

Plant Adaptations

What does Adaptation mean?

The special characteristics that enable plants and animals to be successful in a particular environment are called **adaptations**.

Camouflage, as in a toad's ability to blend in with its surroundings, is a common example of an adaptation. The spines on cycad leaves, keep animals from eating them. These special features have evolved over long periods of time, through the process of natural selection. Adaptations afford the organism a better chance to survive in its surroundings.

Adaptations help a plant to:

- Get **S**unlight, **W**ater, **A**ir, or **N**utrients (SWAN)
- Not be eaten
- Stay attached to a tree or rooted in the ground
- Reproduce

Tropical Rainforest Adaptations

The climate of the tropical rainforest is hot and wet. With hundreds of inches of rain per year, as opposed to San Francisco's 20 inches, plants have adaptations that enable them to shed water efficiently. The leaves of many rainforest plants have drip tips for this purpose. Buttress and stilt roots are thought to provide extra support for trees growing in spongy, wet soils.

Tropical rainforest plants also have adaptations to take in what little sunlight is available on the dark forest floor. Leaves with burgundy or purple colors are common; they increase the amount of sunlight a plant can absorb. Other plants, like orchids, bromeliads and ferns, grow as epiphytes high up in the canopy where there is more sunlight.



Lianas

Lianas are climbing woody vines that drape rainforest trees. They have adapted to life in the rainforest by having roots in the ground and climbing high into the tree canopy to reach available sunlight. Many lianas start life in the rainforest canopy and send roots down to the ground. (Goal = Sunlight, Example: Imperial Philodendron)

Drip Tips

The leaves of forest trees have adapted to cope with exceptionally high rainfall. Many tropical rainforest leaves have a drip tip. It is thought that these drip tips enable rain drops to run off quickly, sometimes serving a secondary purpose of directing water to the plant's roots. Plants need to shed water to avoid growth of fungus and bacteria in the warm, wet tropical rainforest. (Goal = Sunlight, Example: African mask)



Buttresses

Many large trees have massive ridges near the base that can rise 30 feet high before blending into the trunk. Why do they form? Buttress roots provide extra stability, especially since roots of tropical rainforest trees are not typically as deep as those of trees in temperate zones. (Goal = Stay Put, Example: kapok in Lowlands)

Prop and Stilt Roots

Prop and stilt roots help give support and are characteristic of tropical palms growing in shallow, wet soils. Although the tree grows fairly slowly, these above-ground roots can grow 28 inches a month. (Goal = Stay Put, Example: stilt palm in Lowlands)



Bromeliads

Bromeliads are found almost exclusively in the Americas. Some grow in the ground, like pineapple, but most species grow on the branches of trees. Their leaves form a vase or tank that holds water. Small roots anchor plants to supporting branches, and their broad leaf bases form a water-holding tank or cup. The tank's capacity ranges from half a pint to gallons. The tanks support a thriving eco-system of bacteria, protozoa, tiny crustaceans, mosquito and dragonfly larvae, tadpoles, birds, salamanders and frogs. Bromeliads give them a home and gain nutrients from the feces of these creatures. A symbiotic relationship.

Epiphytes

Epiphytes are plants that grow on other plants. They don't require soil structure for rooting like terrestrials do, but rather rely on other plants for physical support. They can be found growing on the trunks, branches and even leaves of their host plant.



Unlike parasitic plants, epiphytes produce their own food through photosynthesis. They gather moisture from the air, capture and store water in spongy roots, and sometimes capture water in cups or pockets created by the structure of their leaves. Their leaves and roots trap dust and dirt, building up a "mat" that holds moisture and nutrients. If in abundance on any one host plant, they may cause damage.

Some epiphytes found in the Conservatory:

- Bromeliads
- Orchids
- Ferns
- Nepenthes
- Mosses

Also look for lithophytes, plants that grow on rocks. The boulders in the Highland Gallery are home to ferns, Impatiens, and this Gesneriad.



The following is excerpted from Treasures of the Conservatory of Flowers by Nina Sazevich.

When so much water must be harvested from the air, it is no wonder that so many plants of the cloud forest are epiphytes. In Greek, 'Epi' means upon and 'phyton' means plant. Mosses, orchids, bromeliads and ferns are some of the plants that cling to the forest canopy, living on the surface of trees and other plants. The lowland tropics are host to a whole variety of epiphytes, but nowhere are they so absolutely the kings of the jungle as in the highland mountains. In the cloud forest, epiphytes make up roughly half of the total biomass.

Epiphytes thrive here, being well adapted with their specialized roots and leaves to collect water and nutrients from the surroundings and store them away for a dry day. This is critical because, wet as this environment might be, without the benefit of soil, epiphytes live in a virtual Sahara. So every drop of moisture and every trace of minerals count. Epiphytes hang on to their precious leaves; rarely dropping them as there is no way to get back any nutrients from them once they fall to the ground.

To cut down on moisture loss, many epiphytes also have a specialized form of photosynthesis called C_4 photosynthesis. All plants require carbon dioxide for photosynthesis. Most collect this during the day when the sun is shining and they are actively photosynthesizing. They open the pores in their leaves to do this. But this does allow water to escape. Epiphytes can't afford the risk. So they open their pores in the cool of the night and convert the carbon dioxide into an acid they can use later when it is light. The other benefit of this system is that most other plants release carbon dioxide at night making the supply plentiful.

Epiphytes are very good at this kind of relationship game. After all, their life depends on it. Epiphytes cling tightly to their plant supports, but do not penetrate and pilfer nutrients from them. When they die, they decompose and create "suspended humus," an organic sponge that can be deeper and richer than the soil on the ground. On very old trees this can reach depths of a foot or more. Suspended humus is a gold mine



for a huge number of animals, insects, worms, other epiphytes and even the host tree itself. Some trees send out special roots to take advantage of the moisture and nutrients from this material building up on their own branches.

So, epiphytes are not parasitic, but they can be a heavy load. It is not unusual for a tree in the cloud forest to be loaded up with 300 pounds or more of various epiphytes, not necessarily the best arrangement for the tree. Epiphytes cover up solar-absorbing surface area and can shade lower branches. They soak up a lot of the water and nutrients that fall through the canopy before they reach the ground and the roots of the trees. The weight makes the tree expend greater amounts of energy to reinforce limbs, and sometimes it is just all too much and the branch and all of the epiphytes fall to the forest floor. This breakage is one of the reasons trees in the cloud forest have such a gnarled appearance.



Staghorn Fern

Epiphytes come in all shapes and sizes. Bryophytes like mosses and liverworts are the smallest of the group. These grow so thick in the cloud forest that the landscape almost has a furry or fuzzy appearance. Like a soggy welcome mat, they sprout first and become the foundation that allows other epiphytes to take root.

Several kinds of epiphytic ferns also share life in the trees. The roots of aerial ferns grow like sponges, allowing them to trap and store water and nutrients. Some of these are great garbage collectors. Organic debris is full of nutrients, so the staghorn fern's basket-like form allows it to catch as much as possible. When a leaf of the bird's nest fern dies, it curls back in towards the plant, rolling up any

debris along the way and delivering it right to its sponge.

The beautiful bromeliad family ranges from the most famous of its members, the pineapple, to the most unexpected, Spanish moss (neither Spanish nor a moss). Some bromeliads are terrestrial, growing in the ground. Others are lithophytes, which means they grow on rocks. But the epiphytic members of the family, which can even be found growing on telephone lines at times, have earned them the name "air plants." Bromeliads are recognizable for their fantastic, tightly wrapped spirals of fleshy leaves.

Carnivorous Plants

Carnivorous plants have adapted to living in nutrient-poor environments. To supplement their diet they attract, capture, kill and digest animals; this is how they derive their nutrients. Carnivorous plants are not very different from other plants. They still have leaves that photosynthesize to make sugar for energy and growth. They reproduce in the same manner as other flowering plants, often with very pretty flowers. In fact, in cultivation carnivorous plants do not respond well to commercially formulated fertilizers, because bugs are their fertilizer!

What makes a plant carnivorous?

1. The plant must lure with odor, color, nectar, etc
2. The plant must capture the prey
3. The plant must have a digestive enzyme not just passive absorption

Close to 600 species and subspecies have been identified.

At the Conservatory we mostly find ants, gnats and cockroaches in the traps. In the wild, they generally eat gnats, flies, or moths. Rarely, some may capture a bird, frog or small rodent.

The following is excerpted from [Treasures of the Conservatory of Flowers](#) by Nina Sazevich.

***Nepenthes*: Killing Them Softly**

The allure of the Asian pitcher plant or *Nepenthes* is unmistakable. With a brightly colored rim around the mouth and a teasingly half-open lid, these pendulous pitchers invite curiosity. But woe is the curious insect or small animal because one peek could mean a slide into death.

The Asian pitcher plant is a vining carnivorous plant and like other flesh-eaters must trap living things in order to get needed nutrients. Most carnivorous plants grow where the soil is poor, lacking in nutrients or too acidic so, over thousands of years, they have evolved to make the best of a challenging situation.



Nepenthes trap their prey passively, relying on their color, shape and the promise of nectar to lure in dinner. Animals and insects can walk easily on the pretty rim where they catch the scent of the sweet nectar just below or spy the possibility of

a cool drink of water at the bottom. When they reach for it, a waxy surface sends most unsuspecting victims skiing down into a liquidy death because this is no ordinary water. The liquid at the bottom of the pitcher contains a digestive enzyme and once in, creatures are not likely to get out. The interior wall sports a mean set of downward pointing hairs to ensure that even the most avid climber cannot escape.

Struggling only makes it worse as this encourages the plant to secrete more of the enzyme. Soon it is death by digestion. Something small like a midge is digested in a day. A fly might take up to a week.

The pitchers of most species generally grow to about 6 inches in length – the right size for feasting on insects. But some like *Nepenthes truncata* grow to as much as 16 inches and have been known to consume rats, lizards and even small monkeys. A growing heap of small bones and exoskeletons at the bottom of the pitcher attests to the democratic palette of an older, larger plant. (Goal = Nutrients, Examples: Aquatics Gallery)

“Does the Conservatory feed its carnivorous plants?”

We do not hand feed them insects. Insects do find their way into pitchers on their own. We use a fertilizer called Maxsea, which is very mild and contains fish emulsion.

More Adaptations in the Conservatory

Brown or Red Leaves:



TOP LEFT: Brownea coccinea 'Grandiflora'

common name: scarlet flame bean

Location: Lowlands

Adaptation: New leaves emerge in pale pinkish brown or red. Look around the Conservatory and you'll see the same thing happens with cycads, palms, ferns, and philodendrons. The presence of the red pigment anthocyanin may be to protect the developing chlorophyll inside the new leaves from too much ultraviolet light. There are also theories that brown leaves give the appearance that the leaves are dead, making them unappetizing to predators.



Philodendrons, Ferns

Adaptation: New leaves may be red for a variety of reasons. The presence of the red pigment anthocyanin may be to protect the developing chlorophyll inside the new leaves from too much ultraviolet light. It has also been suggested that these colorful pigments may contain fungicides and other poisons. Herbivores prefer soft, fresh growth to the older, tougher leaves so the brighter colors of the fresh growth may serve as a warning that the new leaves are toxic or distasteful.





Orchid Pseudobulbs

Location: Highlands, display on branches

Adaptation: Canes (left photo) are actually modified pseudobulbs. They serve the same purpose (storing water) as the more typical pseudobulb (right photo).



Tree Roots

Topsoil in rainforests is much shallower than one would expect. The heat, moisture, and hungry insects speed up decomposition, and the plants quickly absorb minerals and nutrients in the soil.

Many rainforest giants grow 200 feet tall, yet like all jungle trees, they are anchored by roots growing only a few feet into the soil. They make up for this

shallow foundation by spreading in dense mats across the forest floor, interwoven with the roots of their neighbors.

Madagascar Palm

Pachypodium lamerei

Location: Potted Plants

Adaptation: The spines often point downward so the moisture falls directly to the roots. While cacti spines evolved from leaves, Pachypodium spines evolved from stipules.



Staghorn Fern

Platycerium bifurcatum

Location: Highlands and Potted

Adaptation: They get nutrition from air born soil and the decomposition of their own dead fronds or dead leaves that fall from other plants.

Snowflake Plant

Trevesia palmata sanderii

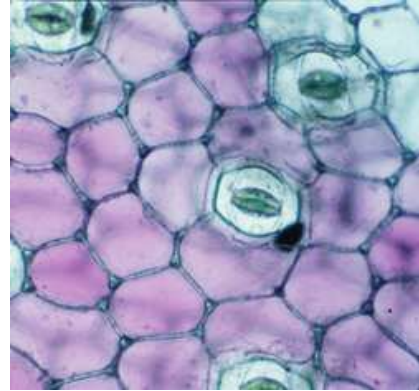
Location: Lowlands, left of Goldman display

Adaptation: leaves appear to be eaten so leaf-eaters aren't interested. Holes also allow more sunlight to get through to the leaves below, which maximizes sun absorption and photosynthesis.



Orchid Pores

Adaptation: During the heat of the day's sunlight, most plants open stomata (pores) in their leaves to take in carbon dioxide from the air for photosynthesis, while allowing some water to escape. Because Highland orchids can't afford to lose water, they photosynthesize by opening their leaf pores during the cooler temperature of the night and use the converted carbon dioxide for nutrients throughout the day.



Bromeliad Trichomes

All species of bromeliads have tiny scales called trichomes on their leaves, which aid in water and nutrient absorption. Trichomes are what give Tillandsia their grey hue. These photos of Spanish moss (*Tillandsia usneoides*) show how trichomes work. When the plant is dry, the scales flex and pull away from the surface. When wet, the scales lie flat on the surface of the plant allowing absorption to take place. You can show visitors this adaptation in action by spraying the Spanish moss with water. It will quickly turn green.



Cauliflory



Examples: Pavonia, Papaya, Cacao

Cauliflory is an unusual botanical trait in which plants flower and fruit directly on their trunks or main branches. The term cauliflory is derived from the Latin *caulis*, meaning

stem, and flor, meaning flower. Some cauliflorous plants produce large flowers or heavy fruits that can be more easily supported on the trunk or main branches. The flowers and fruit benefit from being closer to the accumulation of resources in the plant's main stems and trunk. There are many ecological advantages of cauliflory for pollination and seed dispersal. Flowers located on the trunk of trees are more visible to pollinators in dark understory of the tropical forest than those in the canopy. Mammals such as bats and monkey can more easily access and more efficiently disperse seeds in plants that exhibit cauliflory as well.

How Monkeys Make Chocolate

Brown capuchin monkeys and spider monkeys in Peru aid cacao trees in reproduction. The strong skin of the cacao pod protects the seeds while they are ripening, and it changes to a bright orange color to attract monkeys when ripe. Since the pods grow from the trunk they are easy for monkeys to reach. The monkeys pick the pod and with both hands, pound them on branches to open them. The pod breaks and reveals several rows of seeds the size of large beans. Each bean has a sweet white coating of pulp. The seeds however are bitter, so the monkey eats the pulp and then spits the seed on the forest floor, where it can germinate into a cacao seedling. More on this topic can be found in the book *How Monkeys Make Chocolate: Foods and Medicines from the Rainforest* which can be checked out from the volunteer library.



Unripe Pineapple

Adaptation: When unripe, the pineapple is not only inedible but poisonous, irritating the throat and acting as a drastic laxative. Excessive consumption of pineapple cores has caused the formation of fiber balls (bezoars) in the digestive tract. This adaptation may keep animals from eating the seeds before they are fully developed.



Fool with Fragrance

The delightful coconut smell of the *Maxallaria tenuifolia* and the foul stench of the *Amorphophallus konjac* and *Stapelia* flowers are fool their insect pollinators into landing on the flowers.



Jungle Guide Tour Outline

Key Concepts for Adaptation Tours

Use the Adaptation Booklet as your guide and focus on these key concepts:

- Adaptations: Plants adapt to survive and thrive in their environment.
- SWAN: All plants need sun, water, air, and nutrients to survive.

When You Arrive

1) Check your assignment posted in the Volunteer Center:

- Greeter: Meet the teacher when the class arrives and introduce the children to their Jungle Guides.
- Boxes: Move boxes to galleries and return them after the tour. Make sure there's water in the containers in the Highlands bin.
- Backpack Bins: Bring one bin for every Guide. Put up in lobby. Return after tour.
- Stock your tote bag or apron with supplies. Include booklets, pencils, nametag labels, crayons, laminated photos, tape measure, and full spray bottle. Remove items after your tour.
- Adaptation tours are a team effort, so work with your fellow Guides and help them with their set-up and clean-up responsibilities.

2) While waiting for the class, discuss with Guides:

- Which gallery each of you will start in. We try not to be in the same gallery at once, if you must, move away from the boxes when you are done them.
- What order you will go in.
- Synchronize watches. End time is always 11:10.

Start Your Tour

- Distribute nametags if students aren't wearing them.
- Ask students to write name on booklet.
- Start with questions to encourage discussion. Questions for your introduction might include:
 - Have you ever been to the Conservatory?
 - Did you eat a plant for breakfast?
 - Where are the tropics? Show on map on back of booklet.
 - What do plants need to live? Have them write out SWAN on page 2.
- Build context for the children:
 - Spend a minute to set up the context as you enter each gallery. What is the temperature like? Is it colder or warmer than the last gallery? Wetter? More humid? Page 3 discusses weather.
 - Encourage them to imagine themselves as the plants to help them understand the concept of adaptation. As they begin to empathize with the plants, they will see the need to adapt more intuitively. Specific examples are illustrated in gallery sections that follow.

LOWLANDS GALLERY

Materials in Bin:

- *Philodendron Leaf*: Page 5. Measure with the tape measure. Why so big? To get sunlight!
- *Bamboo items*: Lots of materials are made of bamboo: towels, serving spoons, wood for building.
- *Baggies filled with edibles*: Why does fruit smell? To attract animals that will eat and disburse seeds.
- *Calabash shaker*: fun to see what people make out of plants in our galleries
- Discuss economic plants: vanilla (in potted plants), coffee, cacao, and banana.

More Adaptations:

- *Prop Roots*: Page 4. What part of the plant do you think that is? Aren't most roots underground? Why are the roots of this plant not growing in the soil?
- *Surviving tropical storms*: Page 4. Some palms have feathered leaves so wind passes through them and trunks that bend with the wind.
- *Leaves look chewed so insects don't want to eat them*. Snowflake plant. Others, like the scarlet flame bean, have brown or red leaves. The brown pigment acts like sunscreen to protect the delicate new leaves from sunburn.
- *Cycad leaves* are spiky to keep them from being eaten. Cycads have been around for 200 million years, since the time of the dinosaurs!

HIGHLANDS GALLERY

Materials in Bin:

- *Bromeliads*: Page 6. Show capacity to collect and hold water, provide home for insects, frogs. They get nutrients from dead insects, waste material from frogs. Why do they hold water instead of letting it run out?
- *Water bottle*: To pour water into bromeliad.
- *3 pieces of wood*: (ipe, redwood, balsa) Shows density and porosity. Have the children hold them to feel the different weights.
- *Pineapple* is a bromeliad fruit

More Adaptations:

- *Epiphytes*: Page 7. Moss, ferns, orchids, bromeliads. Look at the tree sculpture. Is that one plant or lots of little plants? Are the leaves the same or all different? Why does living on another plant help the epiphytes? How did it get there? How do they attach to the plants?
- *Drip Tips*: Can you find a leaf with a point? Leaf adaptation that helps leaves stay dry to avoid mildew, fungus, and directs rainwater to the plant's roots on the ground. (Spraying drip tips can be done in any gallery.)

- *Why are the plants in here so small* compared to Lowlands? Page 6. They get less water, filtered light, no nutrients from soil.
- *Water storage for orchids*. Page 7. Why are their leaves and pseudobulbs so thick? Why do they need to store the water? They don't have roots in the ground to absorb water so they only get water when it rains.

AQUATICS GALLERY

Materials in the bin:

- *Nepenthes leaf (pitcher plant)*: Page 10. Leaf adaptation for catching bugs. Why might a plant eat insects? Nutrients! Why would it want nutrients from an insect instead of soil like other plants? The soil doesn't have enough nutrients. Point out how pitcher grows from, and is part of, the leaf. Point out where insects enter and how they are digested.
- *Cotton*: Not adaptations, just neat
- We try to keep a fly trap in this bin when there isn't one on display in Potted Plants

More Adaptations

- *Water Lily sculpture*. Page 9. Why does it have spines? If you were a fish, would you eat that leaf? Why does the leaf have an upturned lip? So other aquatic plants can't grow over it and block sunlight. Why does the leaf have a slit? To let water drain out when it rains. Point out venation in leaf. Adds strength to help it stay afloat. A small child can sit in it! Also point out the difference in the tropical and Amazon water lilies. The tropical are smaller and the leaves overlap.
- *Spray Bottle*: Page 8. Spray taro leaf in mini pond. Shows water beading. Why does it want to stay dry?

Other Points for Aquatics

- *Amazon river*: What lives in the river? Fish, turtles, insects, crocodiles.
- Where does all the rain go when it rains so much in the tropics?
- Point out rice, pomogranite, and pineapple.

POTTED PLANTS GALLERY

Adaptations

- *Vines on arbor*: If you were growing in a crowded place, what might you do to get more sunlight?
- *Madagascar Palm*: What role do the spines perform?
- Nepenthes, fly traps, other carnivorous plants
- Mimosa plant
- Ariel roots on *Clusia* next to the entrance from Lowlands
- It's fun to have the kids smell the nice and terrible smelling orchids in Potted

Conservatory of Flowers