Chapter 10. **Fabaceae: The pea family**

The pea family:

Fabaceae

FABACEAE (Pea Family)

General physiognomy. Herbs, shrubs or trees with usually compound leaves; flowers variable in size and shape, mostly similar to the sweet-pea or mesquite; the fruit always a legume (a one-carpeled, beanlike, seed pod).

Vegetative morphology. Annuals, perennials, shrubs, and small trees with nitrogen-fixing nodules on the roots, and alternate, often compound leaves with stipules. Stipules are sometimes modified into glands or spines. Leaves may be trifoliate, palmately compound, pinnately compound, or divaricately bifoliate (i.e., having two folioles partially fused along the central vein).

Reproductive morphology. Flowers in three different forms, according to the subfamily; the fruits are peapod-like, single-chambered legumes with parietal placentation and one single row of large seeds. The seeds are often laced with poisons as defense mechanisms against predators.

Taxonomic relationships. Despite the variation in flower design within the taxon, the pea family stands by itself. The legume-type fruit is unique to this family as is the flower design in each subfamily.

Biodiversity and distributions. A huge, prominent family with 18,000 species worldwide and important in most floras including a vast number in Australia, where the genus *Acacia* alone has several hundred species.

Economic uses and ethnobotany. The peas are second in economic importance to the all-important grass family (Poaceae); besides the ability of the nitrogen-fixing nodules to enrich soils, the family is a source of highly nutritious fodder for livestock (alfalfa, vetches, sweet-clover, and clovers), and of protein-rich seeds for the human diet (beans, peas, lentils, chickpeas, fava beans, soybeans, among myriad more). In addition, the family contains many tropical and temperate ornamental species, too numerous to list. Prominent in California gardens are wisterias, acacias, redbuds, lupins, and clovers, among many more.

Nitrogen fixation: Making proteins out of thin air

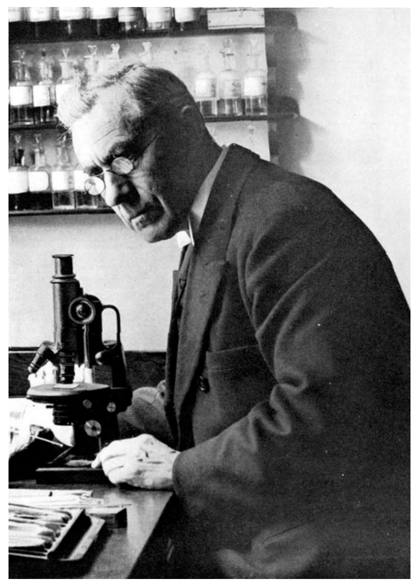
Nitrogen is an abundant element in nature, it forms 78% of the Earth's atmosphere in the form of gaseous nitrogen (N_2). However, converting nitrogen gas to nitrogen compounds like ammonia or nitrate is a complex process that demands a large amount of energy, because atmospheric nitrogen is a relatively inert gas that does not easily react with other chemicals to form new compounds. That is why, despite its abundance in the atmosphere, many plants are limited by the scarcity of available nitrogen in the soil.

Atmospheric nitrogen fixation, that is, the process by which nitrogen in the atmosphere is converted into ammonia (NH_3), nitrate (NO_3^-), or other molecules available to living organisms is essential for life because nitrogen compounds are required for the biosynthesis of the basic building blocks of living beings: nucleotides for DNA and RNA, and amino acids for proteins. Nitrogen fixation can occur through the electrical discharges of storm lightning and thunderbolts, and also some soil bacteria have evolved the ability to fix nitrogen from the atmosphere. Within these, a group of nitrogen-fixing bacteria called **rhizobia** have evolved a symbiotic relationship with legume.

There are as many species of rhizobia as there are species of legumes, but the mechanism is similar in all: Rhizobia infect the roots of the legume host. The growth of the bacterial colony generates a reactive response from the plant inducing the localized growth of the periderm tissues, the root's outer layer. This response reaction rapidly develops into a root nodule, where the plant houses the *Rhizobium* species inside its root tissue, in a process called **endosymbiosis**.

Safely protected inside the nodule, the bacteria convert atmospheric nitrogen into ammonia and then convert it into nitrogen compounds that are absorbed by the plant. The plant, in turn, provides the bacteria with energy-rich organic compounds, mostly sugars, made through the process of photosynthesis. There are many species and a number of genera of rhizobia, but, not surprisingly, the most common genus is called *Rhizobium*.

Until humans learned to synthesize urea from atmospheric nitrogen, in an energy-expensive and costly industrial process called Haber's synthesis, planting legumes in agricultural fields was the most common and sustainable form of replenishing nitrogen in the soil. The technique, used all over the world for centuries, is known as **crop rotation** and it consists of planting legumes such as clover, alfalfa, or beans after 5–10 years of agriculture to recover the fertility of the soil by allowing the rhizobia in the roots of the plants to harvest nitrogen out of the air and convert it into nitrogen compounds in the soil's root layer.



Martinus Willem Beijerinck, a Dutch microbiologist, was the first to describe the symbiotic interaction between legumes and nitrogen-fixing root bacteria.

Ah, those smelly beans! Seed lectins and human digestion

Beans, beans, they're good for your heart
The more you eat, the more you fart…

(English playground song, collected by Robert Crumb in *The Complete Crumb Comics* 1995, 11:42. Fantagraphics Books, Seattle)

Legumes, as a fruit, are extraordinarily variable. Some are winged, and finely adapted for wind dispersal. Others have a fleshy mesocarp and very hard seeds, and depend on animals eating the fruit for their dispersal. But how do beans disperse? Short-range dispersal is achieved by the abrupt opening of the dry pods, often shaken by storms, with the subsequent release of the seeds into the environment. Once on the ground, some of the seeds may be carried away from the mother plant by runoff water. But “explosive release”, as it is called, does not guarantee long-range dispersal. This normally achieved by seed-eating animals or “granivores”, mostly wild rodents such as field mice or squirrels. Although granivores collect the seed to eat it, they often store seeds in caches for times of scarcity, and fail to consume the stored seeds before a rain sets in and they germinate. So, the reward for seed-dispersing granivores is often the seed itself. The plant gives dispersers part of its seed crop, but some of these harvested seeds will escape predation and germinate.

But granivorous seed dispersers are not the only ones eating bean seeds. Because of their high protein content, beans are very enticing to other animals too. The bean weevils, a subfamily of beetles (Bruchidae), infest the seeds of beans, spending most of their lives inside a single seed. In contrast with vertebrate seed dispersers, who eat a large proportion of the seeds but provide an invaluable service in terms of long-range dispersal, weevils are true parasites: they eat the seeds and provide no beneficial service for the plant. For this reason, beans have evolved a series of defenses against weevils, filling the seeds with substances that are toxic to the insects, such as lectins, saponins, and trypsin inhibitors. Granivores will often also be affected by these toxic substances, but, given their larger body size, they are normally not lethally affected by the plant’s toxic defenses.

Humans may also react to the lectins and to some oligosaccharides in the beans. Because of our large body size, bean lectins are seldom seriously toxic to us (although cases of acute poisoning by eating poorly-cooked beans have been reported), but they can wreak havoc with the bacterial microbiome in our guts, the microbial ecosystem that resides in our colon and helps us digest our food. The end result of a dysfunctional gut microbiome is a bad digestion of our food with anaerobic fermentation/decomposition taking place in our intestines and with the subsequent release of methane and sulfide in gaseous form. Or, to put it bluntly, flatulence.

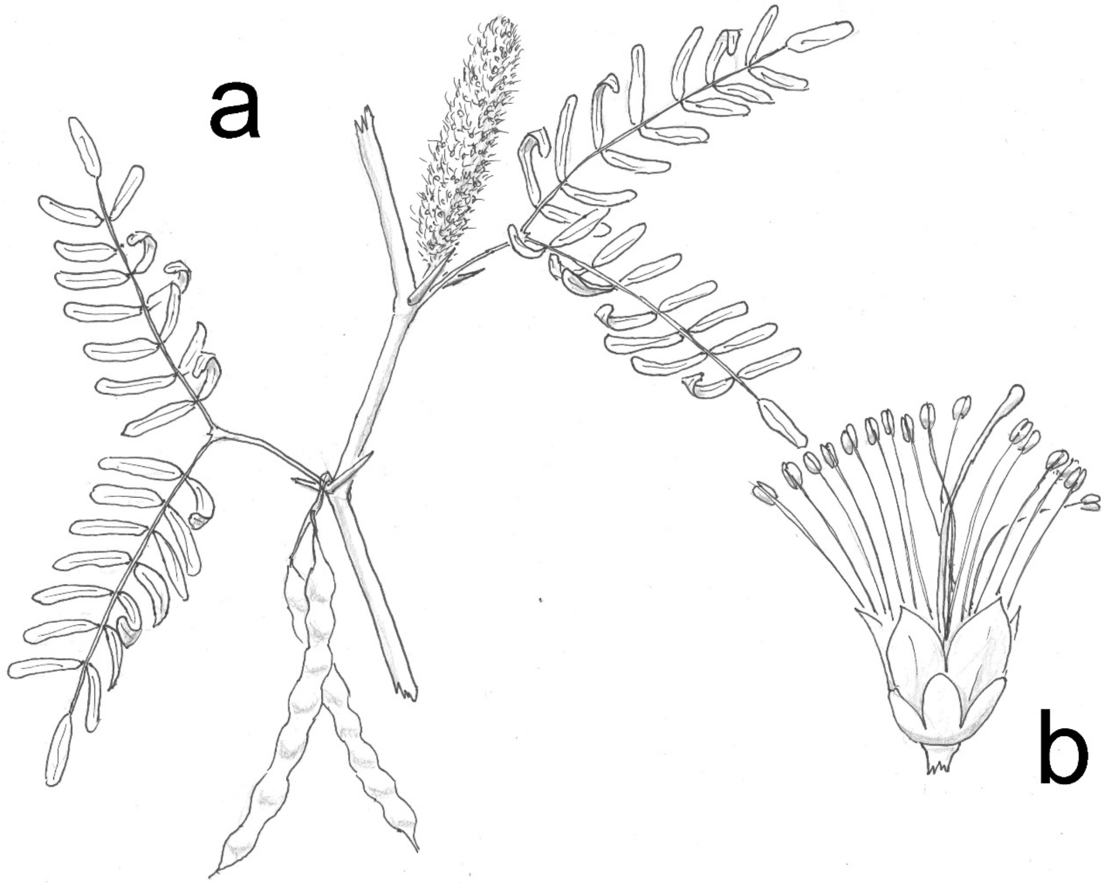
Lectins, however, as well as other weevil-attacking proteins are easily denaturalized with high temperature. Soaking the beans for a night, washing them to eliminate soluble saponins and lectins, and thorough cooking to degrade the toxins will make beans perfectly edible, and a very healthy food source. This is a case in which the high-temperature pressure cooker is preferable to the low-temperature crock-pot.

In short, cook your beans well (unless you want to feel like a weevil)!

Subfamilies. The family is divided into three subfamilies, (a) the **Faboideae** (pea subfamily), (b) the **Cesalpinoideae** (palo-verde subfamily), and (c) the **Mimosoideae** (the mesquite subfamily). Each subfamily has a unique and distinctive floral pattern that makes them easily recognizable.

***Mimosoideae** (Mimosa Subfamily)*

The mimosoid legumes have small, yellow, pink, or white flowers, clustered into dense heads or spikes. The flowers are regular or actinomorphic (a distinctive trait of this subfamily) with five separate sepals; five tiny, separate petals, very reduced in size and inconspicuous; five-to-many long, colorful stamens; and a single pistil with a superior, one-carpeled ovary. Leaves are bi-pinnately compound.



Mimosoids at a glance: (a) Compound, often bi-pinnate leaves with small actinomorphic flowers arranged in dense clusters. (b) Individual flowers have many long, colorful stamens that function as pollinator attractants as well as pollen providers (mesquite, *Prosopis glandulosa*).

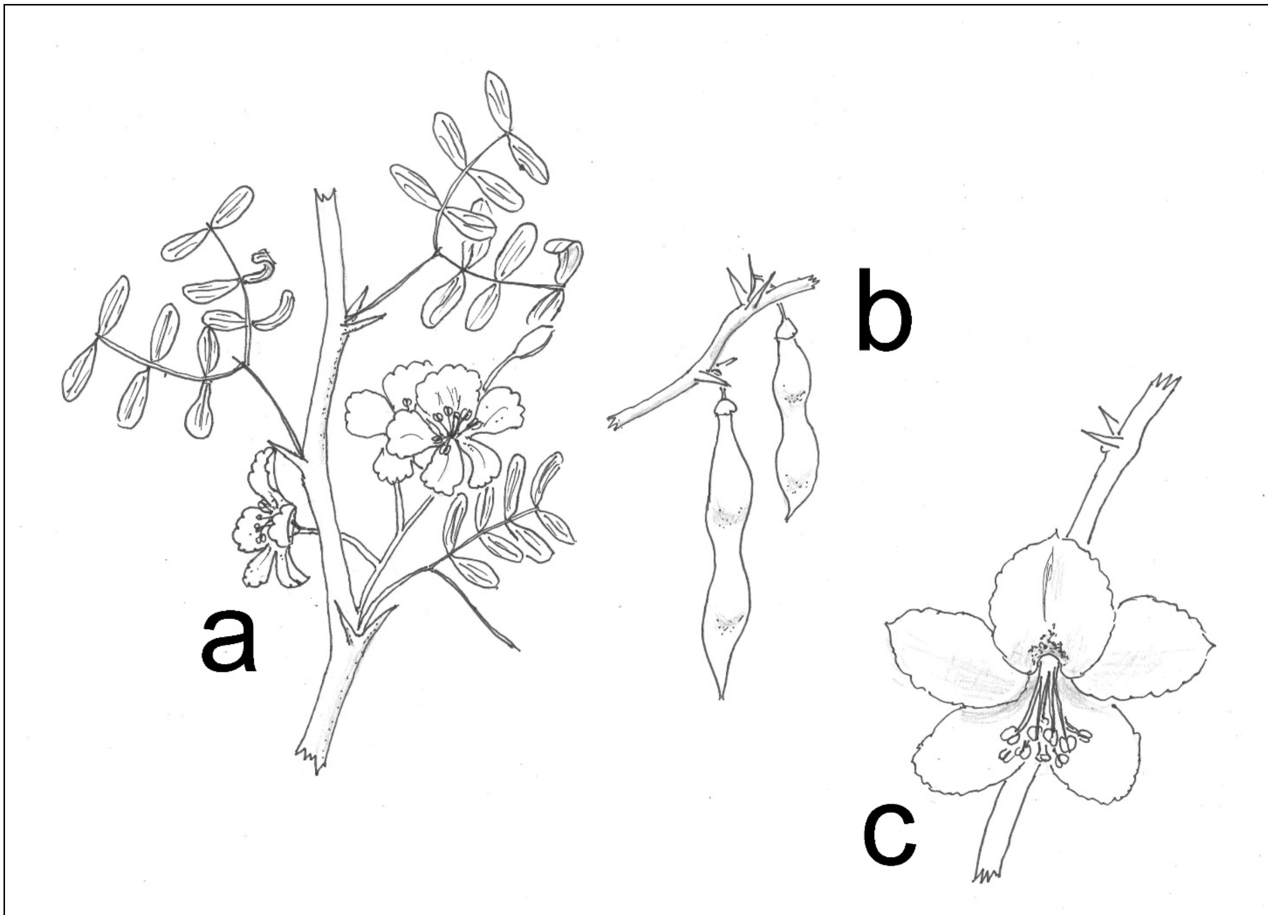
Regional genera and species. The region has three native genera (*Acacia*, *Calliandra*, and *Prosopis*) found primarily in deserts and drylands. Acacias (*Acacia* spp.) are shrubs and trees with yellow or white, rounded flower spikes, with many species introduced from Australia and often naturalized near the coast. Our native species, the catclaw (*Acacia greggii*), occurs in the deserts of southern California. The larger, and more outstanding, mesquite tree (*Prosopis glandulosa*) is often found in these same deserts, especially along dry arroyos in in flat sandy plains.

Acacia greggii (catclaw) – Woody shrub to small tree common in the eastern Sonoran and Mojave deserts, with clusters of small, pale-yellow flowers, and nasty cat-claw-like prickles growing from the epidermis of the shoots.

Prosopis glandulosa (mesquite) – Long-lived desert tree with elongated inflorescences of pale white-yellow color and long spines derived from transformed leaf stipules.

Caesalpinoideae *(Paloverde Subfamily)*

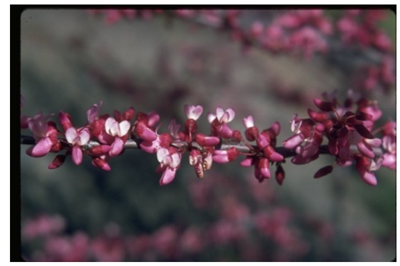
In the caesalpinoids the flower are bilateral (zygomorphic), although at times only slightly so; the calyx, and the corolla are conspicuous; five mostly free petals (the two lowermost may be partially fused); the lateral petals (wings) larger than the central one (banner). The flowers are showy, and open widely; leaves are pinnate, bipinnate, or bilobed.



Cesalpinoids at a glance: (a) Compound or sometimes bi-pinnate leaves and open, zygomorphic flowers with exposed androecium (10 stamens) and gynoecium; (b) fruit a legume, and (c) the flower has five petals: the upper banner petal is commonly larger and colorful, the lateral wind petals guide insects to the center of the flower, and the two lower keel petals form the landing surface for arriving pollinators (paloverde, *Parkinsonia florida*).

Regional genera and species. Our region has six native genera (*Cercis*, *Caesalpinia*, *Parkinsonia*, *Senna*, *Gleditzia*, and *Hoffmannseggia*) found primarily in deserts and drylands. The exception is the redbud (*Cercis occidentalis*), which grows in the slopes of the sierras and transversal ranges in upper chaparral and temperate forests. East of the Peninsular Ranges, in the California Deserts, the palo verde (*Parkinsonia microphylla*) is commonly found along desert plains and washes.

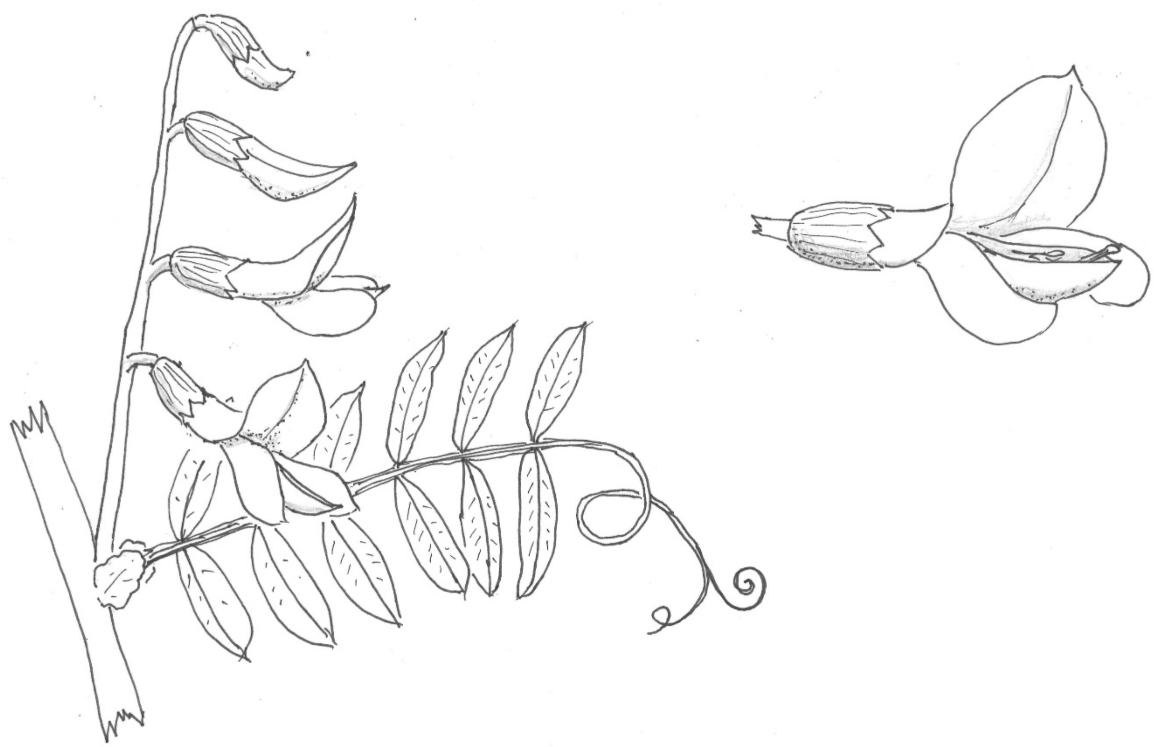
Cercis occidentalis (redbud) – Shrub to small tree with colorful, purple spring flowers and bilobed leaves. Common in the sierra slopes from oak woodlands to pine forests.



Parkinsonia microphylla (palo verde) – Small desert tree with thorn-tipped, broom-like branches; yellow, wide open flowers and small, pinnately compound leaves.

Faboideae *(Pea Subfamily*, also known as Papilionoideae*)*

The papilionoid legumes are by far the most diverse subfamily in California. Their flowers are showy, in many colors, and often clustered in spikes and racemes. The plants in the subfamily can form perennial shrubs, creeping vines, or herbaceous annuals, but never woody trees. The most distinctive trait of the subfamily is the showy and strongly zygomorphic *papilionoid flower*, with five partly joined, sometimes bilateral sepals, five petals with an upper showy banner, two side wings, and two central petals joined into a boat-shaped keel containing 5 or 10 stamens, with 9 of them often joined into a tube. The form of the petals is called papilionaceous or "butterfly-shaped" (from the Latin *papilio*, butterfly).



Papilionoids at a glance: Compound, palmate, or trifoliate leaves and open, zygomorphic flowers with anthers and a single pistil enclosed within a keel formed by the two lower petals. The flower has five petals: an upper, showy banner, two lateral wing petals, and two lower petals fused into a single keel that opens when pollinators land on it (San Diego pea, *Lathyrus vestitus*).

Regional genera and species. With more than 30 genera in our region, the diversity of the papilionoid legumes is very high. The most common species in our valleys' sage scrub, and our mountain slopes chaparral are all herbaceous. The Pomona locoweed (*Astragalus pomonensis*), the arroyo lupine (*Lupinus succulentus*), the winter vetch (*Vicia villosa*), and the chaparral sweet pea (*Lathyrus vestitus*) are all common native annual plants of the Santa Rosa Mountains and the hills around Riverside, often growing together with the winter vetch (*Vicia villosa*), and introduced European annual climber that has become naturalized here. The deer weed (*Acmispon glaber*) is common in the cooler slopes of the San Bernardino Mountains, where patches of the showy, but highly invasive, Spanish broom (*Spartium junceum*) can be found. The common white clover (*Trifolum repens*), also of European origin, is commonly seen in the Riverside lawns.

Astragalus pomonensis (Pomona locoweed) – A regional endemism, the locoweed grows in plains and sandy banks. The clusters of pale-yellowish flowers mature into inflated, rattle-like pods.

Acmispon glaber (syn. *Lotus strigosus*; deer-weed) – A common annual or herbaceous perennial with spike-like flower clusters; corolla yellow, turning red as the flower ages; fruit and indehiscent legume with 2-to-few seeds.

Lupinus succulentus (arroyo lupine) – The most common lupine in our region, especially along roadsides and disturbed areas. Vivid blue-purple flowers.