Chapter 6. **The three-parted families**

The three-parted families:

Polygonaceae and Liliaceae

POLYGONACEAE (Buckwheat Family)

General physiognomy. Mostly herbaceous plants with simple leaves in basal rosettes, or, if cauline, attached to swollen nodes, sometimes with papery stipules. Flowers tiny (< 2 mm) normally pink or whitish, and arranged in dense clusters or corymbs. Sepals and petals similar to each other, flowers showing 4 to 6 tepals in two identical series.

Vegetative morphology. Herbaceous annuals, perennials, and small shrubs with jointed stems; simple, alternate leaves with un-toothed, smooth margins, frequently arranged in basal rosettes in annual species. Stem (cauline) leaves frequently attached to swollen nodes, with sometimes papery stipules, called **ochreas**, sheathing the base of the petiole.

The Polygonaceae at a glance: Tiny, chiefly pinkish-white flowers, clustered in dense inflorescences sometimes inside cup-shaped bracts called involucres. The perianth is composed of 6 (sometimes 4) tepals (sepals and petals similar in size and color), 3 to 9 stamens and a single pistil with a superior, 3-carpelled ovary bearing a single fruit. The fruits are small, hard, usually 3-sided achenes (Illustration: *Eriogonum fasciculatum*, "California buckwheat").

Reproductive morphology. Flowers are tiny, normally pinkish-white, but sometimes also green, brownish, yellow, or red, and grouped in dense clusters of umbels, cymes, spikes, or racemes; sometimes inside cup- or vase-shaped bracts called **involucres**. The perianth is composed of 4 to 6 tepals (no distinction between sepals and petals), 3 to 9 stamens, and a single pistil with a superior, 3-sided ovary and 3 styles. The fruits are small, hard, usually 3-sided achenes.

Taxonomic relationships. The floral plan of a typical flower in the buckwheat family is different from most other families, especially those species that have 6 tepals, 9 stamens, and a 3-sided ovary. Nonetheless, some species that feature green, wind-pollinated flowers might be mistaken for members of the related goosefoot family (Chenopodiaceae) or amaranth family (Amaranthaceae). Those families, however, lack papery stipules on their leaves and do not have 3-sided ovaries.

Biodiversity and distributions. Over 1,100 species widespread throughout the globe, most richly represented in the northern hemisphere, with a few species in tropical areas. Arid Western North America (California, Arizona, Nevada, and Colorado) is rich in species of the subfamily Eriogonoideae. Among the species in this subfamily, the Californian desert buckwheat (*Eriogonum* spp.) has radiated spectacularly in the region into more than 120 species and a similar number of subspecies nested within those species, occupying a panoply of ecological niches, from desert scrub, to moving sand-dunes, to montane chaparral, to coastal scrubs. No other part of the world harbors the immense biodiversity of *Eriogonum* buckwheats that are found in California.

Economic uses and ethnobotany. Some of the edible plants in the family include the tropical sea-grape (*Coccoloba uvifera*), whose sweet fruit bunches are commonly found in beaches of the Caribbean; rhubarb (*Rheum rhabarbarum*) cooked in winter for it mildly acidic, fruity, leaf stalks (i.e., the enlarged petioles and midveins); the French sorrel (*Rumex acetosa*) used as cooking greens, and the buckwheat (*Fagopyrum esculentum*), an economically important pseudo-cereal used frequently in Asian cuisine to make soba noodles.

Impersonating the goddess of plenty: The pseudocereals

Ceres, Roman goddess of agriculture (English engraving ca. 1789)

"Ceres, most bounteous lady, thy rich leas
of wheat, rye, barley, vetches, oats and peas…"
William Shakespeare
The Tempest, Act 4, Sc. 1

In Roman mythology, Ceres—also called Demeter in the Greek tradition—was the goddess of agriculture, the benign and generous overseer of bountiful harvests. In her honor, we give the name cereals to those carbohydrate-rich seeds that provide us with the majority of our calories and keep us going. Together with the seeds of legumes, called pulses, and tubers such as the potato, cereals form the base of a balanced diet: Cereals and tubers provide the bulk of our calories in the form of starch—the main fuel for our metabolic engines—while pulses provide quality protein necessary to build muscle. All cereals belong in the grass family, the Poaceae, and include such important foods as wheat, rice, corn, barley, oats, and millet. Their grains are rich in starch, and can be ground into flour that is then used to make baked loaves or flattened *tortillas*. We seem to have evolved our most productive agriculture, and indeed our whole civilization, around the cultivation of these grain-yielding grasses.

However, in some parts of the world early farmers learned to cultivate plants that also produce starchy seeds but belong in families quite distant from the grasses. The fruit of these plants is normally an achene and not a caryopsis, and they belong in the dicotyledons not in the monocots. They look nothing like a grass, but their agricultural use is the same as that of grasses, that is, to provide bulk carbohydrates for humans consuming them. For this reason, we call these species pseudocereals, Pseudocereals arose independently in different civilizations as an alternative to the cultivation of true cereals. The main pseudocereals in the world are buckwheat, amaranth, and quinoa. Buckwheat (*Fagopyrum esculentum*) belongs in the Polygonaceae and was first domesticated in China some 6000 years BP. It is now a major crop in Asia, where it is consumed in various forms, especially for noodles. Amaranth (*Amaranthus* spp., family Amaranthaceae) was domesticated in Mexico, Central, and South America over 5000 years ago. It was known as *huauhtli* in Nahuatl, the language of the Aztecs, and is still successfully cultivated in Central Mexico. Quinoa (*Chenopodium quinoa*, family Chenopodiaceae) was domesticated in the Andes by the Quechua people and is still widely cultivated today as a healthy, high-protein and non-gluten grain.

There is evidence that all three pseudocereals originated as weeds of true cereals. The farming process selects weeds that resemble the crop they infest by acquiring the same life cycle, environmental preferences, and seed propagation mode. After long periods of selection by plowing and farming, the weeds become perfect "crop mimics", very similar to their host crop in their agricultural requirements and life cycle. At this point, many traditional farmers simply have given up and started cultivating the weed instead of the original crop. Quinoa and amaranth, which originated as weeds of potatoes and corn, have the added advantage that their leaves can be eaten as nutritious greens during their juvenile stages.

California genera and species. The region has 17 native genera and four non-native or partly nonnative genera. Locally common plants include the following:

Eriogonum fasciculatum (California buckwheat) – The most abundant native buckwheat (*Eriogonum*) in our area. Perennial small shrub, small pinkish-white flowers subtended by involucral bracts in dense umbel-shaped clusters that change into a coppery brown as they age. Acicular leaves in cauline clusters or fascicles.

Polygonum arenastrum (knotweed) – Dense prostrate annual with slender but tough, wiry stems. Leaves with a conspicuous basal sheath (ochrea). White pale flowers borne in leaf axils.

Rumex crispus (curly dock) – Perennial herb displaying large green, oblanceolate leaves (30 cm) with wavy margins. Pale green flowers on panicles at the end of slender stems.

LILIACEAE (Lily Family)

The lily family has been controversial for many years, and different studies have treated it in many different manners. Now with modern molecular evidence we can no longer accept the lily family as an all-encompassing group held together by a similar basic flower plan, and the large group of Liliacaeae in California has been divided into several (ca. 17) splinter families. Many of these families are not evolutionarily related and represent several distinct lineages. For convenience in field identification, however, we are placing the members of this group into this extended (and, under the light of modern research, somewhat artificial) version of the lily family, including two distinct and important groups: the agave family (Agavaceae) and the onion family (Alliaceae). As a result, our coverage of the lily family embraces all 3-parted monocotyledons, including not only true lilies but also long-lived desert plants with succulent leaves and massive clusters of flowers (the Agavaceae), and most bulb-bearing monocots that display their flowers in umbels (the Alliaceae).

General physiognomy. Often bulb-bearing plants with simple, parallel-veined leaves and clusters (umbels, panicles, or racemes) of showy flowers with usually six colored tepals in two series of three sepals each.

The Liliaceae at a glance: Mostly herbaceous, short-lived plants with parallel-veined leaves arranged in basal rosettes before reproductive elongation of the stem. Actinomorphic, often showy, flowers with six colored tepals (three sepals and three petals of similar color and shape); single pistil with a 3-chambered ovary formed by three connate carpels. The fruits are normally dry capsules that dehisce along the carpel sutures, gradually releasing the seed as the dry (Illustration: *Dichelostemma capitatum*, "blue dicks").

Vegetative morphology. Mostly annuals or root-perennials with bulbs, tubers, or rhizomes, leaves with parallel veins, normally arranged in basal whorls before reproductive elongation of the short, ground-level stem.

Reproductive morphology. Flowers usually showy, sometimes small, of many different colors and shapes, actinomorphic, borne singly or arranged in clusters of umbels, panicles, or racemes. Perianth composed of 6 colored tepals (similar sepals and petals), 6 (sometimes 3) stamens, and a single pistil with a 3-chambered ovary formed by the connation of 3 carpels. The fruits are normally dry capsules, or, more rarely, many-seeded berries.

Taxonomic relationships. The iris family (Iridaceae, also a monocot) may be sometimes confused with the Liliaceae. The Iridaceae, however, differs by having lanceolate (sword-shaped) leaves, 3 stamens (most lilies have 6), an inferior ovary (most lilies have superior ovaries), and flower buds hidden inside a pair of leaf-like bracts. As mentioned before, as a group the Liliaceae is controversial and recent botanists have split it into many separate families based on major differences in embryo development, seed details, leaf-vein patterns, and molecular studies. For this chapter, two distinct lily-like families have been lumped together within the larger Liliaceae: the Agavaceae (agave family), which is easily recognizable by its large, succulent leaves attached to a long-lived basal rosette and its immense inflorescences in gigantic flowering stems (or scapes); and the Alliaceae (onion family), recognizable by its characteristic onion odor and bracted umbels of flowers.

Biodiversity and distributions. The larger lily family has around 1,500 species worldwide and is poorly represented in tropical rainforests, although several live in tropical highlands and valleys. The family is particularly diverse in South Africa, the Mediterranean Basin, Australia, and California.

Economic uses and ethnobotany. The genus *Allium* contains a number of economically important crop plants, such as the onion (*Allium cepa*), garlic (*A. sativum*), leek (*A. porrum*), shallot (*A. oschaninii*), and chives (*A. schoenoprasum*). The genus *Agave* contains plants that are fermented to distill alcoholic spirits, such as the cultivated *Agave tequilana*, used for the production of tequila, and many other species of wild agaves used to distill mescal, an artisanal but powerful spirit. Because the leaves are rich in strong, parallel vascular bundles, two other species (*A. fourcroydes* and *A. sisalana*) are used to produce a natural fiber called henequen hemp. The widely cultivated *Aloe vera*, of African origin, is famous for the healing gel that seeps from inside its fleshy leaves, which is used in myriad herbal remedies. Finally, because of the striking beauty of their flowers, many plants in the family are used as ornamentals, including the tiger lily (*Lilium tigrinum*), the tulips (*Tulipa* spp.), the hyacinths (*Hyacinthus* spp.), and the Andean lily (*Alstroemeria* spp.).

Darwin in the kitchen: Why onions make grown-ups cry and garlic keeps vampires away

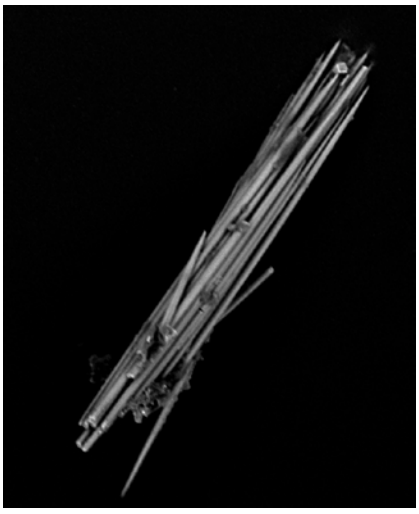
Like all monocotyledons, the Lilliaceae lack true wood. They are really soft, leafy plants that often have two clear life-cycle states: they first spend time as a rosette phase, storing nutrients in underground organs (bulbs, tubers, or rhizomes) and then enter into a reproductive phase in which they produce the flowering stem or scape to reproduce and then die. Because of their herbaceous nature and their ability to store nutritious reserves underground, they are a favorite target for burrowing, or grubbing animals such as gophers, moles, or wild hogs.

Plants in the Lilliaceae have evolved a variety of ways to prevent ground-digging herbivores from eating their bulbs. Species in the onion family (Alliaceae), for example, produce irritating substances called sulfenic acids that act as a lachrymatory agent (triggers tearing and stinging on contact with the eyes) when the plant tissue is damaged. The release is due to the breaking open of the onion or garlic cells. Damaging the cell allows sulfur-containing amino acid (sulfoxides, stored in the vacuoles), to get in contact with specific enzymes called alliinases, which then break down the sulfoxides into irritating sulfenic acids. Sulfenic acids, also called "lacrimatory factors" or LFs, are so hated by many burrowing animals that many gardeners in California plant wild garlic in their flower beds to keep pesky gophers away. Humans are able to consume large amounts of onions because the process of cooking partially breaks down the LFs and also denaturalizes the alliinase enzyme, preventing the formation of the irritants.

The legendary reputation of raw garlic in successfully keeping animals at bay was exploited by the Irish author Bram Stoker in his famous novel *Dracula* (1887) where Professor van Helsing uses garlic to protect helpless Lucy Westenra from the terrifying vampire, Count Dracula, by placing it in her room and around her neck.

Other plants defend themselves by combining calcium from the soil with oxalic acid, a simple product of the plant's metabolic cycle. The result is a set of sharp, needle-shaped crystals of calcium oxalate called raphides. Raphides penetrate into the mucilaginous tissue in the mouth and tongue of any herbivore daring to eat the plant, producing a very painful sensation in the mouth and, if swallowed, tearing the soft tissues of the throat or esophagus of a plant predator chewing on the plant's leaves. If the plant tissue itself contains toxins, raphides can produce severe toxic or allergic reactions by facilitating the passage of the plant's poison through the herbivore's skin. Animals quickly learn to avoid raphide-bearing plants.

Agaves contain large amounts of raphids and most of them are inedible in raw form. However, humans have managed to consume agaves in different ways, such as distilling the fermented tissues, as in tequila and mescal, extracting juicy exudates from the center of the rosette, as in *pulque*, or by pit-roasting the center of the rosette for 2–3 days, until the process blunts down the needles by partial dissolution of the sharp needle-point.



Raphides in *Agave deserti*, in California (photo credit: Yocelyn Villa, Ezcurra Lab)

California genera and species. The lily family is one of the most varied and characteristic of the flora of California. A few examples of locally frequent wildflowers include:

Calochortus splendens (splendid mariposa lily) – Herbaceous bulb-perennial with linear leaves in basal rosettes and sparingly branched slender stems. Flowers with much reduced sepals and large petals of pale violet color.

Dichelostemma capitatum (blue dicks) – A common, onion-like plant with underground bulbs and slender, tall (40–60 cm) stems with corymbose clusters of white, purple, blue, or lavender flowers.

Yucca whipplei (chaparral yucca, Spanish bayonet; now often placed in the Agavaceae) – Ground-level rosette of sharp, bayonet-shaped leaves that terminate in rigid spines. White flowers in conspicuous gigantic racemes up to 2 m tall. Flowers in May.

Sisyrinchium bellum (blue-eyed grass; now often placed in the sister family Iridaceae) – Short-lived perennial, common in grasslands and moist open spaces. Despite its name, it is not a grass but an iris. Star-shaped bluish-purple flowers with a yellow center borne terminally on slender stems,