with winds from the west, forming the classic thunderheads sometimes shaped like an anvil (cumulo-nimbus clouds).

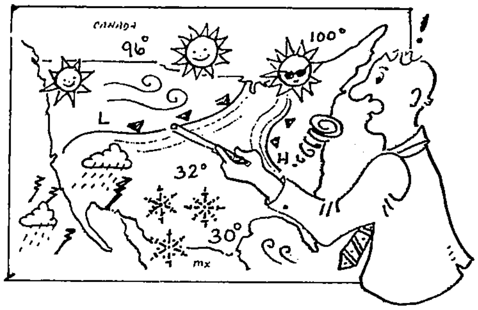
Wind Weather Forecasting

NORTH	cold weather is coming
SOUTH	warm weather is coming
EAST	rain is coming, no matter what the cloud cover is at the moment
WEST	clear weather is coming, no matter what the cloud cover is at the moment

2.4 Forecasting Folklore

Here are a variety of weather forecasting proverbs to predict weather changes:

- A ring around the sun or moon means rain or snow coming soon.
- A warm summer means a cold winter, a dry spring means ample summer rainfall; a windy autumn is followed by a mild winter.
- The first frost in autumn will be exactly six months after the first thunderstorm of the spring.
- A rainbow in the morning is the shepherd's warning; a rainbow at night is the shepherd's delight.
- Red sky at night, sailor's delight; red sky in morning, sailor take warning.
- Clouds on the setting sun's brow indicate rain.
- Evening red and morning gray; a good sign for a fair day.
- Pale moon rains, red moon blows; white moon neither rains nor blows.
- If wasps build their nests high, the winter will be long and harsh.
- It will be a cold, snowy winter if:
  Squirrels accumulate huge stores of nuts.
  Beavers build heavier lodges than usual.
  Hair on bears and horses is thick early in season.
  The breastbone of a fresh-cooked turkey is dark purple.



- Wild geese fly high in pleasant weather and fly low in bad weather.
- Cockroaches are more active before a storm.
- Ants are very busy, gnats bite, crickets are lively, spiders leave their nest, and flies gather in houses before a rain.
- If garden spiders forsake their webs, it indicates rain.
- If spiders are many and spinning their webs, the spell will soon be very dry.
- Spiders enlarge and repair their webs before bad weather.
- On woolly bears, if the brown stripe is wider than the black stripes, the winter will be long and harsh.
- If bees stay at home, rain will soon come; if they fly away, fine will be the day.
- Dandelion blossoms close before a storm.
- If autumn leaves are slow to fall, prepare for a cold winter.
- When the leaves of trees turn over, it foretells windy conditions and possible severe weather.
- When the milkweed closes its pod, expect rain.
- The pitcher plant opens wider before a rain.
- Tulips open their blossoms when the temperature rises; they close again when the temperature falls.
- The daisy shuts its eye before rain.
- If the marigold should open at six or seven in the morning and not close until four in the afternoon, we may reckon on settled weather.
- When leaves show their undersides, be very sure that rain betides.
- If the perfume of flowers is unusually strong, expect rain.

4.1 Botany-by-Compass Direction Cards

A1—Travel NORTH to the big glass greenhouse. Many plants are adapted to the environmental conditions in their regions. What is the purpose of a greenhouse?	A2—Travel EAST to the garden with the short grass in it. 100 years ago huge grasslands, called prairies, covered the Midwest. What kind of animals depended on these grasses? (Hint: The name of this plant will give you a clue.)
A3—Travel NORTH EAST down the stairs to the lower garden. Stop. Travel NORTH WEST to the third garden on your left. These plants are adapted to dry regions. How do these plants keep animals from eating them?	A4—Travel SOUTH EAST up the ramp and stop at the first garden on your left. Find the live oak tree. This tree keeps its leaves all year round. Why would this be an advantage for the tree?
A5—Travel NORTH to the first garden on your left. All the plants in this garden attract songbirds. What part of the plant would songbirds eat?	B1—Travel NORTH EAST to the stone patio in front of the entryway. Stand in the center of the patio, walk WEST until you find a patio stone that contains a fossil. It is 70 million years old. What do you think the plants looked like back then?
B2—Walk down the WESTERNMOST ramp. Stop. Travel NORTH WEST to the farthest garden on your left. All the plants in the garden attract songbirds. What part of the plant would the songbirds eat?	B3—Travel SOUTH EAST and climb the steps to the upper gardens. Stop at the fence. Go to the garden directly WEST of you. Find the live oak tree. This tree keeps its leaves all year round. Why would this be an advantage for the tree?
B4—Travel NORTH WEST toward the shade house (between the two greenhouses). Stop under the covered walkway. Travel SOUTH WEST to the second bed on your left. These plants are adapted to dry, arid regions. How do these plants keep animals from eating them?	B5—Travel EAST to the fifth bed on the right. 100 years ago, huge grasslands, called prairies, covered the Midwest. What kinds of animals depended on these grasses? (Hint: The name of this plant will give you a clue.)

4.1 Botany-by-Compass Direction Cards

C1—Travel NORTH to the stone patio in front of the entryway. Start at the WEST corner. Count 6 stones to the SOUTH. The closest black rock might contain a fern plant from 80 million years ago. What type of habitat would a fern plant live in?	C2—Travel to the top of the SOUTH EAST ramp. Travel NORTH EAST to the 2nd garden on the left. Feel the leaves on the bush in the SOUTH WEST corner. How might their texture be helpful to the bush?
C3—Go to the bottom of the nearest ramp. From the bottom on the ramp, travel SOUTH WEST to the last garden on the right. This garden attracts birds and insects. What role do the birds and insects play in the plant's life?	C4—Go to the EASTERNMOST garden (you may have to go up the ramp). Look at the shrub in the NORTH corner. The seeds of this plant are poisonous. What other mechanisms might plants use to protect themselves?
C5—Go NORTH EAST to the 5th bed on the far left. Many of these plants grow tall in the spring but "die back" in the winter. What is the advantage to being short in the winter?	D1—Travel NORTH to the stone patio in front of the entryway. This patio contains numerous fossils. Can you find them? These fossils represent life from 70 million years ago. What do you think plants looked like 70 million years ago?
D2—Walk down the WESTERNMOST ramp. Travel NORTH WEST to the farthest garden on your left. All the plants in this garden attract songbirds. What part of the plant would the songbirds eat?	D3—Travel SOUTH EAST and climb the steps to the upper gardens. Stop at the fence. Go to the garden directly WEST of you. Find the live oak tree. This tree keeps its leaves all year round. Why would this be an advantage for the tree?
D4—Travel NORTH WEST toward the shade house (between the two greenhouses). Stop under the covered walkway. Travel SOUTH WEST to the second bed on your left. These plants are adapted to dry, arid regions. How do these plants keep animals from eating them?	D5—Travel EAST to the 5th bed on the right. 100 years ago, huge grasslands, called prairies, covered the Midwest. What kind of animals depended on these grasses? (Hint: The name of this plant will give you a clue.)

4.1 Botany-by-Compass Direction Cards

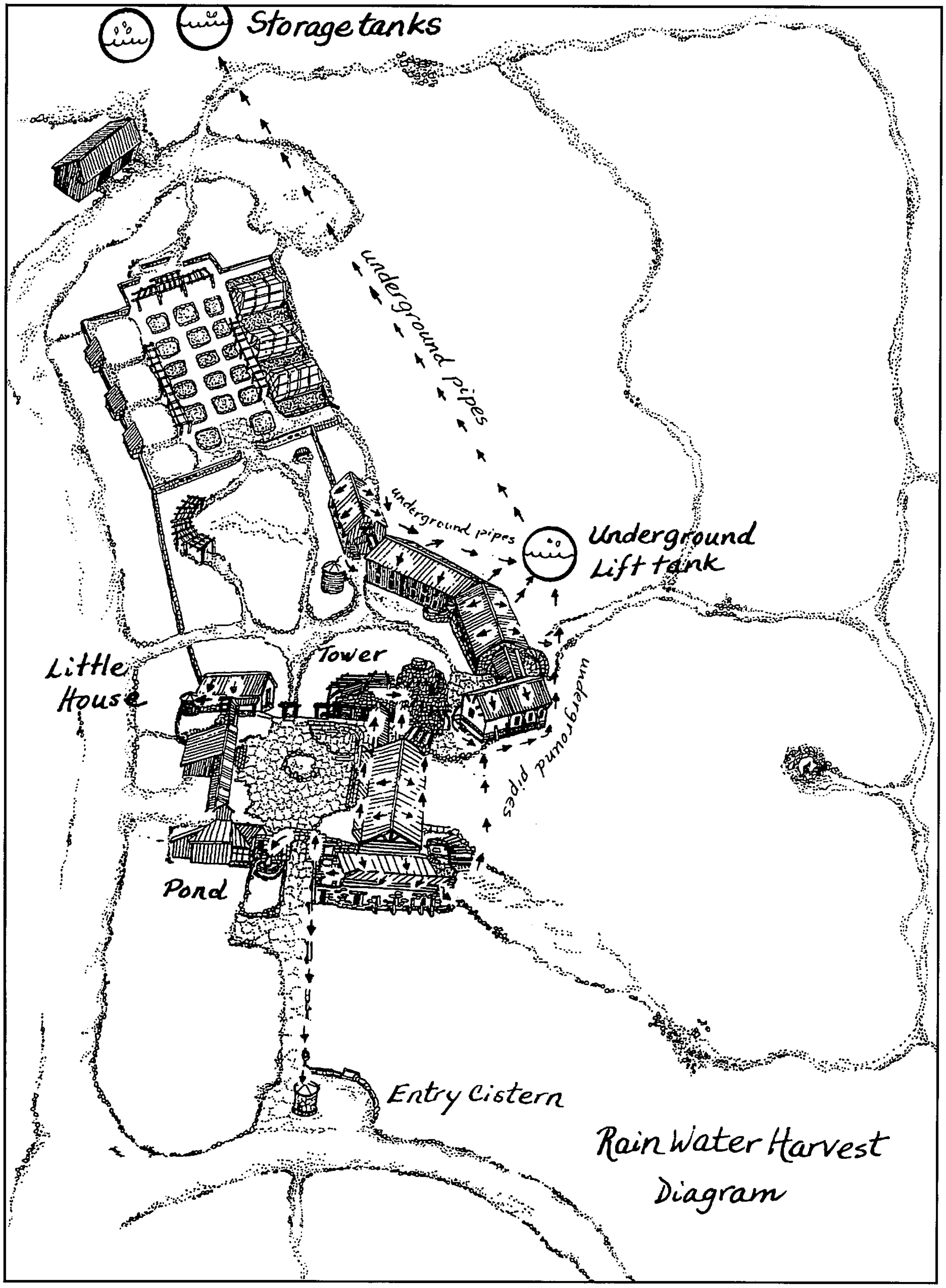
E1—Travel NORTH EAST to the very last bed. (Hint—almost to the wall.) Thinking back on all the plants that you've just seen, why would it be important to preserve such native plants?	E2—Go down the stairs to the WEST of this garden. Stop at the bottom of the stairs. Travel NORTH WEST to the 3rd bed on the right. Count the number of different grasses in this garden. Why do you think there are so many different kinds? Read the tags for help.
E3—Travel WEST to the next garden. These plants are native to this region. What types of adaptations might these plants have that help them live here?	E4—Go SOUTH EAST up the ramp to the upper gardens. Go to the first garden on your right. These plants are not native to North America. Look closely at these plants. What type(s) of habitat do you think these plants live in naturally?
E5—Travel NORTH to the stone patio in front of the entryway. This patio contains numerous fossils. Can you find them? These fossils represent life from 70 million years ago. What do you think plants looked like 70 million years ago?	F1—Travel NORTH EAST and stop at the wall. Travel SOUTH EAST to the garden on your right, just past the stone patio. Thinking back on all the plants that you've just seen, why is it important to reserve native plants?
F2—Travel NORTH EAST to the 4th garden on the left. Many of these plants grow tall in the spring but "die back" in the winter. What is the advantage to being short in the winter?	F3—Go down the closest ramp. Stop. Go to the garden in the WESTERNMOST corner. (Hint—near your original starting point.) This garden attracts birds and insects. What role do the birds and insects play in the plant's life?
F4—Travel NORTH EAST to the last upper garden. Look at the shrub in the NORTH corner. The seeds of this plant are poisonous. What other mechanisms might plants use to protect themselves?	F5—Travel SOUTH EAST up the ramp and stop at the first garden on your left. Find the live oak tree. This tree keeps its leaves all year round. Why would this be an advantage for the tree?

4.2 Plant Structure Search List

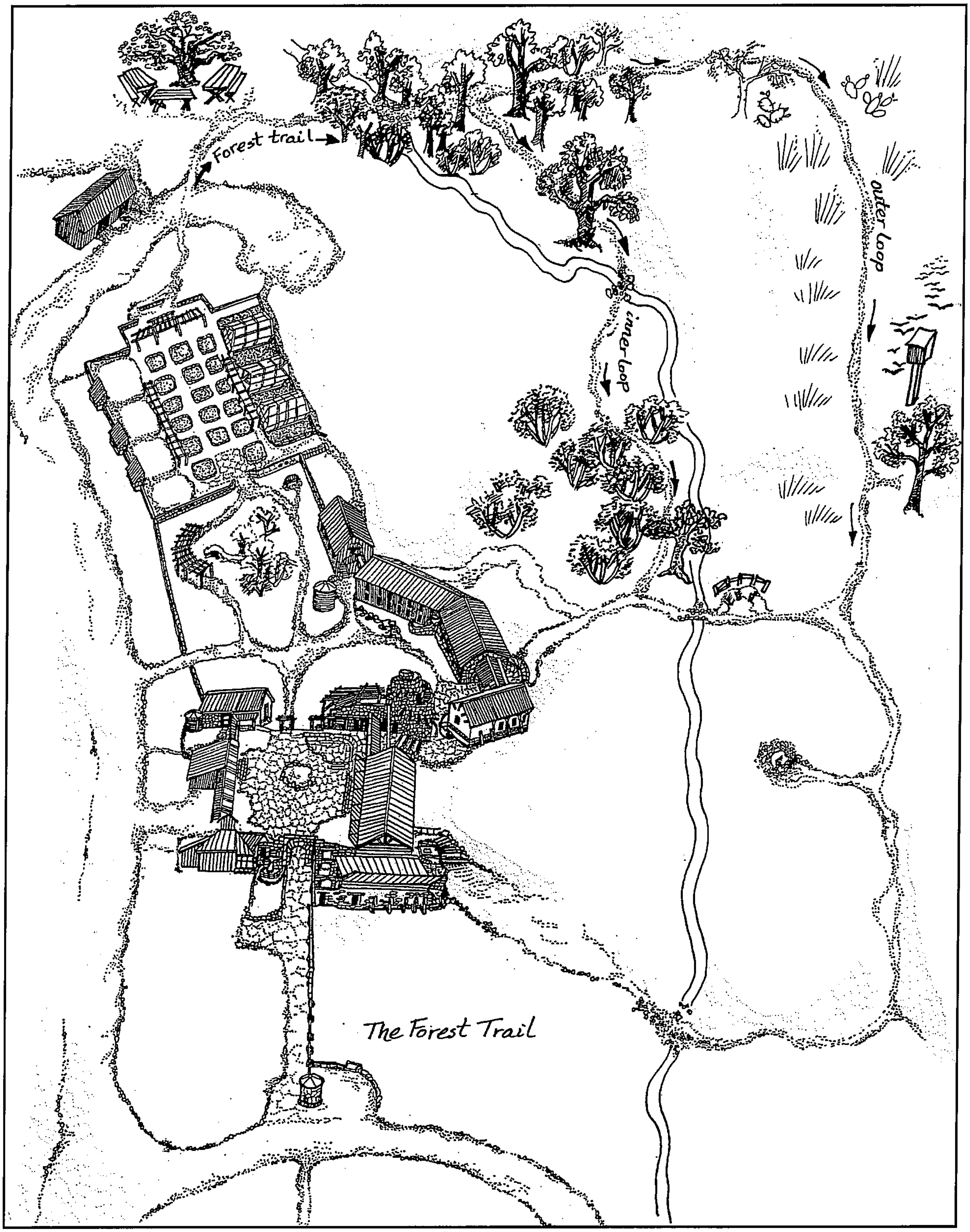
Find a plant structure:

1. Used by a plant to move toward the sun.
2. That helps a plant avoid losing water.
3. That enables a plant to travel short distances.
4. That increases a plant's chances of producing seeds.
5. That offers a plant protection from insects.

4.3 Lady Bird Johnson Wildflower Center Rainwater Harvesting Map



4.4 Lady Bird Johnson Wildflower Center Trail Map



Appendix 3: Texas Essential Knowledge and Skills

Lesson 1 — Plants pass traits to their offspring through genes.

Activity 1.1 Pea Patch Game: *Model changes in plant populations caused by patterns of pollination.*
TEKS: Science: 5.2B,C,E; 5.3C; 5.5B; 5.9A,B,C; 5.10A; 6.2B,C,E; 6.3C; 6.4B; 6.11A; 6.12C
Math: 5.1A; 5.3A; 5.5B; 5.6; 5.12B; 5.13A-C; 5.15A; 5.16A-B; 6.1A, C; 6.2A; 6.3B; 6.4A; 6.9B; 6.10A,D; 6.12A; 6.13A
Language Arts: 5.1A,C

Activity 1.2 Pea Plant Gene Shuffle: *Explore how characteristics are passed in genes from parents to offspring.*
TEKS: Science: 5.2B,C,E; 5.3C; 5.10A; 6.2B,C,E; 6.3C; 6.4B; 6.11A
Math: 5.1A; 5.3A; 5.5B; 5.15A; 5.16A; 6.1C; 6.2A; 6.3A-C; 6.10D; 6.12A
Language Arts: 5.1A,C

Activity 1.3 Tying It Together: *Draw conclusions about genetic characteristics.*
TEKS: Science: 5.2B,C; 5.3C; 5.5B; 5.10A; 6.2B,C; 6.3C; 6.11A
Math: 5.1A; 5.3A; 5.5B; 5.16A; 6.1C
Language Arts: 5.1A,C; 6.12A

Lesson 2 — Plant communities are adapted to an area's climate.

Activity 2.1 Habitat World: *Recognize the ways plant species are adapted to the world's four basic habitats.*
TEKS: Science: 5.5A,B; 5.9A,B,C; 5.12A; 6.12B,C

Activity 2.2 The Water Cycle and Weather: *Observe four physical processes of the water cycle.*
TEKS: Science: 5.1A, 5.2B,C; 5.3C; 5.4A; 5.5A,B; 5.6A,B; 6.1A; 6.2B,C; 6.3C; 6.4A; 6.14C
Math: 5.11A; 6.8B

Activity 2.3 The Climate Connection: *Identify precipitation patterns in different habitats.*
TEKS: Science: 5.2C,E; 5.3C; 5.5A; 5.6A; 5.11A; 6.2C,E; 6.3C; 6.14C

Activity 2.4 Weather Kids: *Use historical data, current trends, and folklore to forecast the weather.*
TEKS: Science: 5.2AB,C,D,E; 5.3A,B,C; 5.5A; 5.6A; 6.2A,B,C,D,E; 6.3A,B,C; 6.14C
Language Arts: 5.1A-C, 5.2A-D, 5.8 A-C; 5.9 A-C; 5.10A-C, H, J; 5.11A; 5.12C; 5.13B-D,G; 6.1A-C; 6.2A-F; 6.8B-D; 6.10A-E,H,J; 6.11A,C; 6.12B,E; 6.13C

Lesson 3 — Plant species must cope in harsh environments.

Activity 3.1 Plant Hiatus: *Observe the revival of a dormant plant.*
TEKS: Science: 5.2B,C; 5.6C; 5.9A,B,C; 6.2B,C; 6.12B

Activity 3.2 Cold Consequences: *Evaluate plant parts most vulnerable to freezing weather.*
TEKS: Science: 5.1A; 5.2B,C; 5.9A-C; 6.1A; 6.2B,C; 6.10A,B

Activity 3.3 Safety in Seeds: *Conduct experiments to compare the ability of plants and their seeds to cope with extreme conditions.*
TEKS: Science: 5.1A; 5.2A,B,C,D,E; 5.3A,C; 5.4A; 5.6C; 5.9A,B,C; 5.10A; 6.1A; 6.2A,B,C,D,E; 6.3A,C; 6.4A; 6.12B,C
Math: 5.11A; 6.8B

Activity 3.4 Fill 'er Up: *Measure the effects of water loss in succulent leaves.*
TEKS: Science: 5.1A, 5.2B,C,E; 5.4A, 5.5A, 5.6A,B; 6.1A, 6.2B,C,E; 6.4A; 6.12A,B,C
Math: 5.11A; 6.8B

Activity 3.5 Made for Heat: *Compare transpiration levels among plants adapted to different habitats.*
TEKS: Science: 5.1A, 5.2B,C; 5.4A; 5.5A; 5.6A,B; 6.1A; 6.2B,C; 6.4A; 6.12A,B,C; 6.14C
Math: 5.11A; 6.8B

Lesson 4 **Plant structures and adaptations help plants survive in their habitats.**

Activity 4.1 Botany-by-Compass: *Search for specific plant adaptations.*
TEKS: Science: 5.1A; 5.4A; 5.9A,B,C; 6.1A; 6.4A; 6.10A
Language Arts: 5.1A, 5.2A; 6.1A; 6.2A

Activity 4.2 Plant Structure Search: *Look for adaptations that help plants obtain more resources or avoid predation.*
TEKS: Science: 5.1A; 5.2B,C; 5.9A,B,C; 6.1A; 6.2B,C; 6.10A; 6.12A,B,C
Language Arts: 5.1A, 5.2A, 5.5F; 6.1A; 6.2A; 6.5F

Activity 4.3 Water Harvesting: *Construct rainwater collectors and test their effectiveness.*
TEKS: Science: 5.1A,B; 5.6B; 6.1A,B; 6.14B
Language Arts: 5.5E,F; 6.5F

Activity 4.4 Habitat Mapping: *Locate and record microhabitats that favor certain plant adaptations.*
TEKS: Science: 5.1A; 5.2B; 5.4A; 6.1A; 6.2B; 6.4A
Art 5.1A; 6.1A

Lesson 5 **Human communities affect plant communities.**

Activity 5.1 Past Destruction: *Explore the effects of human communities on plant communities.*
TEKS: Science: 5.1B; 5.2A,B,C,D,E; 5.3A,E; 5.9A,B,C; 6.1B; 6.2A,B,C,D,E; 6.3A,E; 6.12A,B,C
Social Studies; Geography: 5.9A-C; 6.7B

Activity 5.2 Bottleneck: *Discover the impact of genetic diversity when large populations are eliminated.*
TEKS: Science: 5.1A, 5.3C, 5.9A,B,C; 6.1A; 6.3C; 6.10A; 6.12A,B,C
Social Studies Geography: 5.2A-B; 5.9A-C; 6.2A; 6.7B

Activity 5.3 Save a Bucket: *Play a stewardship game.*
TEKS: Science: 5.1B; 5.3A; 5.5B; 6.1B; 6.3A
Social Studies Geography: 5.9A-C; 6.7B
Math: 5.3A