Prehistoric Plants

Overview: Plants make all other life on earth possible, and they always have! Like the great reptiles that used to roam the earth, many prehistoric plants have disappeared, but some of the green species that grew millions of years ago still thrive today. Through this lesson, students will learn about three distinct types of plants (ferns, gymnosperms and angiosperms) and how plants have changed over millions of years.

Grade Level/Range: 6- 8th grade

Objective:
Students will learn common characteristics of ferns, gymnosperms and angiosperms through observation and how their characteristics help them to adapt differently to their environments.

Time: 1 hour

Materials:

- Samples of fern plant parts, including leaves (look for some with sporangia on the back), fiddleheads, and if possible prothallus (the first stage of growth of a fern is represented by translucent, heart-shaped plants – this may be tricky to find, but you can try growing your own). You can collect from both indoor and outdoor ferns.
- Samples of gymnosperm plant parts, including leaves/needles and a cone with seeds. Collect these from common plants such as pine, fir, and spruce trees and junipers.
- Samples of angiosperm plant parts, including leaves and fruits with seeds. Collect from fruit trees and common landscape trees like maples, sweet gum, and oaks.
- Plant Comparison Chart (below)

Background Information:
Who isn't intrigued by dinosaurs? The mystery behind their lives and extinction engages the imagination of young and old alike, inviting visions of a world dominated by huge lizards. Using fossil evidence, researchers use science and imagination to interpret the stories of these magnificent creatures. Like the great reptiles, many prehistoric plants have disappeared, but some of the green species that grew millions of years ago still thrive today.

The earliest plants actually prepared the path for animals evolve. They harnessed the sun's energy for creating their own food from water and carbon dioxide via photosynthesis, releasing oxygen as a byproduct. Plants form the foundation of every food chain. We know that they were an important part of the dinosaurs' world and that they evolved significantly during the

mighty lizards' 80-million-year reign. But if plants don't have bones to leave behind, how do we know *which* plants were around back then?

Scientists track the appearance and evolution of plant life by analyzing fossils, but they haven't found many specimens because plants decompose so quickly. Fortunately, nature has its ways of recording history. Plant fossils are formed when plant matter (such as stems, leaves, roots, spores, seeds, or fruits) is protected from rapid decomposition by being covered with sediment such as clay, mud, sand, and volcanic ash. The resulting fossils vary:

- Some contain plant matter that has not fully decomposed, leaving trace amounts of tissue or a layer of carbon.
- Others contain no actual plant remains, but the surrounding sediment retained an imprint of the plant material.
- Some are preserved as a sculptural likeness of plant material via the process of petrification. Minerals in solution replace the water in cell cavities and then precipitate, forming stone. (Petrified wood is the result of entire tree trunks and limbs preserved in this manner.)
- Scientists also obtain information about prehistoric plants from dinosaur coprolites (AKA fossilized dinosaur poop) and from remains found in the stomach cavities of dinosaur skeletons!

By studying these various types of fossils, scientists have pieced together the following record of the appearance of terrestrial plants:

Era	**Period**	**Million Years Ago (mya)**	**Plant Life on Land**
Precambrian		3800? to 543	
Paleozoic		543 to 248	The first land plants appeared, including mosses, horsetails (~400 mya) and ferns (~350 mya).
Mesozoic	Triassic	248 to 206	
	Jurassic	206 to 144	First seed-bearing plants emerged, including conifers such as bald cypress, ginkgos, and cycads (~200 mya)
	Cretaceous	144 to 65	True flowering plants appeared, including magnolias and palms (~140 mya)
Cenozoic		65 to present	

(Dates provided by the Geologic Time Scale from the Geological Society of America)

Evolution of Plants

Plant reproductive structures have changed significantly over time and are a good indicator of evolutionary progress. The first land plants, including horsetails and ferns, produced new plants

via spores. Gymnosperms were the next major group of plants to evolve. They produced true seeds in cone-like structures. After that came the angiosperms — plants with “true flowers” that produce seeds within protected ovaries (fruits). This innovation gave angiosperms an adaptive advantage over naked-seeded gymnosperms, and now they're the most abundant type of plant on the earth.

Dino Plants for Your Garden

Here are descriptions of some plants with prehistoric origins that are still around today that you can bring in to help your students recreate a Mesozoic environment in your youth garden.

Spore-Bearing Vascular Plants

Spore-bearing vascular plants do not have seeds, but instead reproduce through spores in alternating generations. They can also propagate asexually from their underground stems.

Ferns were once the primary vegetation covering the earth! The ancient species were probably similar to the tree ferns, now found only in some tropical regions. These dominant plants of the dinosaur era decomposed to become a major component of coal deposits, an important energy source for us today.

The ability of ferns to adapt and evolve has resulted in more than 12,000 known living species growing in climates from the tundra to the tropics. Some of the earliest species include the maidenhair ferns (*Adiantum* species), lady ferns (*Athyrium* species), and autumn fern (*Dryopteris erythrosora*). Fern leaves, called fronds, grow from rhizomes (underground stem structures that grow just below the soil surface). Ferns range in size and shape from low mounding ground covers to the tree ferns mentioned above. Most ferns grow in woodlands and are well adapted to shady beds and indoor plantings.

The life cycle of ferns varies from the cycle of other common garden plants. Ferns reproduce from spores produced over two distinct generations. The part of the cycle we can easily observe is the development of the green fronds. On the undersides of delicate fern fronds, microscopic, dust-like spores are encased in structures called *sporangia*. Clusters of sporangia called *sori* are the scale-like bumps one can see on the underside of the fronds. When the sori turn brown (in natural settings, this is typically after midsummer), they are ripe and ready to release spores. Use a hand lens to look closely at sori —those that are ragged looking have probably already opened and released their spores.

The spores fall to the ground and sprout when temperature and moisture conditions are right. But instead of producing fronds, spores develop into small, green heart-shaped plants known as *prothallia*. This is the *gametophyte generation* because male and female reproductive organs form on the prothallia that produce gametes, akin to pollen and ovaries in seed-bearing plants, which

combine with the help of moisture to form spores. It's easy to miss this part cycle because prothallia are tiny and lie close to the ground. When spores are released, they grow into the familiar frond-bearing plant (the *sporophyte generation*).

Horsetails (*Equisetum* species) are among the oldest plants in existence. Like their close relatives, the ferns, horsetails reproduce via spores rather than seeds, and horsetail species are also adapted to grow around the globe. They grow in marshy areas and sport two different types of vertical, hollow stems. The first stems appear in the spring and look something like asparagus topped with brown cone-like structures that bear the spores. Later in the year larger stems with stringy, tough leaves emerge, and these give plants a feathery appearance (like a horse's tail). If planted in a favorable location, horsetails spread quickly — in fact, they are considered invasive weeds in some areas. Check with local native plant organizations or your state's conservation agency about the invasive status of horsetails in your region before planting them in your school landscape. If you do choose to plant them, consider planting in a container to keep them from spreading aggressively.

Another common name for horsetails is scouring rush. This gives away one if its important uses. Horsetails have very fibrous stems that contain silica crystals, making the stems an excellent material for cleaning pots and pans. Historically, people tied bunches of horsetail stems together to form homemade scouring pads for cleaning dishes. Furniture makers also used them to polish their wares. Even though steel wool and sandpaper have replaced them in most places, there are some cultures that still use horsetails for cleaning and polishing.

Gymnosperms

Gymnosperms produce true seeds in cone-like structures. The word gymnosperm means “naked seed,” ' pointing out the fact that the seeds aren't covered with an ovary (fruit).

Bald Cypress (*Taxodium distichum*; USDA Zones 5-10) is a tree that can grow in both saturated and dry soils, making it a popular street tree. Bald cypress can reach 120 feet tall, and in wet areas develops distinctive “knees” (hump-shaped roots that grow out of the ground). Although many gymnosperms are evergreen, the bald cypress is deciduous and provides attractive fall color.

Bald cypress seeds are a food source for wildlife, including turkeys, wood ducks, and squirrels. Some have referred to the lumber as "wood eternal," not because the species has been in existence for ages, but because the heartwood is resistant to decay and thus is used to make docks, boats, and bridges. Historically, the Choctaw used the bark for string and rope, and the Seminoles found bald cypress useful for making houses, canoes, and ceremonial objects.

Dawn Redwood (*Metasequoia glyptostroboides*; USDA Zones 4-8) is another deciduous tree first identified from fossils. Scientists thought it was extinct, but during World War II a grove of surviving trees was discovered in a remote location in China. Seeds were harvested and you can now find this attractive tree in landscapes throughout the world. Dawn redwood can reach heights of more than 120 feet, and it is useful for stabilizing soil in wet areas.

Gingko (*Ginkgo biloba*; USDA Zones 4-9) is another deciduous landscape tree with unique fan-shaped leaves known for beautiful fall color. Until it was "discovered" growing Japan by a 17th-century Dutch botanist, Europeans believed all ginkgo species were extinct. Male and female reproductive structures form on separate trees, and because the fleshy outer layer of seeds borne on female trees gives off a putrid odor, male trees are a better choice for landscapes. Despite the smell, the seeds are a delicacy in many Asian cultures. Extract from the leaves has become a popular herbal remedy purported to improve memory.

Cycads are gymnosperms that resemble palms. The cycad commonly called coontie (*Zamia pumila*), with its soft fern-like leaves, is a good candidate for a youth dinosaur garden. This mounding shrub reaches approximately three feet tall and sports evergreen foliage that grows well in either full sun or shade. It's hardy only to Zone 8, but gardeners in cooler climates can grow it in a container and bring it inside during the winter. Although coontie seeds are poisonous, the Seminoles and early European settlers used the root as an ingredient to make bread. Sago (*Cycas revoluta*) is another ancient cycad popular for landscape use, but its sharp-edged leaves make it a less appealing choice than coontie for a youth garden.

Angiosperms

Angiosperms are plants that produce seeds enclosed in an ovary (fruit). This is the major feature that sets them apart from gymnosperms. This evolved packaging can serve as protection for the seeds and also aid in distribution to help the plant spread to new locations. Both of these features are enhancements because they are beneficial to overall survival of the species.

Magnolias (*Magnolia* species; USDA Zones 4-10) are some of the earliest angiosperms. There are more than 80 different species ranging in size from small shrubs to huge trees. Some, like the southern magnolia, are evergreen, and others, like the saucer magnolia, are deciduous. All are known for their beautiful and often fragrant flowers. Look for varieties that grow well in your area.

Palms are native to tropical and subtropical areas of the globe. Even today the fruits of many palm trees are used for food (think dates and coconuts). Two of

the hardiest palms to consider for your dinosaur garden are the pindo palm and the windmill palm. The pindo palm (*Butia capitata*; USDA Zone 8-9) has a very graceful appearance with feathery leaves that curve down towards the trunk. It also produces a healthy crop of edible orange fruit that some people use to make jelly. The windmill palm (*Trachycarpus fortunei*) is among the most cold-tolerant palms (hardy in USDA Zones 7b-10, and known to survive winter snow) and is a common landscape plant.

Laying the Groundwork:
Ask students:
-Do all plants have flowers? Can you name a plant that does not have a flower? (If students list plants in the latter category that do have flowers, such as an oak tree, collect a sample, or use photographs to show the variations in flower shapes.)
- Do all plants have fruits? Can you name a plant that does not have a fruit?
- Do all plants have seeds? Can you name a plant that does not have seeds? (ferns, mosses)

Exploration:
1. Introduce students to the common characteristics of ferns, gymnosperms and angiosperms as listed in the background information above. For quick reference:

Ferns reproduce from spores produced over two distinct generations. The sporophyte generation is the part of the cycle we can easily observe is the development of the green fronds. The *gametophyte generation* is when spores develop into small, green heart-shaped plants known as *prothallia* and form male and female reproductive organs that then form spores that produce the frond-bearing plants. Some common characteristics of ferns include

- fern fronds which before opening are known as fiddleheads
- sporangia located on the back of leaves
- reproduce by spores rather than seeds
- water is necessary for reproduction to occur

The word gymnosperm means "naked seed," which refers to the fact that the seeds are produced in a cone structure rather than being enclosed in a flower/fruit like angiosperms. Some common characteristics of gymnosperms include:
- needle- or scale-like leaves, frequently evergreen
- no "true" flowers
- seeds produced in cones
- pollinated by wind

As always, there are exceptions to every rule. For instance, the gingko is a gymnosperm, but it is deciduous and has broad leaves.

Angiosperms produce their seeds in enclosed fruits. Common characteristics include:
- broad leaves, often deciduous
- seeds produced by flowers and enclosed by fruit

- pollinated by insects

Exceptions exist here, too. Many trees and grasses, which are angiosperms, are pollinated by wind.

Provide samples of plant parts from ferns, gymnosperms and angiosperms and ask students to fill out the following plant comparison chart:

	Fern Samples	Gymnosperm Samples	Angiosperm Samples
Describe the leaves.			
What are advantages to having this kind of leaf?			
What are some disadvantages of this type of leaf?			
Describe the location of the spores/seeds.			
What are some advantages of this type of spore/seed for the plants survival?			
What are some disadvantages of this type of spore/seed for the plants survival?			

Making Connections:

Make a list of all of the plants that are considered economically important in our society (for food, shelter, clothing, etc.). Ask students to research whether these plants are gymnosperms or angiosperms and also find out what they need to make new seeds (wind, water, pollinators, etc.). Use this information to introduce the current issue of decrease in pollinator populations. What could this mean for our society? Are there are non-plant alternatives for these economically important products?

Branching Out:

- Take a nature walk around your school or home. Look for angiosperm and gymnosperm plants along your way. Bring a guidebook if necessary to help confirm your identification. Create an inventory to discuss your findings.

- Ferns are being studied for their ability to help clean both air and soil. Ask students to explore phytoremediation, the process of using plants to help clean up pollution. Have them bring in current event articles to share related to this topic.