How Plants Work

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Botany of Gesneriads

Plant Families

All plants are classified based on the arrangement of their reproductive structures or flowers. Although different species of Gesneriads appear distinctive from one another, with different flower colors, root structures, and are found on different continents in different habitats, botanical classification places all these species in the same family based only on flower structure. All Gesneriads (with some minor exceptions) have 5 petals, 2 stamens, and an ovary located above the flower petals (superior), which contains two carpels, forming a dry capsule of seeds upon fertilization. Flowers are also zygomorphous, where the top two petals appear somewhat different than the bottom 3 petals, allowing the flower to be divided down the center in only one way that would produce two equal sections or mirror images.

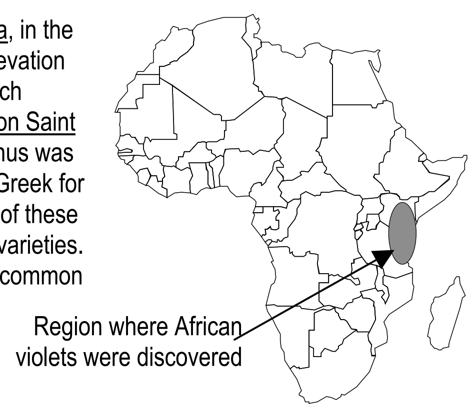
African violets and their relatives are members of the plant family Gesneriaceae (JEZ-nare-i-ace-e-ay), or Gesneriads (JEZ-nare-e-ads), which are plants that are mostly herbaceous (or having no woody stems) flowering plants closely related to the common garden perennial foxglove, and the olive and ash trees. There are approximately 2000 species of Gesneriads in the world, most being found in Africa and South America, although the African violet species are only found in the small mountainous rain-forest regions of eastern Kenya and Tanzania. The Gesneriad family was named after Konrad Gesner, a Swiss botanist born in 1516 who studied plants as sources of medicine. Although the Gesneriad family was not described until 1893, long after Gesner's death, a French botanist suggested this family be named to honor Gesner's contributions to the field of botany.

Genus and Species

Once classified in the Gesneriad family, plants are further sub-classified into genus and species. Genus names are given to distinguish these groups from others in the family Although categorization is still based solely on flower structure, plants in the same genus are usually easy to categorize, as most of these plants are similar in appearance. The first letter of a genus is always capitalized, with the whole name either italicized or underlined. Examples are *Saintpaulia*, *Columnea*, and *Sinningia.* To further classify plants, individual species names are given, based on both subtle and obvious differences of plants in the same genus. Obvious differences include flower color, size and leaf type, while subtle differences include habitat, microscopic flower structures, and even differences in DNA. Species names are always in lower case and italicized or underlined. Plants typically can not be pollinated by plants that are not the same species in the wild, either because they are genetically incompatible or found in different habitats. Hybridizing by humans has brought different species together in conditions that allow cross-breeding between species, although genetic differences typically don't allow cross-breeding between plants belonging to two different genuses.

The African Violet

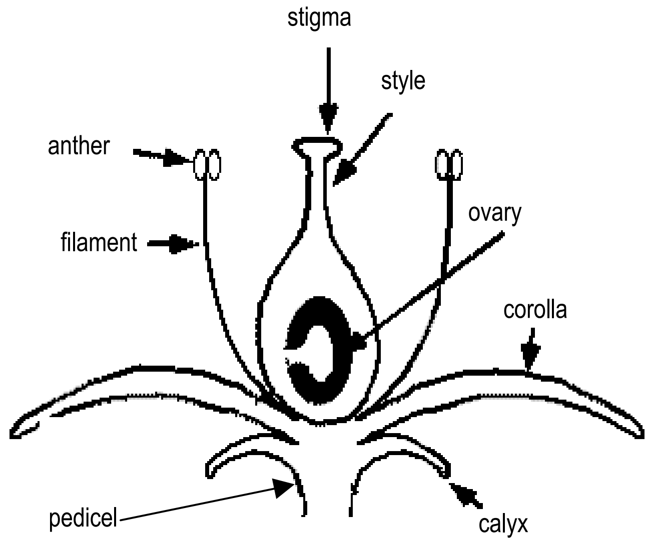
African violets were discovered in 1892 growing in the Usumbara mountains of Tanzania, in the eastern part of Africa. The mountainous region where the plants were found, with an elevation of approximately 3,000 feet, is considered a cloud forest, a cool, lush, humid habitat which produces a wide diversity of plant species. The discovery was made by Baron Walter von Saint Paul-Illaire, whose father was a patron of a botanical garden in Germany. The plant genus was named *Saintpaulia*, for its discoverer, and the particular species was named *ionantha*, Greek for a violet-like flower, hence the botanical name *Saintpaulia ionantha*. Further exploration of these mountainous regions of eastern Africa yielded approximately 20 additional species and varieties. From a handful of these species, hybridizers have created thousands of varieties of the common houseplant known as the African violet



GENERAL FLOWER STRUCTURE

anther + filament + pollen = STAMEN (male)

stigma + style + ovary = PISTIL (female)



FEMALE PARTS

Pistil	Refers to all the individual female parts of the flower
Stigma	Tip of female portion of flower where pollen is received for fertilization
Style	Supporting structure for stigma
Ovary	Where seeds form after fertilization. In Gesneriads, this spherical structure is found above the petals of the flower, referred to as a "superior ovary."
Carpel	A section of the ovary which contains one or more seeds. All Gesneriads have two carpels, each containing 15-100 or more seeds, depending on the species.

MALE PARTS

Stamen	Refers to all the individual male parts of the flower. Most Gesneriads have two stamens, while some, including African violets, have their pollen encapsulated in a sac.
Filament	Supporting structure for anther and pollen
Anther	Where pollen is formed and released for fertilization
Pollen	Reproductive male portion of the flower needed for fertilization

FLOWER PARTS

Perfect flower	When male and female parts are both found in the same flower, allowing for self-fertilization. All Gesneriads are perfect flowers.
Corolla	Colored portion of the flower
Petal	One section of the corolla. All Gesneriads have 5 petals.
Calyx	Green portion of the flower, typically found beneath the corolla
Sepal	One section of the calyx. All Gesneriads have 5 sepals.
Pedicel	Stem which attaches the flower to the plant
Capsule	A type of fruit which forms as a dry packet containing many seeds.. Most Gesneriads form fruit in this dry capsule form, although some species form fleshy berries containing many seeds.

NUTRIENTS

- Plants require 14 (16) mineral nutrients to remain healthy, grow, bloom, and reproduce. These essential elements each play a key role in plant production and can not be replaced by different elements.
- Some nutrients are required in large amounts (macronutrients), while some are only needed in small concentrations (micronutrients).
- Nutrients are typically obtained from the soil, dissolved in water throughout the soil matrix. We provide nutrients in our fertilizer solution.
- A good fertilizer, in addition to supplying the common macronutrients of nitrogen, phosphorus, and potassium, should also contain micronutrients to assure the plant is receiving all the minerals it needs for healthy growth.
- While some nutrients are mobile in plant tissue and can be transported where they are needed throughout the plant, some nutrients become immobile once metabolized by the plant and remain where they are deposited. As mobile elements are transported to new growth, older leaves may show signs of deficiency, such as yellowing leaves.
- Plants also need carbon, hydrogen and oxygen, all obtained from water and air (carbon dioxide), to sustain growth and energy.
- More is NOT better: Although these minerals are essential to plant growth, too much of one or more of these minerals may be toxic to the plant! For example, urea provides a source of nitrogen directly to the plant without the need to metabolize the nitrogen from another form. This "quick" form of nitrogen from urea can sometimes be too much of a good thing! Applying nitrogen as nitrate nitrogen provides nitrogen as the plant needs it, similar to a slow-release capsule.
- Soil pH is essential to the ability of plants to obtain nutrients. If pH is too high or too low, some nutrients can remain bound to soil particles, or wash out of the soil completely. Maintaining a slightly acidic soil pH (5.5-6.5) will assure all nutrients are optimally metabolized by the plant. Soil pH can easily be adjusted by adjusting your watering solution with vinegar (more acidic) or baking soda (more basic). A pH test kit can be obtained in any store selling aquarium supplies.

Nutrient	Amount in plant tissue	Mobility in plant tissue	Function
MACRONUTRIENTS			
Nitrogen	1.5%	Mobile	Building block of genetic material (DNA) in nucleus of plant cell, component of plant enzymes and proteins.
Potassium	1.0%	Mobile	Plays a key role in chemical reactions to obtain energy for the plant, sustains proper water content in plant cells.
Calcium	0.5%	Immobile	Component of cell walls, regulates some metabolic functions of cells.
Magnesium	0.2%	Mobile	Main constituent of chlorophyll molecule, involved in reactions to obtain energy for the plant through photosynthesis.
Phosphorus	0.2%	Mobile	Man component of compounds used to obtain energy for the plant, component of many compounds involved in plant cell reproduction and growth, component of genetic material (DNA).
Sulfur	0.1%	Immobile	Component of genetic material (DNA) of plant cells, contained in compounds regulating cell growth and obtaining energy.
Silicon	0.1%		Structural component of cells walls, assists in cell rigidity and elasticity. Not an essential element for all plants.
MICRONUTRIENTS			
Chlorine	100 ppm	Mobile	Involved in the photosynthesis reaction
Iron	100 ppm	Immobile	Involved in the photosynthesis reaction and respiration (release of oxygen by the plant).
Boron	20 ppm	Immobile	Component of plant cell walls, involved in cell elongation, involved in formation of plant genetic material (DNA).
Manganese	50 ppm		Involved in some plant enzymes and plant respiration.
Sodium	10 ppm	Mobile	Involved in cell growth and water retention in plant cells. Not essential for all plants.
Zinc	20 ppm	Mobile	Component of many plant enzymes needed for growth and photosynthesis.
Copper	6 ppm	Immobile	Component of enzymes needed for photosynthesis.
Nickel	0.1 ppm		Component of enzymes needed for growth.
Molybdenum	0.1 ppm	Mobile	Component of enzymes needed to convert nitrogen to a form usable by the plant's metabolism. Deficiency of this element directly effects the ability of the plant to metabolize nitrogen.

Table derived from: Taiz, L., and E. Zeiger, 1998 *Plant Physiology*, 2nd ed. Sunderland, MA: Sinauer Associates, Inc.

PHOTOSYNTHESIS

Photosynthesis is the process which converts the sun's energy into a chemical form that can be utilized by plants to grow and reproduce. Glucose, a form of sugar, is the most common form of energy used by plants.

The chemical reaction:

Carbon dioxide (CO_2) + Water (H_2O) + Light ➔ Glucose ($C_6H_{12}O_6$) + Oxygen (O_2)

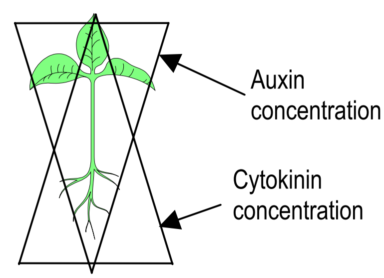
- A lack of water severely limits plant productivity more than any other component of this reaction. Water is obtained through the roots.
- Carbon dioxide is obtained by the plant from the atmosphere through small openings (stomata) in the leaves. The atmosphere is approximately 0.1% carbon dioxide.
- Glucose is produced by a complex of chemical reactions, where light energy causes pigments within the plant cell to produce reactive particles which cause water and carbon dioxide to combine and form glucose.
- Enzymes and intermediate molecules, partly consisting of several essential elements such as iron and phosphorus, are essential to this energy transfer reaction.
- The release of oxygen is referred to as respiration. Oxygen is released through stomata in the leaves.
- Glucose can react further to form the complex sugar, starch, which is the main energy storage mechanism for the plant. Think of potatoes and tulip bulbs! Starch is a main component of most seeds.
- Common herbicides interrupt this energy transfer process and give the light energy absorbed by the plant no viable outlet, thus killing the plant. Grasses utilize a different set of chemical reactions for energy transfer, which is why a broad leaf herbicide applied to your lawn only kills the dandelions!

Several molecules within the plant cell are specialized in absorbing light for conversion to energy.

- Chlorophyll, typically the pigment with the highest concentration, absorbs red light (long wavelength, low energy). The essential element magnesium, is an integral part of the chlorophyll molecule.
- Carotene absorbs blue light. (short wavelength, high energy).
- Other pigments exist in plants in varying concentrations which can absorb a broad spectrum of light energy.
- Because red and blue light are absorbed by the plant, only green light is reflected, hence the green color of leaves.
- When providing plants with artificial light, be sure to provide light in both red and blue wavelengths to maximize energy production.

HORMONES

Like people, plants also produce hormones. These compounds are present in very low concentration in plant tissue and function as signals which cause a response in another part of the plant, such as increasing growth, growing against gravity, or growing towards light.



Auxin

- Concentration highest in young, growing, green tissues and lowest in the roots.
- Promotes overall plant growth and signals plants to grow against gravity and toward light.
- Some herbicides use this hormone in high concentrations, which overload plant cells, resulting in plant death.

Cytokinin

- Regulates plant cell growth.
- Concentration highest in root tips and lowest in young, growing, green tissues.

The combination of auxin and cytokinin in plants regulates where new tissues will grow. These hormones are the reason roots grow on African violet leaves we "put down."

- Removed leaf has high levels of auxin in leaf tip and low levels cytokinin at the cut petiole because roots were removed.
- High overall concentration of auxin versus low concentration of cytokinin in the cut leaf results in root growth.
- Cutting off the tip of the leaf to put more "energy" into root production doesn't work, as you are removing the part of the leaf with the highest auxin concentration, which is needed for root production.

The ratio of these hormones also causes new sprouts when growth is removed from a plant, like a columnea.

- While the trimmed pieces behave like a cut violet leaf, the plant now has a sprout which still has high levels of cytokinin at the roots, but has lower levels of auxin where the plant was trimmed.
- High overall concentration of cytokinin versus low concentration of auxin at the trimmed area results in increased sprout growth, hence the appearance of several new sprouts from where the old one was removed.

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