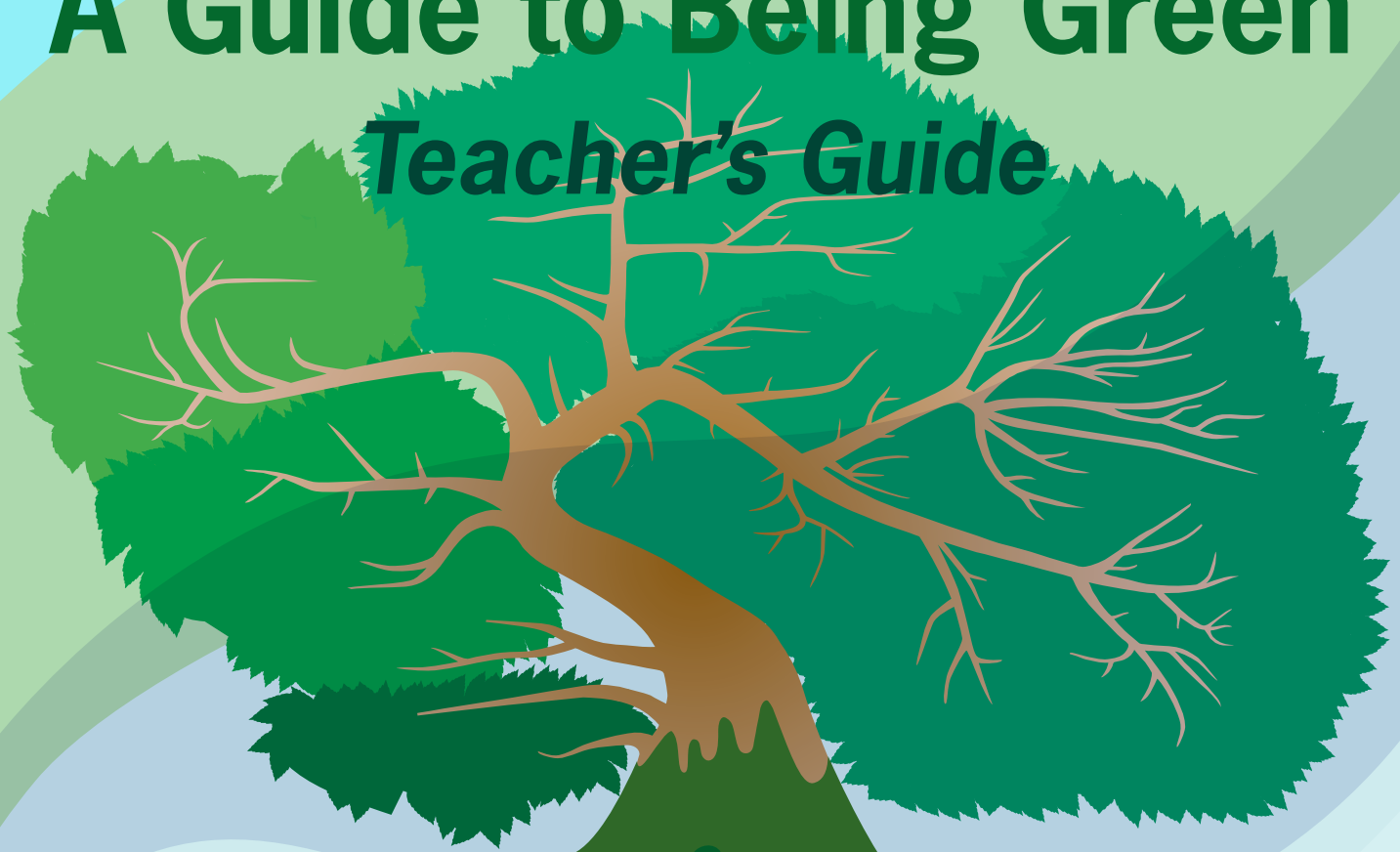
How Plants Work: A Guide to Being Green

Teacher's Guide



United States Botanic Garden
www.usbg.gov

Welcome

to the United States Botanic Garden!

How Plants Work: A Guide to Being Green will help your students explore four Big Ideas relating to plants. Through their investigations, your students will discover the intriguing life, structural design, adaptability, and resourcefulness of plants.

The Big Ideas

Your students will investigate four Big Idea topics as they venture into the Conservatory. While trekking though the different habitats, your students will discover living examples of how plants work and see each Big Idea in action.

1. **Are Plants Like Us?**
   Explore the phenomenal things plants can do and how thoroughly humans depend on them. Use the provided family tree to trace familiar plants back to their ancestral roots.

2. **A Puzzle of Plant Parts**
   Discover the many forms plants take as a result of being adapted to unique environments.

3. **Surviving Against the Odds**
   Learn to appreciate the incredible variety of ways in which plants meet their daily challenges (e.g., battling predators, surviving drought, finding enough light, etc.).

4. **Plant Multiplication**
   Explore reproductive cycles for four recognized plant groups: ferns (vascular, spore-producing plants), mosses (non-vascular, spore producing plants), gymnosperms (cone-bearing plants), and angiosperms (flowering plants).

Getting Started

How Plants Work is not about creating a list of facts and figures. Instead, the intent is to challenge students to explore, think, and come up with their own questions and conclusions about how plants work and the various ways plants impact human life.

How to Use This Guide:

Each Big Idea area is explored in this guide by:

- introducing the topic;
- presenting activities that enable students to explore the Big Idea topic throughout the Conservatory;
- providing students with a detailed exploration of each Big Idea topic via a "Dig Deeper" section; and,
- concluding with remarks and discussion points to help students summarize and reflect on their Big Idea-related learning experience.

Guidelines for Managing Your Class Visit:

1. Depending on your use of the Journal, allow anywhere from one to three hours for your visit.
2. Divide students into four groups (each group gets a Big Idea) and assign a chaperone to each group.
3. Provide the class with an introduction into each of the Big Ideas using the included Introductory Lesson.
4. This curriculum is available on line by going to our website: www.usbg.gov

Have fun! The more fun your students have at the U.S. Botanic Garden, the more likely they are to be interested in "digging deeper" into the lives of plants.

National Science Education Standards

- **NS.K-4.1 – Science as inquiry**
  As a result of their activities in grades K-4, all students should develop an understanding of scientific inquiry and abilities necessary to do scientific inquiry.

- **NS.5-8.1 – Science as inquiry**
  As a result of their activities in grades 5-8, all students should develop an understanding of scientific inquiry and abilities necessary to do scientific inquiry.

- **NS.K-4.3 – Life science**
  As a result of their activities in grades K-4, all students should develop an understanding of the characteristics of organisms, life cycles of organisms, and organisms and environments.

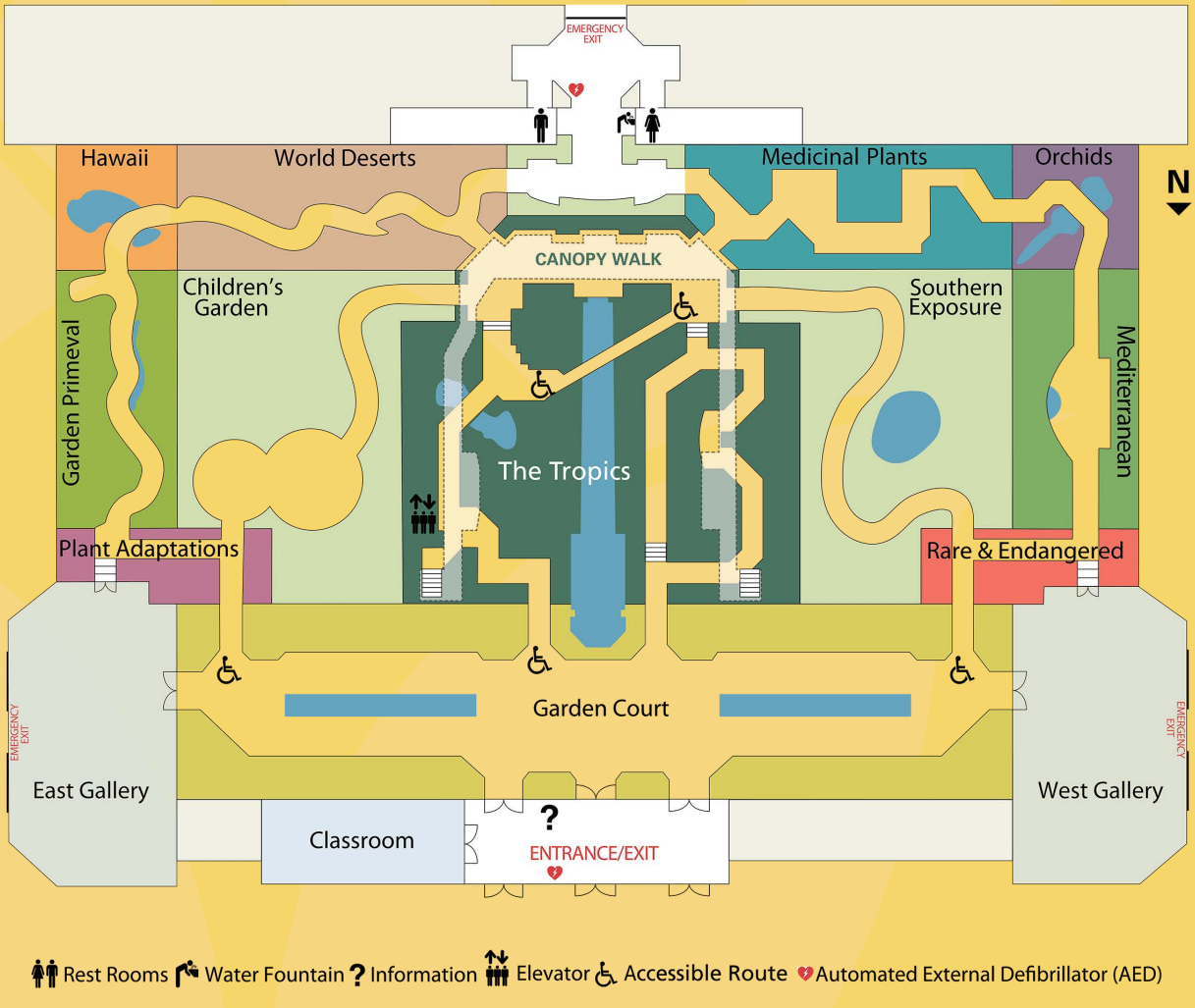
- **NS.5-8.3 – Life science**
  As a result of their activities in grades 5-8, all students should develop an understanding of structure and function in living systems, including reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptations of organisms.

How Plants Work: **Introductory Lesson**

Exploring the Conservatory...

Using the map provided, guide your students quickly through the Conservatory to give them a sense of the layout. This should take approximately 15 minutes.

United States Botanic Garden Conservatory Directory



Big Ideas About Plants

Big Idea 1: Are Plants Like Us?

Plants are like humans because both need energy to survive. However, plants are different because they capture energy from the sun and make their own food.

Highlight: Learn that plants photosynthesize and make their own food and people cannot.

Big Idea 2: A Puzzle of Plant Parts

Plants have a number of parts that work together to ensure the plant's survival.

Highlight: Point out different plant parts (such as stems, roots, seeds, flowers, etc.).

Big Idea 3: Surviving Against the Odds

Plants have evolved to look and function the way they do to thrive in local temperature, light, moisture, and soil conditions.

Highlight: Contrast the large dark green leaves in The Tropics with the tiny, light blue/green or no leaves in the desert; contrast the fat bottoms and fleshy, soft stems of cacti, which act as water tanks, to the drip tips of jungle plants that act as rain gutters to whisk the water away.

Big Idea 4: Plant Multiplication

To ensure species survival, plants, like humans, must reproduce and create offspring. Unlike humans, plants cannot travel to find their mates or places to live. Instead plants depend on wind, water, and other vectors, such as animals, to disperse their seeds, spores, and pollen.

Highlight: Have students use their Plant Family Tree, observe live plants, and discuss these four recognized plant groups (ferns, mosses [reproduction with spores and not seeds], gymnosperms [cone-bearing plants], and angiosperms [flower-bearing plants]).

Let's Get Started!

Becoming a Savvy Plant Sleuth!

If you have not already done so, have students break up into four groups, and assign each group a Big Idea. Students, guided by their chaperones, should complete the Student Discovery Journal activity relating to their assigned Big Idea section.

Please remind students that we are a living museum, and to enjoy the plants not by touching, but by seeing. Upon returning to school, each group can share what they learned.

Big Idea 1
Are Plants Like Us?
Do you really grow like a weed?

Student Objectives
Upon completing this Journal section, the student will be better able to:

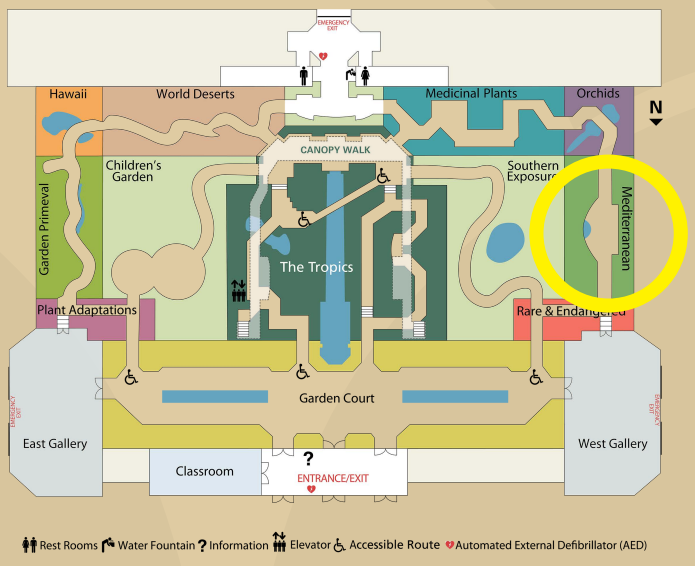
1. Compare and contrast human and plant growth.
2. Use observational skills to develop hypotheses about plant growth and development.
3. Synthesize knowledge about plant growth and development.

Time Needed: 45 minutes

Become a Savvy Plant Sleuth!
Proceed into Mediterranean.

Exploring the Conservatory…
Think Tank Prompt:
Have your students select a partner. Consider the following: How are humans and plants alike? How are they different? e.g., composed of cells; both grow; both need energy to function; plants capture energy from the sun and make their own food, while humans get energy from eating plants and animals; plants have cell walls and contain chloroplasts; etc.

UNITED STATES BOTANIC GARDEN
CONSERVATORY DIRECTORY



Have students choose any plant in Mediterranean and compare it to their partner. They should complete the activity in the Student Discovery Journal. This activity is designed to familiarize students with ideas like: Both humans and plants grow, but the ways we attain and metabolize energy are different.

List three things both the plant and your partner can do:
Examples: grow, use water, eat, sunbathe, etc.

List three things the plant can do that your partner cannot do:
Examples: make his/her own food, produce oxygen, make flowers, make perfume

List three things your partner can do that the plant cannot do:
Examples: walk around, talk, put on a sweater if it gets cold, sleep

Time permitting, have students share one item from each list with the rest of the students in their group.

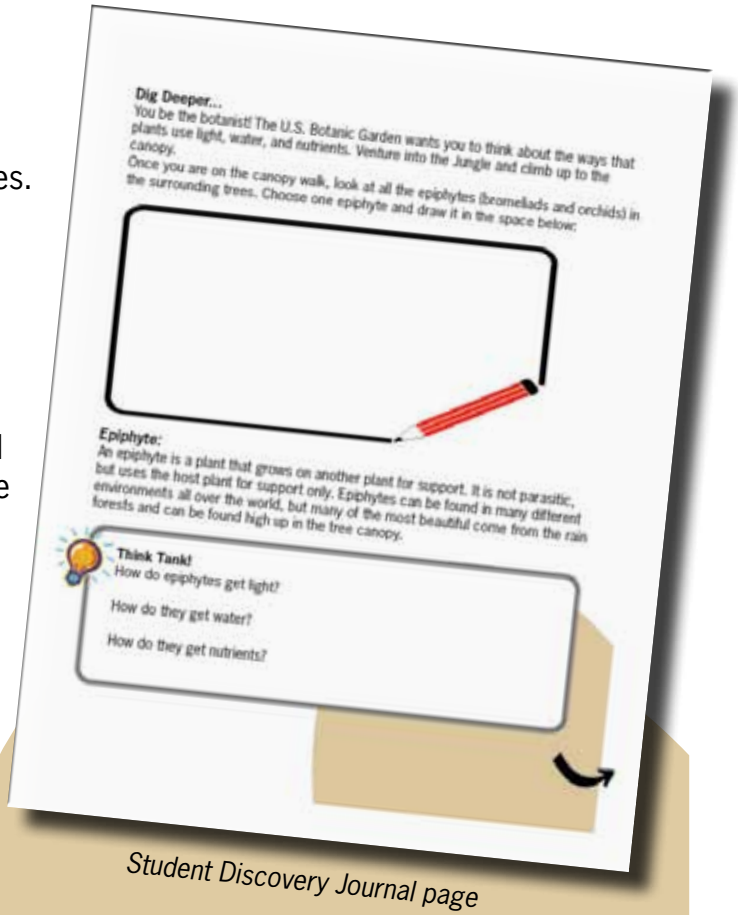
Dig Deeper...

Tell your students they will have a chance to take on the role of a botanist by exploring the plants of the U.S. Botanic Garden and developing ideas about how plants use light, water, and nutrients. Student responses do not need to match the provided examples. This activity is designed to challenge students to express logical thought and explore scientific inquiry.

Take your students up the canopy walk in the Jungle. Have them observe several epiphytes (non-parasitic plants that grow on top of, or are attached to, other plants–e.g., bromeliads and orchids) Students should choose one epiphyte to draw in their Journal. Why are some plants epiphytic?

Think Tank Prompt:
How do epiphytes get light? How do they get water? How do they get nutrients?

Focus student attention on the epiphytic orchids with root systems and epiphytic bromeliads high up in the canopy of The Tropics. These plants get all of their water and nutrients from within the atmosphere.



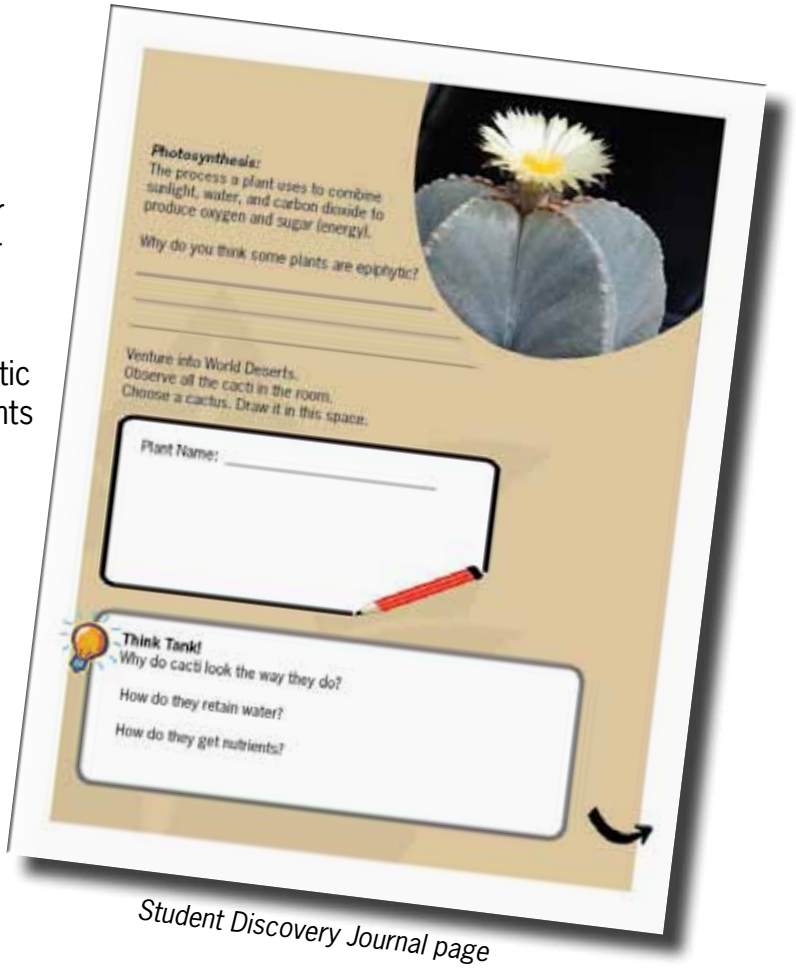
Student Discovery Journal page

Have students develop a hypothesis about how epiphytic plants use light, water, and nutrients. Samples include:

a. Epiphytes depend on other plants to get closer to sunlight, which epiphytes use to make their own food.

b. Epiphytes don't need soil to grow. They draw water and nutrients from the air. (Fact: epiphytic orchids' aerial roots and leaves absorb nutrients and moisture brought by rain, mist, and other organisms. Epiphytic bromeliads have special leaf scales that absorb water.)

Take your students to World Deserts. Have them observe the different cacti. Students should choose one cactus to draw in their Journal. A desert typically receives less than 10 inches of rain a year. Contrast this with The Tropics, which typically receives more than 70 inches of rain a year.



Student Discovery Journal page

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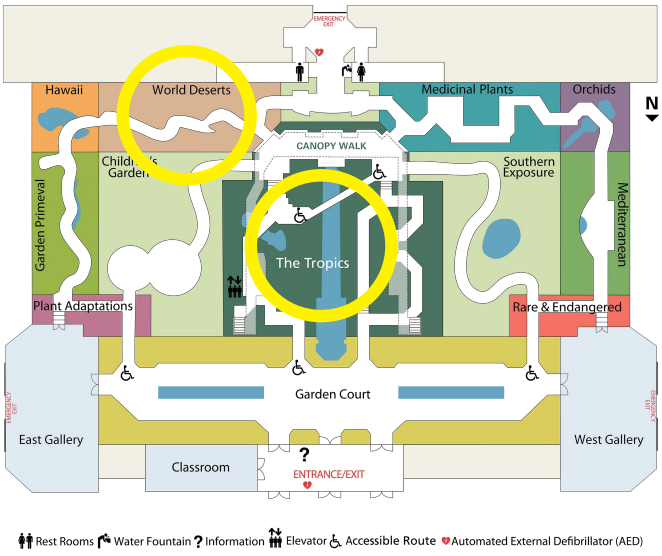
CONSERVATORY DIRECTORY



Think Tank Prompt:
Why do cacti look the way they do? How do they retain water? How do they get nutrients?

Focus student attention on the cacti skin and stems. *Examples:* Old Man Cactus, hair acts as suncreen; spines prevent animals from eating the plant and deflect winds; fat bottoms (caudex) act like water tanks.

Have students write about how cacti survive in the desert heat. Samples include:

a. Cacti can retain moisture in their tissues and remain succulent for long periods of time because of their waxy skin.

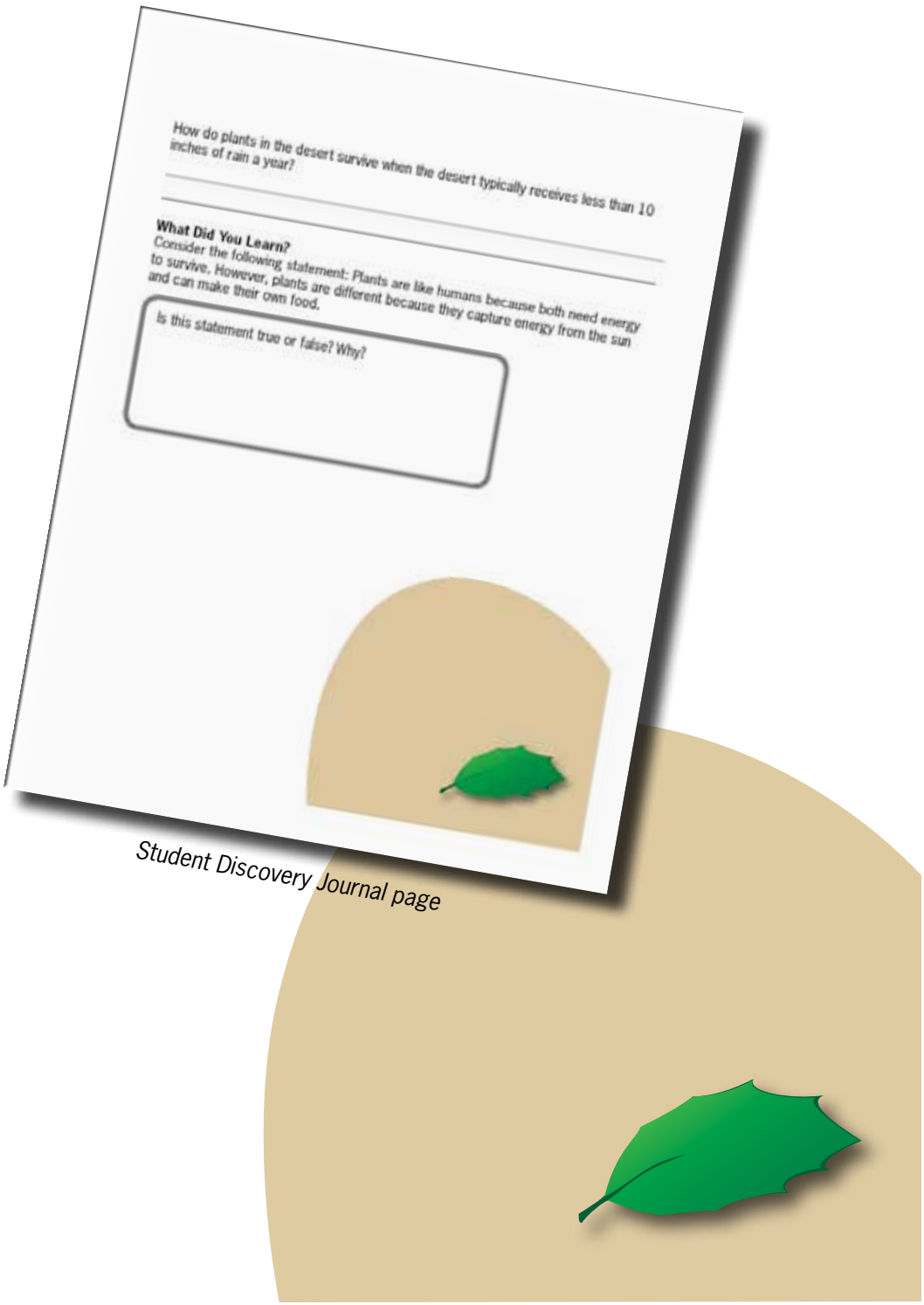
b. Cacti have roots that are close to the surface of the ground to help them absorb water and nutrients, taking advantage of even the smallest amounts of rainfall.

Tell students they can add ideas as they progress through their Student Discovery Journals and learn more about plant life, adaptation, and survival.

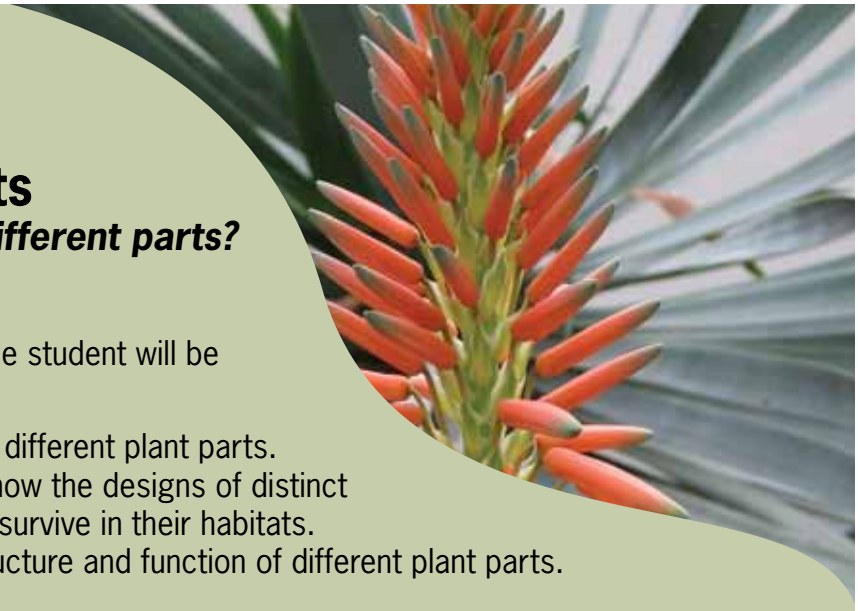
What Did You Learn?

Discussion Prompt: Consider the following statement: “Plants are like humans because both need energy to survive. However, plants are different because they capture energy from the sun and make their own food.” Is this statement true or false? Why?

Students should use information from their observations and explorations to support their responses.



Student Discovery Journal page



Big Idea 2
A Puzzle of Plant Parts
Why do plants have so many different parts?

Student Objectives
Upon completing this Journal section, the student will be better able to:

1. Explain the structure and function of different plant parts.
2. Use observational skills to theorize how the designs of distinct plant parts help plants adapt to and survive in their habitats.
3. Synthesize knowledge about the structure and function of different plant parts.

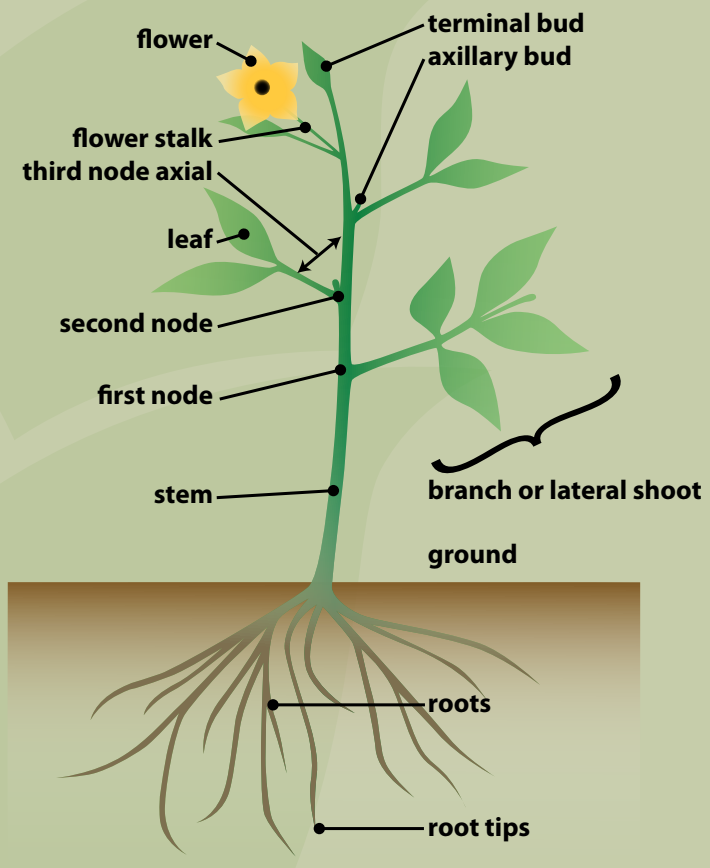
Time Needed: 45 minutes

Exploring the Conservatory…
Discussion Prompt: Look at the accompanying drawing of plant parts. Ask your students to name the major plant parts. What are the jobs of each part?

Puzzle Piece #1: STEMS!
Starting in the Garden Court, have your students identify the stems on plants and draw the stem of the plant they choose. *Discussion Prompt:* What would happen to a plant if it did not have a stem?

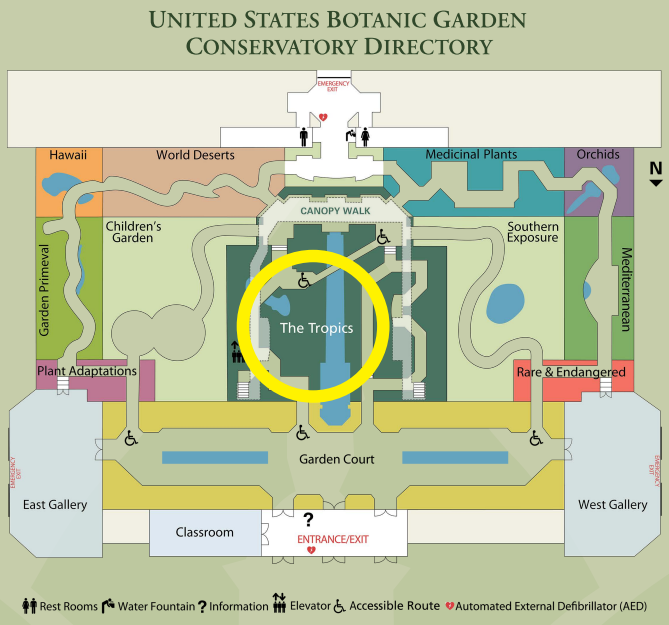
The stem holds up the leaves and flowers of a plant. This is important because the leaves need to be held up to the sun to get light for photosynthesis and the flowers need to be held up to be available for pollination. Stems carry water and minerals up from the roots to the leaves to help with photosynthesis and take food back down to be stored.

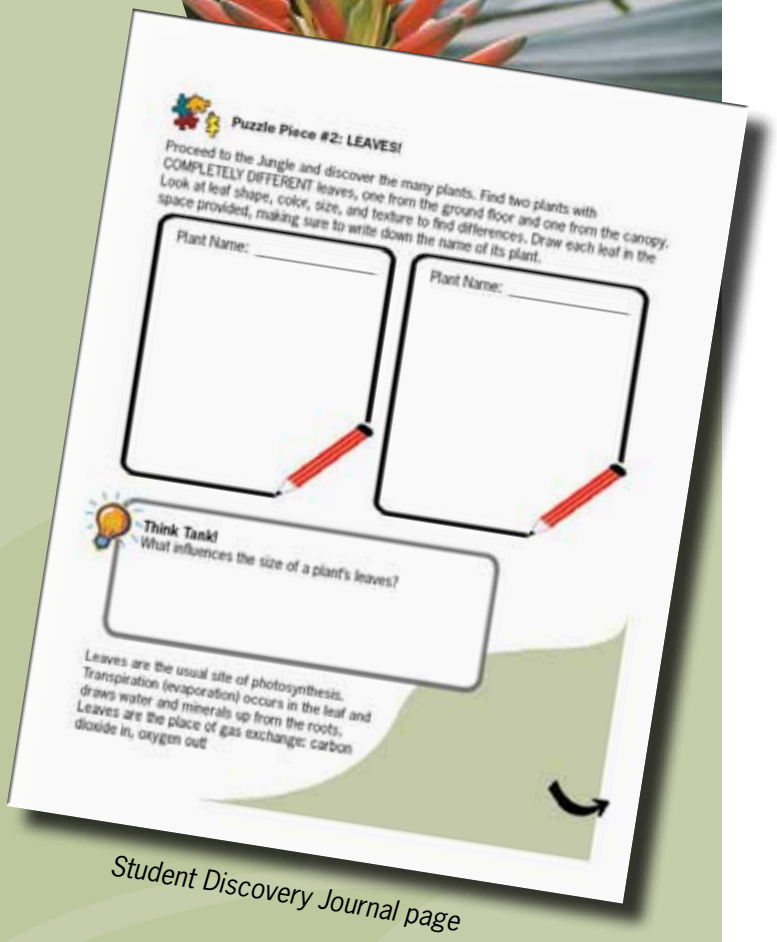
Parts of a Plant



Become a Savvy Plant Sleuth!

Bring your students into The Tropics.





Student Discovery Journal page

Puzzle Piece #2: LEAVES!

Ask students to find and draw two different kinds of leaves displayed in The Tropics, one from the ground floor and one from the canopy. The leaves they choose should be completely different in size, shape, texture, and color.

Think Tank Prompt:
What influences the size of a plant's leaves?

Facts for discussion:

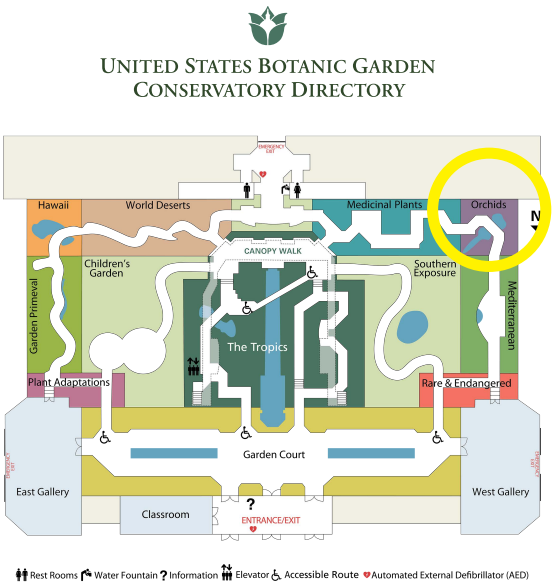
- Many plants found in the understory of tropical forests (i.e., in the shade of large trees) usually have large leaves to catch the sunlight that falls through the forest canopy. Even though they live in a tropical environment with a lot of light, there is tremendous competition for light because of the dense plant growth. As a result, leaves are usually large to serve as good "solar panels." In a true jungle, the higher one gets, the smaller the leaf.

- For a contrast, take your students into World Deserts. Plants in the desert usually have very small or reduced leaf surfaces. They don't need to compete for light because there is a lot of light available and fewer plants to compete with. Instead, the adaptive pressure is to avoid water loss. In fact, some desert plants have no leaves. See if your students can find one. How do they think the plant captures the sun's energy?

Photosynthesis Refresher:
The process by which a plant uses sunlight, water, and carbon dioxide to produce oxygen and sugar (food).

Leaves are the usual site of photosynthesis. Transpiration (evaporation) occurs in the leaf and draws water and minerals up from the roots. Leaves are the place of gas exchange: carbon dioxide in, oxygen out! Other plant parts that are green may contain chlorophyll, the pigment necessary for photosythesis to occur. In many desert plants, photosynthesis mostly occurs in the stems.

Puzzle Piece #3: ROOTS!
Proceed to Orchids.



Student Discovery Journal page

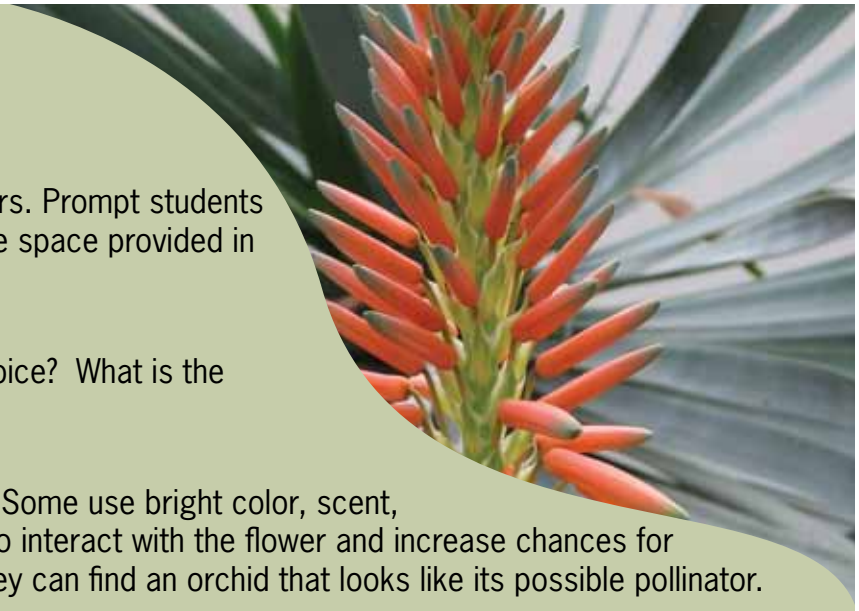
Ask students to find a plant that does not have underground roots. Students should sketch both the plant and its surrounding habitat in the space provided in their Student Discovery Journals.

Think Tank Prompt:
As students sketch, ask: Why do some roots grow above ground? What purpose do they serve? In which environment are they most likely to thrive?

Facts for discussion:

- Epiphytic orchids grow on other plants. This is an adaptation to life in the tropical forest, where the climate is warm and moist; the air never freezes, and light is scarce below the canopy. These plants find a perch on other plants above ground level to find more favorable conditions, but they are not parasitic. These orchids' aerial roots and leaves absorb nutrients and moisture brought by rain, mist, and other organisms. Some orchids shed their leaves, and the roots of these plants contain the chlorophyll required for photosynthesis.
- Roots absorb water and nutrients. Roots help anchor the plant. Roots also can act as 'storage closets' for the sugars and starches the plant will need for future growth.

Have your students speculate on how they would differ in appearance if roots were to specialize on only one of these three functions (absorption, anchoring, or storage).



Puzzle Piece #4: FLOWERS!
Have students examine the orchid flowers. Prompt students to draw their favorite orchid flower in the space provided in the Student Discovery Journal.

Think Tank Prompt:
What was the reason for their flower choice? What is the purpose of a flower for a plant?

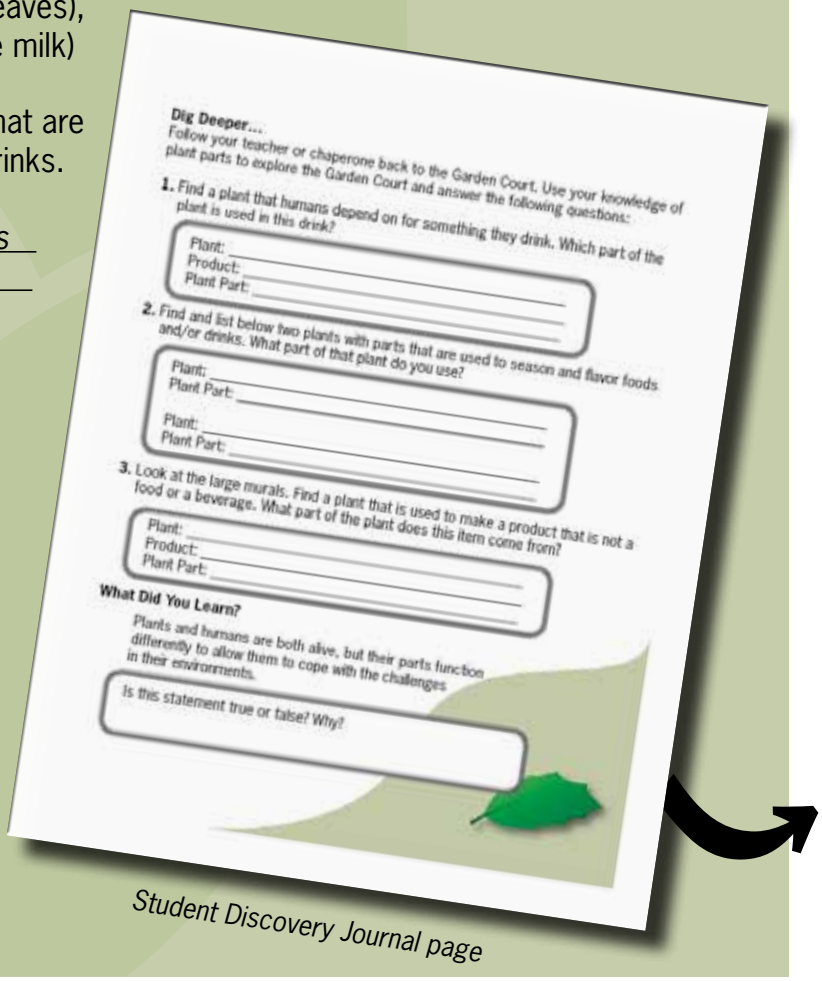
Fact for discussion:
Flowers advertise a plant to pollinators. Some use bright color, scent, or patterns to entice insects and birds to interact with the flower and increase chances for pollination. Have your students see if they can find an orchid that looks like its possible pollinator.

Dig Deeper…

Make your way back to the Garden Court. Through investigations of the Garden Court plants, students should complete the following chart found in their Student Discovery Journal (Sample answers provided).

1. Find a plant that humans depend on for something they drink. Which part of the plant is used in this drink?
Plant: *coffee plant* Product: *coffee* Plant Part: *seed (berries)*
Other choices: Tea plant (tea made from leaves), Cocoa (cocoa from the seed for chocolate milk)

2. Find and list below two plants with parts that are used to season and flavor foods and/or drinks. What part of that plant do you use?
Plant: *Allspice* Usable Part: *berries*
Plant: *Cacao* Usable Part: *seeds*
Other choices: grapefruit (fruit), tarragon (leaves), cinnamon (bark)



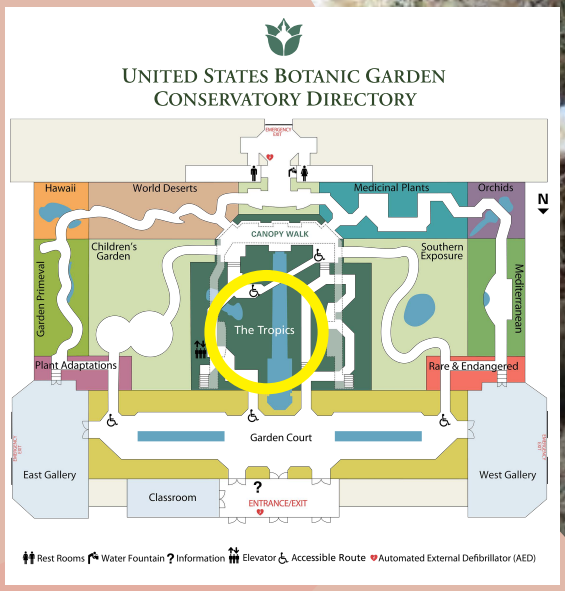
Student Discovery Journal page

3. Look at the large murals. (There are six murals along the north walls of the Garden Court.) Find a plant that is used to make a product that is not a food or a beverage. What part of the plant does this item come from?
Plant: __*cotton*__ Product: __*T-shirt*__ Plant Part: __*seed*__

What Did You Learn?

Discussion Prompt: "Plants and humans are both alive, but their parts function differently to allow them to cope with the challenges in their environments." Is this statement true or false? Why? Have students support their answers with evidence from their journal work and explorations.

Big Idea 3
Surviving Against the Odds
How do plants adapt and survive?



Student Objectives
Upon completing this Journal section, the student will be better able to:

1. List different ways plants adapt to their environment.
2. Use observational skills to evaluate plant adaptations for different environments and outcomes.
3. Synthesize knowledge about plant adaptations.

Time Needed: 60 minutes

Exploring the Conservatory…
Beginning in The Tropics, take your students on a scavenger hunt through the Conservatory.

Pre-Scavenger Hunt Think Tank Prompt: "Plants only have so much energy, so they need to make good use of it. Adaptations take energy and time to evolve, and each one of these characteristics has a specific function that is beneficial to the plant."

Have students brainstorm one or two possible adaptations and their functions. (Possible adaptations include fragrance, color, specialized structures [pitcher plants, seeds that float], or fleshy, edible fruit and berries.)

Become a Savvy Plant Sleuth!
Think Tank Prompt:
What does it mean to adapt? Why do plants need adaptations? What are some examples of different plant adaptations?

Here are some adaptations:
- *Physical adaptations:* drip tips on leaves of jungle plants to direct water away from the plant, sharp spikes that make plants difficult and painful to eat, accordian-like stems that can expand to store water
- *Growth patterns:* stems that reach toward the light, big leaves to catch the light, spines that protect, hair to protect from sun
- *Physiological adaptations:* trees release compounds to heal wounds, plants scents to attract pollinators, bitter leaves to discourage feeding animals
- *Partnerships between plants and animals:* Flowers look like insects (varying size, shape, and color) to attract their pollinator

Have your students list examples of each type of adaptation in their Student Discovery Journal.

Discussion Prompt:
Which adaptation do you find most interesting? Why?

Have your students find the following adaptive traits:

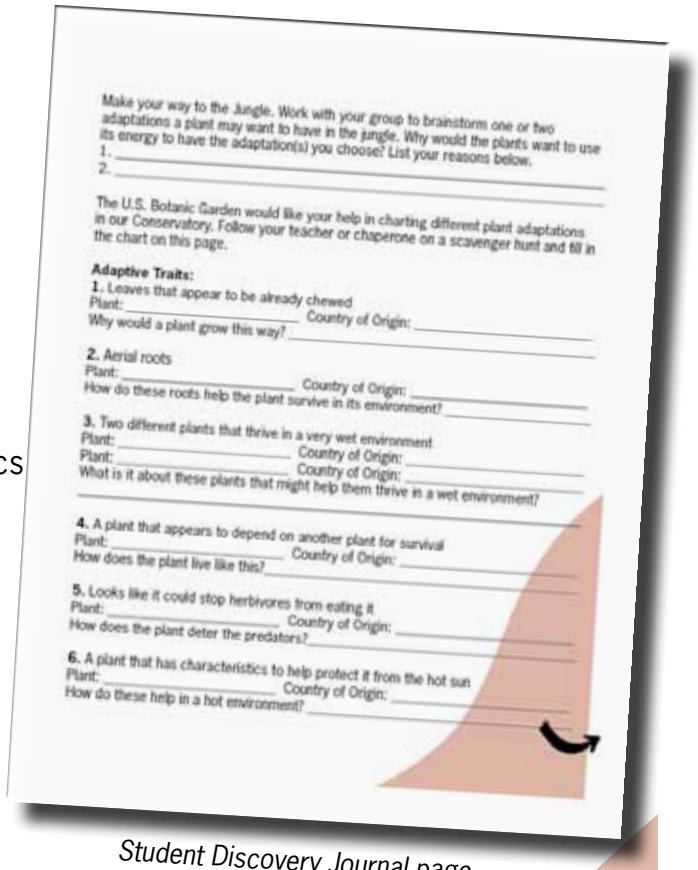
1. Leaves that appear to be already chewed
   Plant: Window Leaf (vine) [a.k.a. Swiss Cheese Plant]
   Suggested Location at USBG: The Tropics

Ask your students why a plant would grow this way.
- To deter predators, some plants have leaves with holes that appear to have been already eaten.

2. Aerial roots
   Plant: Epiphytes (orchids)
   Suggested Locations at USBG: Orchids or The Tropics

Ask your students how these roots help the plant survive in its environment.
- Aerial roots form and remain above ground.
- Generally help to stabilize the plant in addition to absorbing water and nutrients.
- Can allow the plant to climb, increase absorption, and/or exchange nutrients and gases.

3. Two different plants that thrive in a very wet environment
   Plant: Satin Leaf, Capote (Arum Family)
   Suggested Location at USBG: The Tropics


Make your way to the Jungle. Work with your group to brainstorm one or two adaptations a plant may want to have in the jungle. Why would the plants want to use its energy to have the adaptation(s) you choose? List your reasons below.
1. _____
2. _____

The U.S. Botanic Garden would like your help in charting different plant adaptations in our Conservatory. Follow your teacher or chaperone on a scavenger hunt and fill in the chart on this page.

Adaptive Traits:
1. Leaves that appear to be already chewed
Plant: _____ Country of Origin: _____
Why would a plant grow this way? _____

2. Aerial roots
Plant: _____ Country of Origin: _____
How do these roots help the plant survive in its environment? _____

3. Two different plants that thrive in a very wet environment
Plant: _____ Country of Origin: _____
Plant: _____ Country of Origin: _____
What is it about these plants that might help them thrive in a wet environment? _____

4. A plant that appears to depend on another plant for survival
Plant: _____ Country of Origin: _____
How does the plant live like this? _____

5. Looks like it could stop herbivores from eating it
Plant: _____ Country of Origin: _____
How does the plant deter the predators? _____

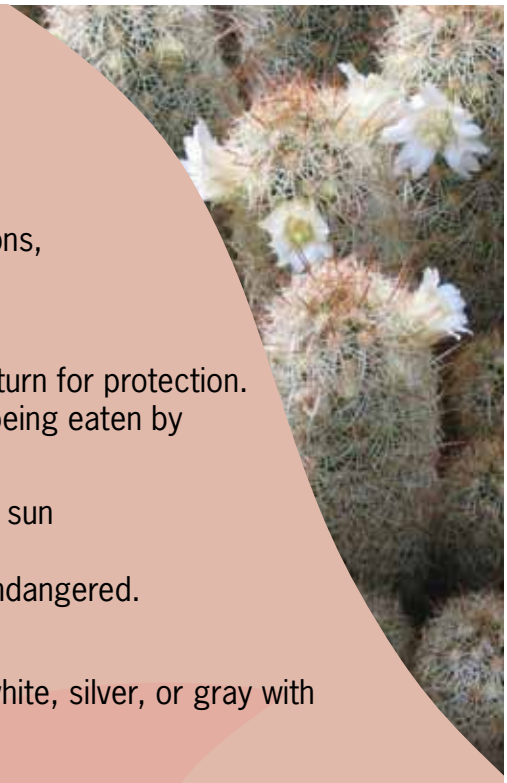
6. A plant that has characteristics to help protect it from the hot sun
Plant: _____ Country of Origin: _____
How do these help in a hot environment? _____

Student Discovery Journal page

Ask your students what it is about the plant that might help it thrive in a wet environment.
- Many plants in rainforests or jungle environments have elliptical leaves with elongated "drip tips" that shed excess water.
- Channeled midribs that act as "gutters" for drainage.
- Waxy leaves that allow water to run off (like a freshly waxed car!).

4. A plant that appears to depend upon another for survival
   Plant: Bromeliad, vines, orchids
   Suggested Locations at USBG: Orchids, Plant Adaptations, or The Tropics

Ask your students how a plant can survive this way.
- Epiphytic bromeliads and orchids get greater light by living in the treetops of the rainforest.
- Vines use trees as support so they can climb high into the canopy in search of sunlight.



5. Looks like it could stop herbivores from eating it
   Plant: Silk Floss Tree, Acacia Tree, cacti
   Suggested Locations at USBG: World Deserts, Plant Adaptations, Rare & Endangered, or Garden Court.

Ask your students how the plant might deter a predator.
- Bull horn acacias provide nutrients and housing for ants in return for protection.
- Spines on cacti not only deflect wind but protect cacti from being eaten by animals in search of water.

6. A plant that has characteristics to help protect it from the hot sun
   Plant: cacti
   Suggested Locations at USBG: World Deserts or Rare and Endangered.

Ask your students how these help a plant in a hot environment.
- Cacti possess thick, juicy stems that can store water often white, silver, or gray with hairs or velvety fuzz – act as light reflectors.
- Thick succulent stems.
- Thorns and spines to keep herbivores from accessing this water.
- Reduced leaf surface – to prevent water loss (transpiration).

The Scavenger Hunt should conclude in World Deserts.

Think Tank Prompt:
List several adjectives to describe the plants you see growing in World Deserts. Why might a plant growing in the desert need these adaptations?

Facts for discussion:
- Some plants have thicker, waxy leaves; some plants have thorns.
- Aloe and jade have waxy coatings that prevent water loss (transpiration).
- Many desert plants have small leaves or spines in place of leaves.
- Some cacti are covered with what appear to be white hairs, which help reflect the hot desert sun.
- Thorns help to deter animal predators that are seeking the water stored in the spongy leaves and stems.

Dig Deeper…

Have your students reflect on their own experiences adapting to their environment. How do they cope with challenges in their environments?

Chart Activity: What do you do if it is…

- Wet? (Sample answers: umbrella, rain coat, bathing suit)
- Windy? (Sample answers: windbreaker, scarf)
- Hot? (Sample answers: go swimming, sit in the shade)
- Dry? (Sample answers: drink, wear chapstick, put on lotion)

Have students repeat the process considering the life of a plant.

Chart Activity: What does a plant do if it is…

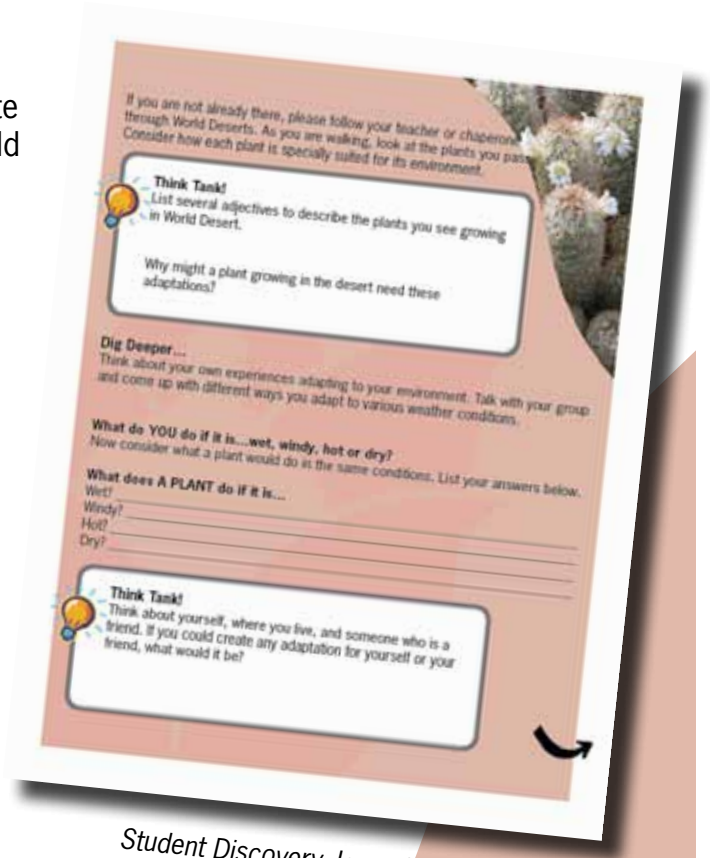
- Wet? (Sample answers: leaves designed for water drainage)
- Windy? (Sample answers: pollinators that are blown around, spines to deflect wind)
- Hot? (Sample answers: thick waxy skin to conserve water, little or no leaves)
- Dry? (Sample answers: losing leaves when dry)

Think Tank Prompt: Think about yourself, where you live, and someone who is a friend. If you could create any adaptation for yourself or your friend, what would it be?

Challenge students to create an adaptation for themselves or a friend. Ask them to draw it, explain why it is important, and how it works.

What Did You Learn?

Think Tank Prompt:
Why do plants need adaptations? Could plants survive without certain adaptations? Why or why not?



Student Discovery Journal page

Big Idea 4
Plant Multiplication

How do plants reproduce?

Take your students to Garden Primeval, a reconstructed Jurassic landscape of ferns and other ancient plant groups that have survived for 150 million years.

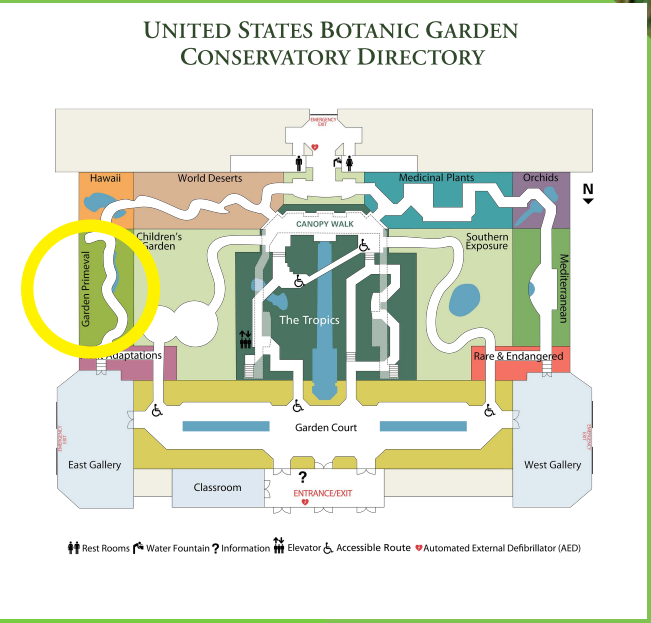
Student Objectives

Upon completing this Journal section, the student will be better able to:

1. Explain the reproductive cycles of recognized plant groups.
2. Use observational skills to compare and contrast the reproductive cycles of various plant groups.
3. Synthesize knowledge of plant reproductive cycles.

Time Needed: 45 minutes

Vocabulary to study in advance: vascular, reproduction, spore, sporophyte, sporangia, gametophyte, egg, sperm, gamete, haploid, diploid, cone, cycle, fruit



Set the Stage:

Plants have been divided into recognized plant groups depending upon their structure and reproduction strategy. See Plant Family Tree provided. The major plant groups, excluding the modern green algae are:

- Mosses (seedless nonvascular – reproduce by spores not seeds)
- Ferns and Club mosses (seedless vascular – reproduce by spores not seeds)
- Gymnosperms (cone-bearing plants with seeds)
- Angiosperms (flower-bearing plants with seeds)

The different reproductive cycles employed by these plant groups reflect that plants adapt to environmental stresses, and innovations in plant form and reproduction produce new opportunities for evolutionary change.

Assign each student to one of the following plant groups:
1. Mosses,
2. Ferns and club mosses,
3. Gymnosperms [note: Gymnosperms are represented by the following plants: ephedra, horsetails, Norfolk Pine, cycads]

(Note: In Garden Primeval, you will not find any angiosperms. There were no flower-bearing plants with seeds during the time of the dinosaurs).

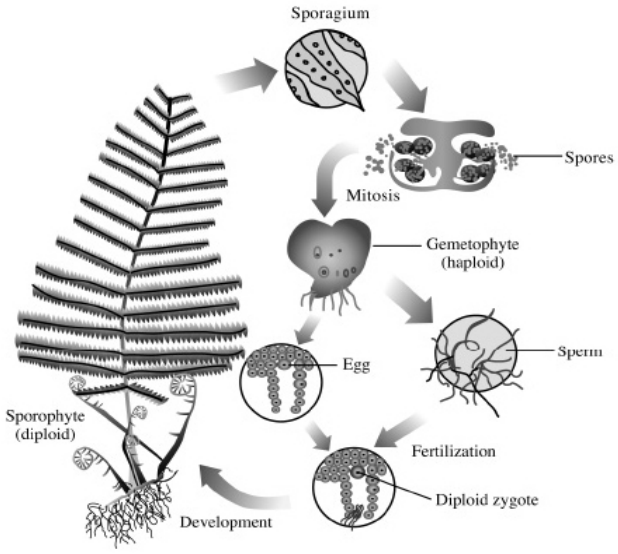
Have the students hunt for an example of their plant group in Garden Primeval. Provide them time to draw and label their drawing. Take a moment to have your students share their findings and drawings.

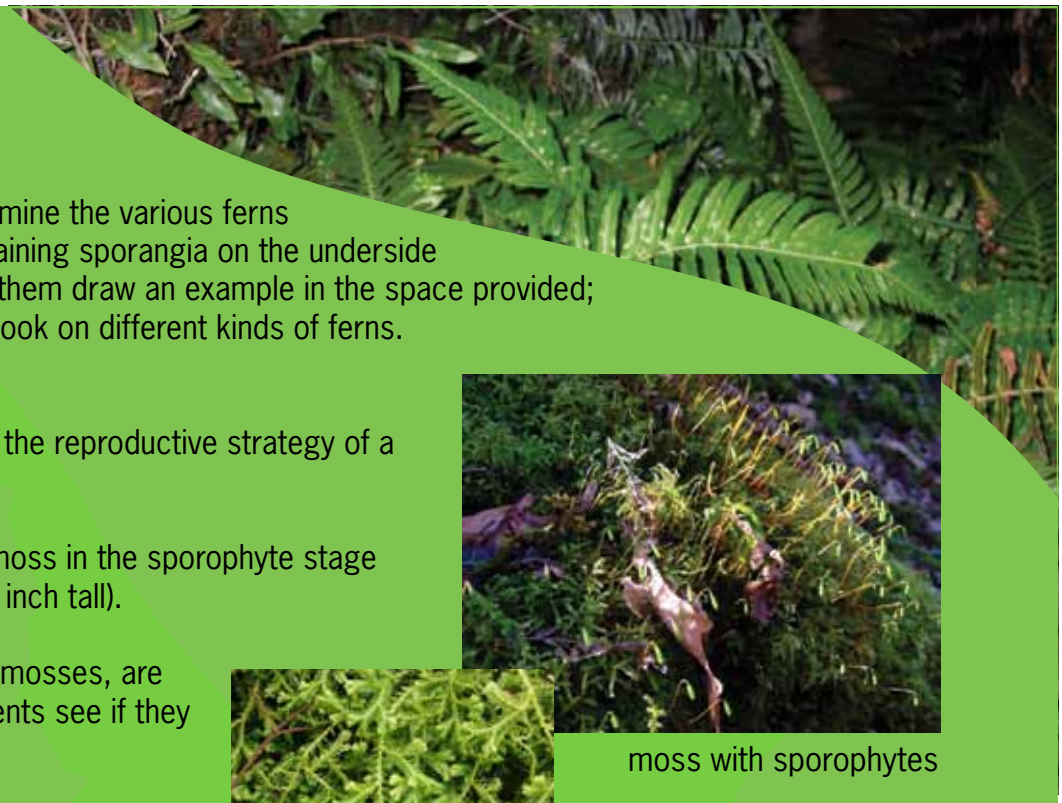
Student Discovery Journal page

Discussion prompts:
Looking at the drawings, which groups show the most variation in size and shape? The least variation? What words describe the plant forms that were drawn (e.g., sheet, tree, bush, clump, etc.)?

Facts for discussion:

- A plant has two life stages: a sporophyte and a gametophyte. One or the other of these stages is the dominant form of the plant. The sporophyte is diploid and it has organs (sporangia) that produce spores that are haploid.
- Each spore grows into a gametophyte plant that produces eggs and sperm; eggs and sperm unite and grow into a new sporophyte. This is the standard plan for plant reproduction and is called 'alternation of generations.'
- Most plants familiar to us are in the sporophyte stage. Some plants have the dominant forms in the gametophyte stage (e.g., mosses).





Have students gently examine the various ferns for sori (brown dots containing sporangia on the underside of the fern leaves). Have them draw an example in the space provided; compare how sporangia look on different kinds of ferns.

Think Tank prompt;
What is the role of sori in the reproductive strategy of a fern?

See if students can find moss in the sporophyte stage (sporophytes are ¼ to ½ inch tall).

moss with sporophytes

Club mosses, unlike true mosses, are vascular. Have your students see if they can find a club moss.

club moss

The ferns we see in our gardens are in the sporophyte stage; it includes the frond, a stem, and exterior roots. The frond first appears as a 'fiddlehead' and then unfurls to reveal the fronds. When the frond matures, small, circular, rust-colored patches appear on the underside of some leaves. These are sori, each contain a cluster of sporangia which release dust-like spores into the wind for dispersal.

The familiar carpet-like moss is in the gametophyte stage. It produces egg and sperm that unite to grow a tiny sporophyte that looks like a pointed hat or capsule on a stalk emerging from the carpet of moss. The sporophyte releases spores that will each grow a new moss plant.

Student Discovery Journal page

Have your students look for cone-bearing plants (*hint:* the two tall trees and the large cycads are easy to find). Have them observe as many cones as they can, comparing their similarities and differences (size, color, structure, placement, etc.

The gymnosperms, or cone-bearing plants, are in the sporophyte stage. They produce male and female cones that contain tiny gametophyte plants (that can't be seen without microscopes). Pollen released from the male cone fertilizes the eggs in the female cone and seeds are produced.

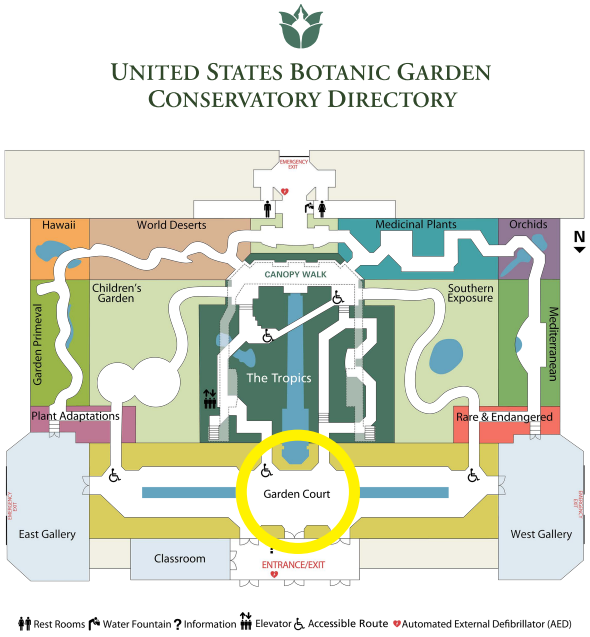
If they have not already seen it, have the students find the dinosaur hiding among the ferns behind the water feature.

Become a Savvy Plant Sleuth!

Take Your Students into the Garden Court.

Have your students find a plant with fruit and sketch it in the space provided. What plant group is present in the Garden Court that was not represented in Garden Primeval (angiosperms)?

Think Tank Prompt: Are plants always in flower? What does a plant look like before and after flowering? Where does the flower fit into the reproductive cycle of the plant?



Facts for Discussion:

- Flowers are the reproductive part of most plants
- Flowers contain stamens (the male gametophyte) that produce pollen, and one or more carpels (the female gametophyte) that produce(s) tiny eggs called ovules.
- After pollination of the flower and fertilization of the ovule, the ovule develops into a fruit.
- After a flower is pollinated, the jobs of the petals and sepals are done and these floral parts usually fall off. The fruit develops at the base of the flower. There are many variations of fruits and seeds depending on the kind of plant. Each has different advantages for dispersal and germination.

Dig Deeper…

Take out the Plant Family Tree. Observe where plants with different reproductive strategies are located on the tree.

While the seed producing plants (angiosperm and gymnosperm) are by far the most abundant, we still find non-seed producing plants (mosses, algae, club mosses, ferns) because there are some environments for which they are better suited.

What Did You Learn?

Discussion Prompt: Plants, like animals, must reproduce and create offspring to ensure survival. However, unlike animals, plants cannot travel around to find mates.

Fun Fact for Thought: What is the difference between a fruit and a vegetable?

Facts: A fruit is what a flower becomes after it is pollinated. The seeds for the plant are inside the fruit. Vegetables are other plant parts. Carrots are roots. Asparagus stalks are stems. Lettuce is a leaf. Artichokes are flower buds.

Review: What Have You Learned?

Concluding the trip:
What have students learned today? What are the important take home messages? Consider what to expand upon back in the classroom.

Big Idea 1: Are Plants Like Us?

Plants, like humans, need energy to survive. However, plants are different from us because they capture energy from the sun and make their own food. Humans must eat their food.

Big Idea 2: A Puzzle of Plant Parts

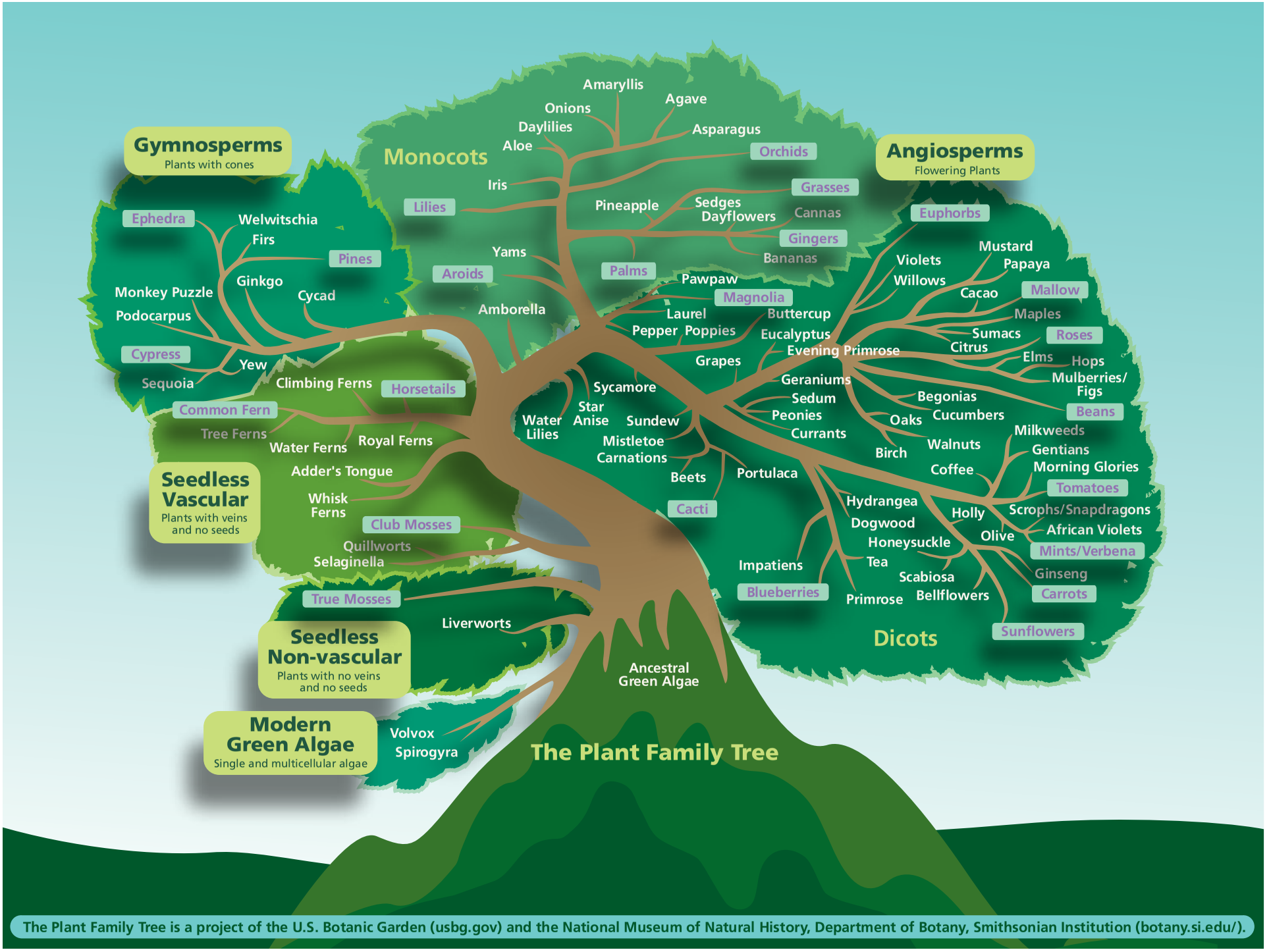
Unlike humans, plants have a number of parts (roots, stems, leaves, flowers, and seeds) that work together to make food. The plants harvest energy from the sun and utilize water and nutrients from the soil to ensure survival where they grow, though may look very different from one plant to another. Humans don't have any of these parts.

Big Idea 3: Surviving Against the Odds

If humans are cold they put on sweaters to fight off a chill. Plants also employ adaptive strategies to adjust to their environment. Plants have evolved to look the way they do to thrive in local temperature, light, moisture, and soil type conditions.

Big Idea 4: Plant Multiplication

To ensure species survival, plants, like humans, must reproduce and create offspring. Unlike humans, plants cannot travel around to find their mates or places to live. Instead plants depend on wind, water, and other factors, such as animals, to disperse their pollen, seeds, and spores.



The Plant Family Tree is a project of the U.S. Botanic Garden (usbg.gov) and the National Museum of Natural History, Department of Botany, Smithsonian Institution (botany.si.edu/).