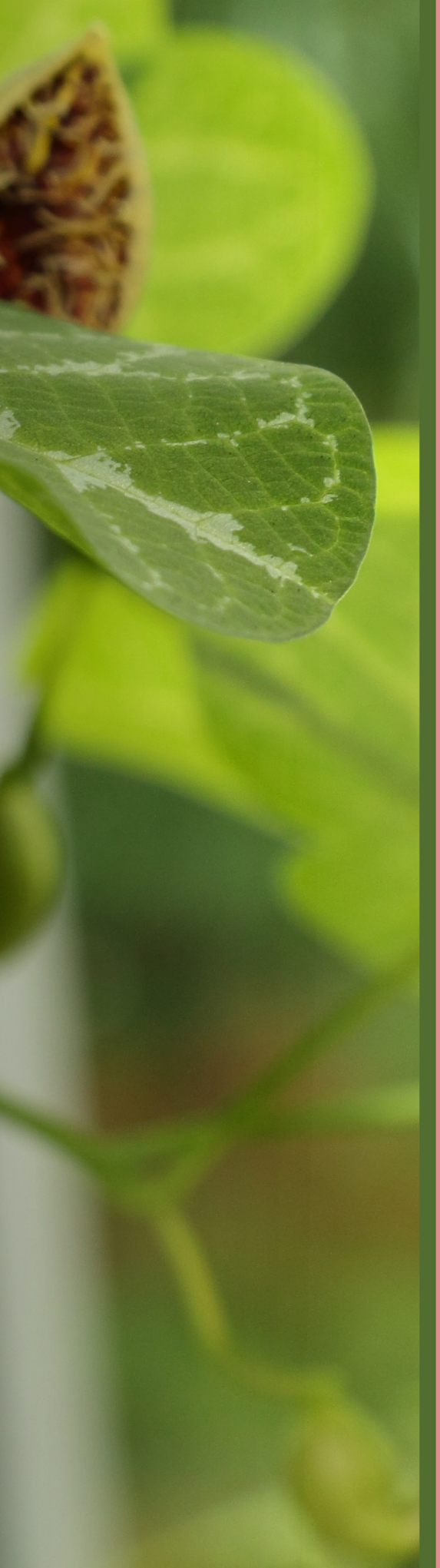


*Aristolochia fimbriata. Photo: C. T. Johansson. Creative Commons License 3.0., via Wikimedia Commons.*



# Flowers, colors and genes

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Flowers and their colors have always fascinated and inspired mankind, but their function is believed to be much more ancient and transcendental: to attract pollinating animals, especially insects. The Evo-Devo in Plants Group studies the genetic basis of the colors of Aristolochia, a genus of plants with very unique flowers.

The fascinating colors of plants and, in particular, of their flowers, provide immense aesthetic pleasure that moves naturalists, artists, gardeners and passers-by alike. For biology, the origin of these colors raises questions of great interest: How did plants develop such an extraordinary palette of colors? Why is it that the widest range of shades is mainly associated with flowers and fruits and not with other parts of the plant?

Alfred Russel Wallace, a noted English biologist, pointed out in 1879 that "the very existence of most of the colors of the organic world is due to the influence of color and light on the senses of animals". Colors promote visits from animals, which depend on the natural banquet that plants offer. Thus, some flower organs attract pollinators, who carry pollen from one flower to another in search of food and promote the reproduction of flowering plants. In turn, fruit attracts birds and mammals, which also, while feeding, disperse the seeds and extend the territory of the original plant populations.

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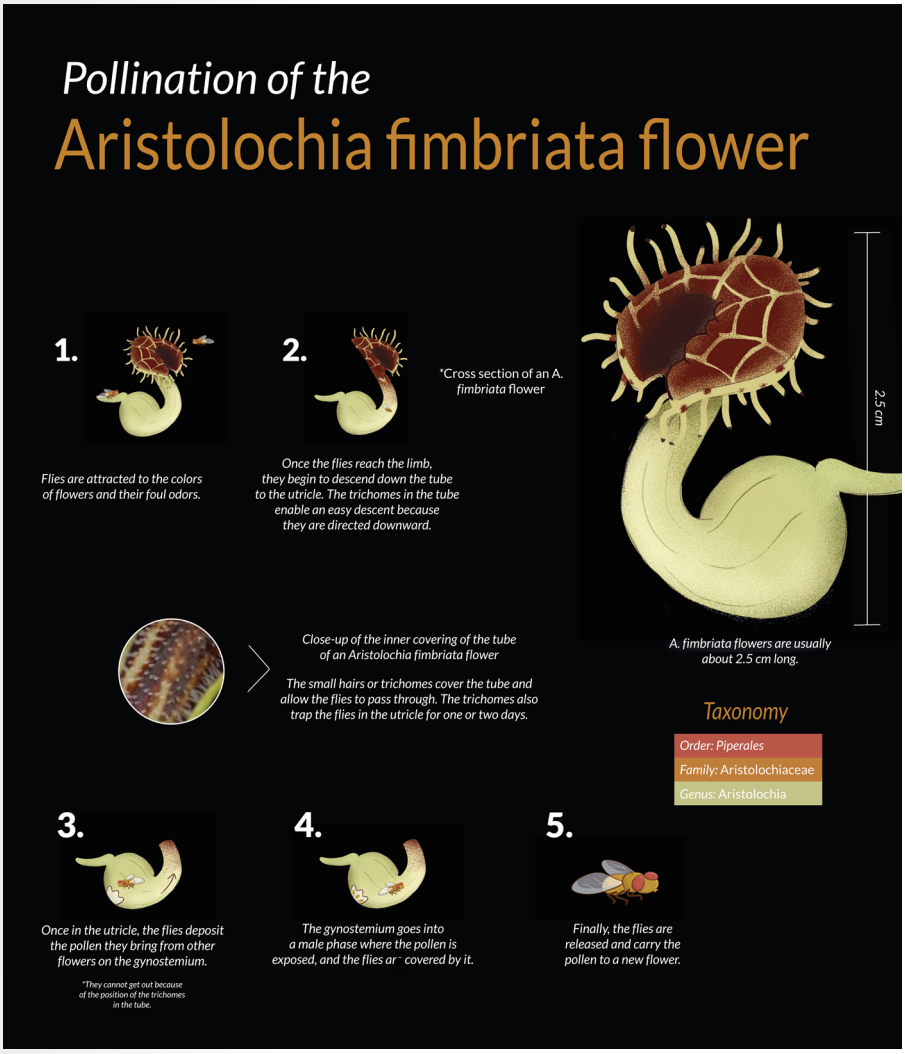
A typical flower is composed of four whorls. From the outside in, sepals, petals, stamens and carpels are formed. Sepals are generally green and usually protect the flower before it opens. Petals are almost always showy and attract pollinators through scent, shape or color. Stamens produce the pollen grains that carry the male sex cells. In the center of flowers are the carpels, which are always green at the beginning of their development and carry the ovules, where the female sex cells are located. If the male gametes from the pollen grains enter the ovules, and fertilization is successful, a new embryo begins to grow. The ovules transform into seeds, and the carpels become fruit, which, in many cases, is also colorful.

In flowers, color is given by the accumulation of molecules known as flavonoids, carotenoids and betalains, as we will see again later.

## *Aristolochia,* a Spa for Flies

Some flowering plants have only sepals, and these may have the appearance of petals. This particular case occurs in the flowers of "patitos" or "guacos", as they are known in Spanish, of the genus Aristolochia, family Aristolochiaceae. This family of flowering plants is ancient, which means that it diversified long ago in comparison to other plants and includes more than 450 species, of which there are about 29 in Colombia. Their petaloid sepals are usually yellow, purple or red and, most of the time, they have lined, dotted and spotted patterns. The colors, coupled with the foul odor of the plant's flowers, are believed to attract flies for pollination. The flowers are very elaborate. They are almost always shaped like a pitcher, as their sepals are totally fused. These flowers have three main parts: limb, tube and utricle.

The *limb* is the most exposed and extended portion, where flies first land. The tubular portion is the tube, which is transverse or descending. Flies enter the flower but cannot leave since the trichomes (hairs that cover the inside of the tube) only allow them to pass in one direction. This direction heads towards the inside




Infography: Sarita Muñoz Gómez, Natalia Pabón Mora / Carolina Gomes.

of the flower, which is an inflated bag that leads to the base, called the utricle. There, the flies are distracted by light rays, hairs, colors, smells, pollen and nectaries during one or two days of confinement. Once the flower is pollinated, the sepals wither, and the flies are released to enter other flowers.

What is most interesting is that, in different species of Aristolochia, these regions of the flower have different colors and can also change color during development in the same species. Colors in particular are produced by the accumulation of anthocyanins, which are molecules derived from flavonoids. These molecules are not only in the flowers. They also exist in the leaves, where they provide protection from UV rays, and in the fruit, where they generate flavors that attract animals so they disperse the seeds.

## The Genetics of Colors

In the laboratory of the Evo-Devo in Plants Group, which belongs to Universidad de Antioquia's Institute of Biology, we are interested in understanding the causes of the presence and distribution of color in these sepals with petaloid characteristics. As in many other biological processes, pigments are made up of metabolites: molecules that result from metabolic processes of cells, such as energy generation or substance production. This production is, in turn, controlled by genes.

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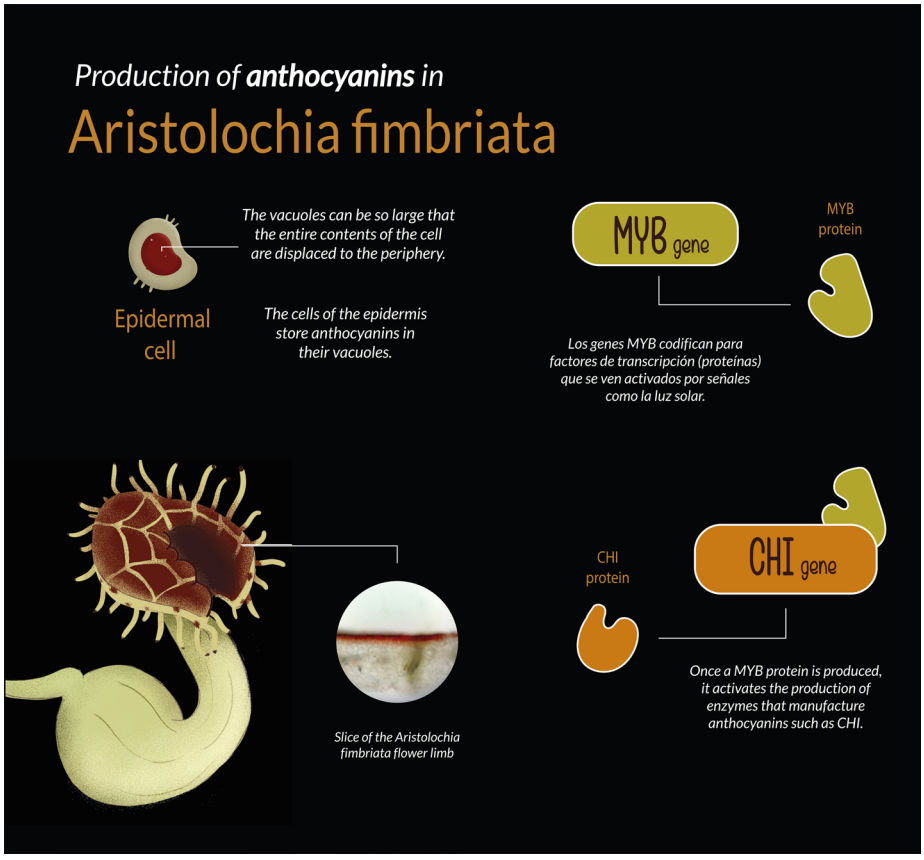


Infography: Sarita Muñoz Gómez, Natalia Pabón Mora / Carolina Gomes.

cies, particularly in *Arabidopsis thaliana*, which, although it has green sepals and white petals, produces many flavonoids. For this reason, for a correct understanding of the in which the pigments that give color to flowers and attract insects are produced and distributed, it is important to study their genes, those tiny hard disks full of memory on how organic processes must be carried out. For our study, we took some genes called R2R3- MYB as our reference. They are found in Arabidopsis thaliana (MYB75, MYB90, MYB113, MYB114).

In this plant, these genes are involved in the production of anthocyanins, which are pigments that give vegetables a red, purple or blue color. We wondered whether similar genes would be associated with anthocyanin production in the sepals of species of the genus *Aristolochia*. In contrast with *Arabidopsis thaliana*, a plant in which four genes related to anthocyanin production have been identified, we found that the *Aristolochia* species have only one gene that regulates this process.

To evaluate in which parts of the flower this gene was present, we decided to study two species of Aristolochia: A. fimbriata and A. manshuriensis. In both species, we could see that the gene was always active in purple parts, while it remained inactive —it did not generate instructions for processes— in yellow parts of the flower. These genes are also present in the leaves and green parts of juvenile flowers. Our results allow us to propose the R2R3-MYB genes as the most important controllers of the production of pigments such as anthocyanins in Aristolochia flowers.

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Our studies on color in these early-evolved species allow us to approach the mechanisms that gave rise to more complex anthocyanin production processes in other species that evolved later. The palette of flower and fruit colors is infinite in tropical plant species, and our research group

will continue to investigate the genetic mechanisms that regulate such diversity. X

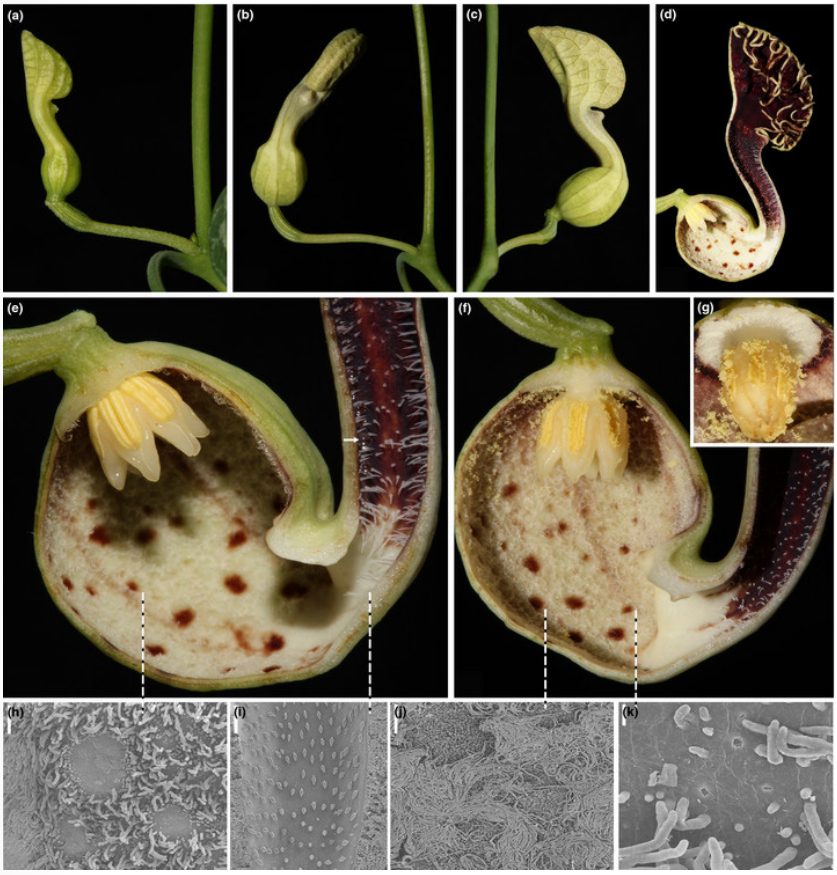
**Glossary**

**Transcription factors:** protein that controls the transcription of a specific gene, therefore, its presence or absence in an organ or plant part.

**Flavonoids:** phenolic compounds highly distributed in plants. They are mainly related to the production of pigments for animal attraction. They can be found in flowers, fruit, leaves and other plant organs.

**Pollinators:** generally, animals that are attracted by smells and colors to flowers, where they come into contact with pollen and carry it to another flower. This gives rise to fertilization.

**Whorls:** arrangement of organs that start at the same point and surround an axis. In flowers, four whorls are recognized: sepals, petals, stamens and carpels.




Cross section of A. fimbriata flower at different stages of development and pollination. Photo: Gonzalez, Favio & Pabon-Mora, Natalia. (2015). Trickery flowers: The extraordinary chemical mimicry of Aristolochia to accomplish deception to its pollinators. The New phytologist. 206. 10-3. 10.1111/nph.13328.