

TAXONOMY: THE STUDY OF IDENTIFICATION, CLASSIFICATION, AND NOMENCLATURE

A COMBINATION OF SCIENCE AND
ART

Taxonomy or Plant Systematics, despite what people would have you believe, really is not an exacting science in many ways

- This statement mainly applies to the identification process, so we'll start there.
- Identification is very different from classification, which is even more problematic
- There are several methods for identifying plants
- Many books rely on matching a description or illustration with the plant you have in hand
- Most people first go to books with color photos, but actually good line drawings can show more detail
- Books with color photos or drawings often are arranged by color, but this is imprecise because of different color perceptions by different people, and some genera fall in many color categories, making finding the species difficult

The vast majority of horticulture books use the color or form method for identifying rather than discrete, consistent characters

- Besides Bailey's *Encyclopedia of Horticulture* and a few others, few horticulture books cover the whole spectrum of garden plants, leaving many possibilities out
- Few horticulture books address a *Key* for correct identification (more about keys in a moment)

If you're interested in a special group of garden plants like roses, chrysanthemums, and cacti there are books covering those subjects in fair detail, making i.d. somewhat more practical

- Currently, the best way to id garden plants is by learning to key to family and then consulting books on genera, if available

Identification of native plants, by contrast, is often a surer thing;
many states have floras of their native plants

- Even better for the beginner are books specializing in one particular geographic area, such as Marin County
- The majority of these i.d. books contain not only some illustrations, but *dichotomous keys* for making a determination
- The inexact part of this aspect of i.d. is because keys contain many inconsistencies and sometimes just plain mistakes
- The other inexact part is that plants vary a lot in the wild, and no keys take all of the variation into account
- For example, the genus *Fragaria* (strawberry) has flowers with 5 petals, but occasionally an individual will display 6 petals, instead. This could completely mislead the identifier because number of flower parts is heavily emphasized

Dichotomous keys also require knowledge of terminology, since many terms are more precise than using ordinary words

- With flowering plants, the starting point is usually determining if your plant is a *monocot* or *dicot*
- Those two major categories are based on several traits, but the terms themselves refer to the number of seedling leaves—two for dicots, one for monocots
- This trait is impractical to use in most cases, since plants lose their seedling leaves soon after germinating
- There are also exceptions to the number of cotyledons, as there also are for most criteria to recognize these two groups

Fortunately, there are other rules that help determine monocots and dicots, which are easier to apply

- The two most important traits are leaf vein pattern (veination) and numbers of petals and sepals
- Dicots usually have a network or featherlike pinnate pattern of veins while
- Monocots have the major veins parallel to each other
- However, there are occasional exceptions *and* some leaves don't show an obvious vein pattern
- For petal and sepal number, dicots have 4 or 5 (except for some early dicots that have a large number),
- Monocots have 3 or multiples of 3
- Again there are occasional exceptions
- There are other traits for the two groups but many, like pollen details and wood anatomy are difficult to deal with

Cow parsnip, *Heracleum maximum*, has leaves with a pinnate vein pattern and is a dicot



Alumroot or *Heuchera* leaves display a netlike vein pattern



Irises, like *I. confusus* are typical monocots with the main veins running parallel the length of the leaf



In some monocots, like calla lily (*Zantedeschia aethiopica*), the parallel veins come of a midrib, making the vein pattern potentially confusing



The leaves of salvia blanca, *Sideritis* sp., are so densely covered with woolly hairs that the vein pattern is obscured. Sometimes rubbing the hairs off will reveal the veins.



The second part of a key is finding the family

- There are roughly 450 families of flowering plants in the world, with around 160 for California
- Because the majority of our natives belong to 40 to 50 diverse families, learning the field traits to recognize them helps greatly in the i.d. process
- For horticultural families, especially including tender indoor plants, the number of families is vaster and thus more difficult
- Families consist of anywhere from a single species to 20,000 or more (orchids and composites)
- Most families have a cluster of *key* features that aid in i.d.; we'll be practicing those during the course

Once the family has been determined, it's time to find the genus.
Every family has one (*type* genus) to hundreds

- In California's flora, there are many genera that you can also learn to recognize in the field including *Eriogonum*, *Arctostaphylos*, *Ceanothus*, and *Delphinium*.
- In some families, the genera (plural of genus) are better defined but some overlap with each other (although very few genera are capable of crossing)
- Once the genus has been found out, the species or kinds need to be figured out. Some genera have a single species (monotypic) while others have hundreds of species, in which case keying to species can be difficult (especially when microscopic characters are used as in the Boraginaceae)
- Species do often hybridize, making exact i.d. almost impossible in some groups like the oaks

Some genera can also be learned on sight, although sorting out the species may be difficult. Manzanitas (*Arctostaphylos* spp.) are identified by the shiny red bark and nodding, urn-shaped white or pink flowers



Another easy-to-recognize genus is *Ceanothus*, which features hundreds of tiny flowers in dense spikelike clusters, the flowers with 5 colored sepals *and* petals



The genus *Delphinium* (larkspur) has highly distinctive flowers that identify it. The sepals are showy and brightly colored with the upper sepals forming a pointed nectar spur



Although some species are very distinctive, many are variable, making it hard to know where to draw the line between one species and a close relative

- Species with consistent variations (flower size, habitat, flower color) are often subdivided into *varieties* or *subspecies*
- Unfortunately, the distinction between these two categories are now blurred, so either one can apply to what I'm describing here
- These *botanical* varieties are not the same as varietal names used in most nurseries—their varieties are actually more accurately called *cultivars* (short for cultivated variety), and most major groups are loaded with them
- Cultivars are genetic variations that appear in the wild, in a nursery, or someone's garden that have at least one trait different from its sisters and brothers. Examples include flower color, double petals, resistance to frost, height of plant, and more

Next we'll turn to classification, which refers to a system of placing plants for retrieval through i.d.

- Today, many factors determine the generation of classification systems, but first let's take a look at what went on before
- Often the Greeks are credited with the start of classification systems, but we must remember our European bias; many other cultures had systems for grouping plants
- These first systems were what we now call “arbitrary”, meaning they weren't based on sound concepts of relationship and evolution
- Typical categories for these systems included (much as gardeners do today), tree, shrub, herbaceous, vine, etc.
- Such systems are practical especially because the known number of species was very small at that time

Many classification systems suffered inaccuracies when copied and little in the way of new ideas during the so-called Dark Ages

- As the Dark Ages ended, people looked anew at classification, now with an eye to similarity as an indication of relationship and thus position in the system
- One of the early popular ways of doing “natural” systems was counting number of flower parts, which is still done today
- As time went on, people more and more looked at all the obvious, morphological features to produce their version of a system
- Some weighted certain characters over others, again a practice that sometimes (often unconsciously) is done today
- During this period, Carl Linnaeus invented a way of naming the plants in the systems, more about that later

As the concept of evolution came to light by Charles Darwin and others, there was a move to reflect which groups gave rise to other groups, an overview of evolution

- Many of the traits used in natural systems contributed but some new ideas were bandied about, such as which flowers are “primitive” and which “advanced”, an indication of when the groups evolved
- These systems are called *phylogenetic*, and all systems since have been of this kind
- You might be tempted to think that we could figure out the evolution of plants but we still are working at it
- Most flowers do not fossilize, so depending on the fossil record, use in preparing these systems is seldom important
- Often only fragments of plants are fossilized, and we don’t really know if a leaf fragment goes with a wood fragment
- Thus, most of the basis for phylogenetic systems has been selecting characters that are supposedly ancestral and others that are derived. Specializations often indicate this idea.

During the construction of phylogenetic systems, most botanists diagrammed relationship as branches of a tree or something comparable

- In the last 30 years, these systems have evolved and are presented in a new format, what we call *cladograms* (literally stem diagrams)
- Cladograms are based on percentages of similarity, so that many groups don't necessarily form a family, genus, or species—intermediate states exist. We still don't know the best way of naming these groups
- Cladistics (the study of plants) is now computer generated, with dozens (possibly hundreds) of obvious and microscopic traits used to create degrees of relationship
- Contributing to these cladograms is input from the realms of genes—certain genes are followed between groups, and the more they diverge, the less related they are
- Such traits are now turning old concepts on their heads

For example, similar overall appearances are sometimes due to parallel evolution as with cacti resembling certain desert euphorbias

- For such examples, we already knew the groups weren't related because of flower structure, but newer studies...
- Sometimes place plants with very different looking flowers in the same family as, for example, the penstemons from the Scrophulariaceae and the plantains in the Plantaginaceae (many scrophs are now placed there)
- When something like this happens, it wreaks havoc with trying to learn to i.d. plants by appearances, making family concepts sometimes almost impossible to characterize
- As a consequence, many changes, some startling, have come down the pike, and life is not as straightforward
- What we really need are two classification systems: a practical one based on appearance for field botanists, and a theoretical one for those who study evolution

Cacti have evolved to survive in harsh, often desertlike conditions and are confined to the Americas. In this family, water is stored in a photosynthesizing stem armed with spines, and the showy flowers feature multiple petals and stamens



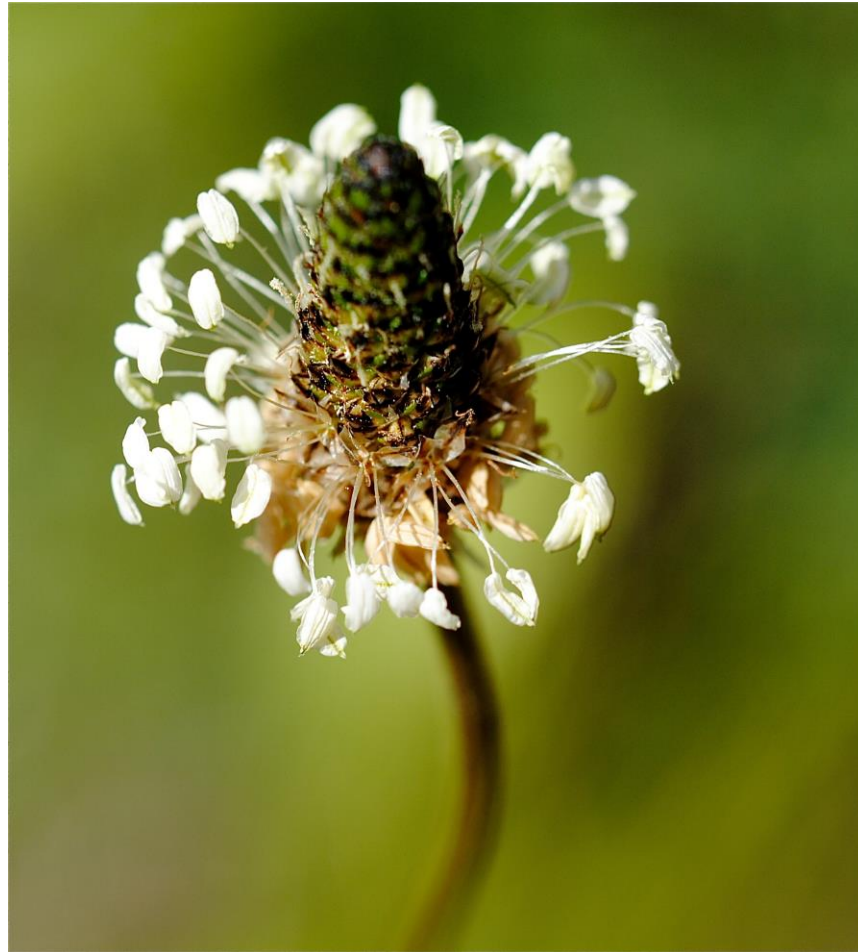
Some of the “cactoid” euphorbias like *E. obesa* resemble the plant body of a cactus, but these are mostly native to the drylands of South Africa.



However, euphorbia flowers are very different from cactus flowers, so that in blossom the two groups are easily distinguished. These tiny yellow flowers of the *Euphorbia* are actually collections of flowers, the yellow petal-like structures nectar-secreting glands and, inside the “flower”, several tiny petal-less male and female flowers



The problem with the revisions of relationship based on chemistry and DNA is that sometimes neither vegetative part nor the flowers like similar. Here you see a typical plantain with its dull, wind-pollinated flowers



With the penstemons which were always placed in the snapdragon family Scrophulariaceae, these lines of inquiry have led to placing these into the Plantaginaceae despite dissimilarity in appearance



To make matters even more confusing, the flower design of the monkeyflowers (*Mimulus* spp.) is similar to penstemons, yet this genus has been moved to its own family, Phrymaceae



And now let's talk about nomenclature or names of plants.
Here we'll skip all the higher categories such as kingdom,
domain, class, and order

- Scientific names are preferred because they're recognized no matter where you are; common names are related to the local language and usually are not standardized
- We have now standardized names of the three most important categories: family, genus, and species
- Family names always end in –aceae, so we get Rosaceae, Orchidaceae, Ranunculaceae, Pinaceae, etc.
- As you may have noticed from these family names, some are similar to common names and thus easy to remember but others like Ranunculaceae are not at all intuitive. This is because scientific names generally are based on Latin and Greek.
- Once translated, some of these names are intriguing; for example, Ranunculaceae means “little frog” in Latin because of their often moist habitats where little frogs live

You should also be aware that a few families until recently retained a different ending, but all current books have changed these to conform to the rule mentioned

- The families of exceptions included Gramineae (grass family, now Poaceae), Labiatae (mint family, now Lamiaceae), Leguminosae (pea family, now Fabaceae), Umbelliferae (parsley family, now Apiaceae), Palmae (palm family, now Arecaceae), and Compositae (daisy or sunflower family, now Asteraceae)
- You'll notice that with the name changes, the usual root word of the family has also changed. That's because a current rule says that a family name has to be based on a *type genus*. Therefore, *Poa*, *Lamium*, *Faba*, *Apium*, *Areca*, and *Aster* are all genera for the families mentioned above

As mentioned, the next category within family is *genus* (plural *genera*). Although genus names can stand on their own, when a species within the genus is not known, the full scientific name, the *binomial*, consists of genus + species

- You can also tell a genus name by the fact that it is not only capitalized like family names but is also *italicized* (sometimes to indicate italics, the name is underlined)
- Every binomial starts with the genus name, followed by the *specific epithet*
- Like family names, genus names are usually derived from Latin or Greek although sometimes they're also based on a person's name
- Learning to demystify genus names can help recognize them as in the case of *Delphinium* (sleek flowers like a dolphin), *Anemone* (flower parts easily blown away by the wind), *Rosmarinus* (dew of the sea for the blue flowers), or *Rhododendron* (red tree for the flowers and sometimes large treelike plants)

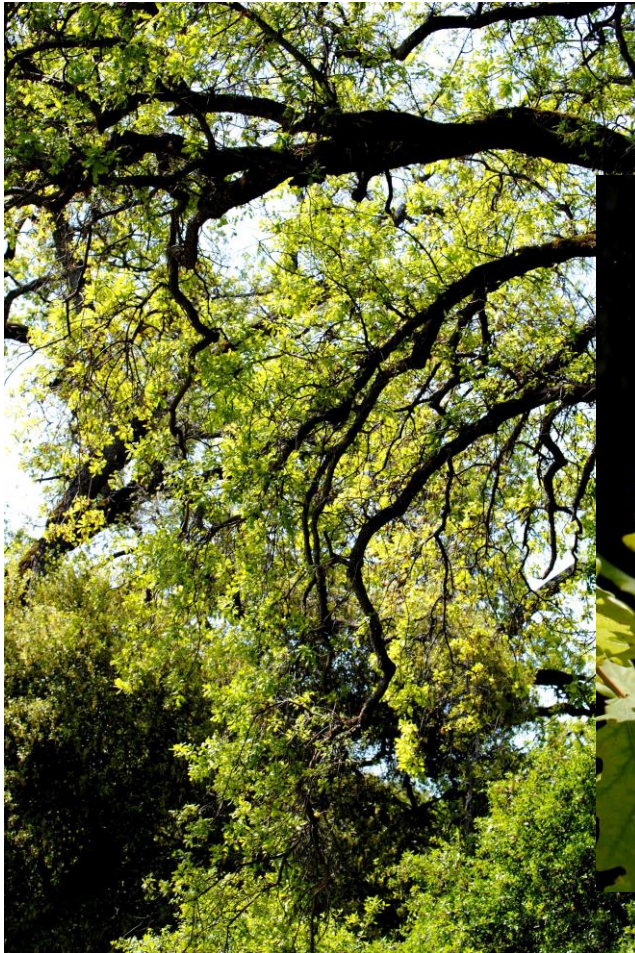
Carl Linnaeus it was who consistently gave organisms a binomial name, much as you and I have a first and last name.

- Therefore, once the genus has been identified, the next step is to find the species, referred to as a *specific epithet*. In essence, this epithet modifies the genus name. When asked for the name of a plant, therefore, you need to give the genus name and specific epithet
- Specific epithets are recognized by the fact that they always follow a genus name, they're not capitalized, but they are italicized or underlined

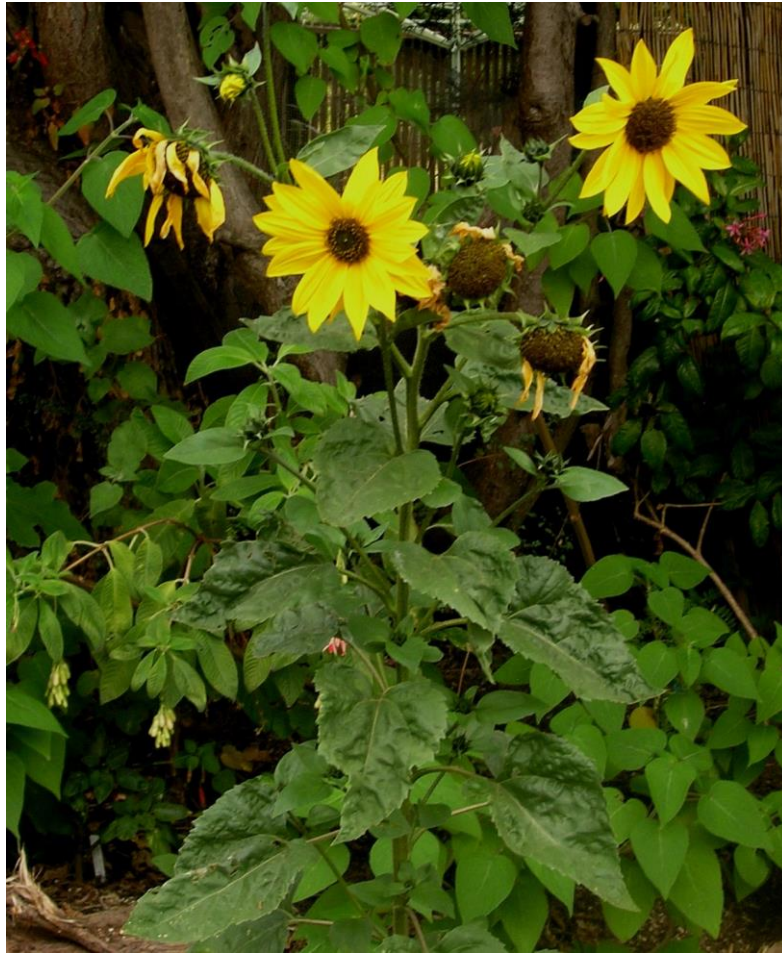
To illustrate binomials, let's look at a few examples

- *Rosa californica* (aka California wild rose) means rose from California
- *Quercus lobata* (aka valley oak) means oak with lobed leaves
- *Lithocarpus densiflorus* (tanbark oak) means stone fruit (hard acorn shell) with dense clusters of flowers
- *Calycanthus occidentalis* (western spice bush) means flowers with a multiple calyx from the west
- *Physocarpus capitatus* (ninebark) means inflated fruits and flowers in headlike clusters
- *Helianthus annuus* (sunflower) means sunflower that is an annual

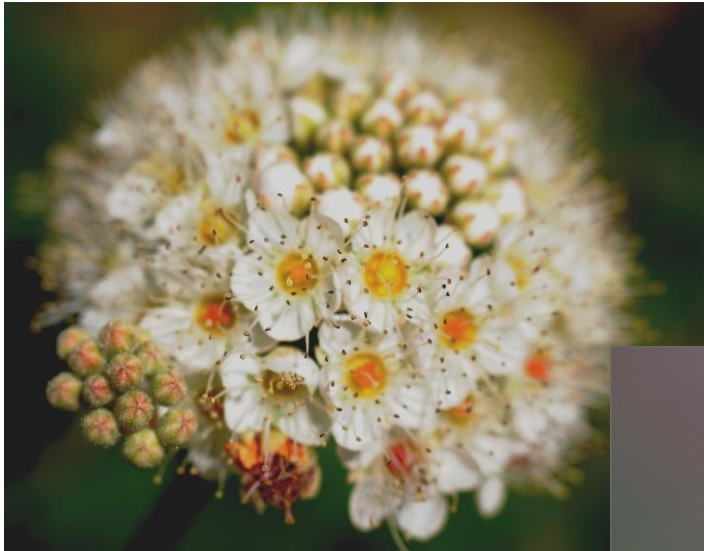
The majestic valley oak, (*Quercus lobata*) is named for its lobed leaves, but other native oaks also have that feature



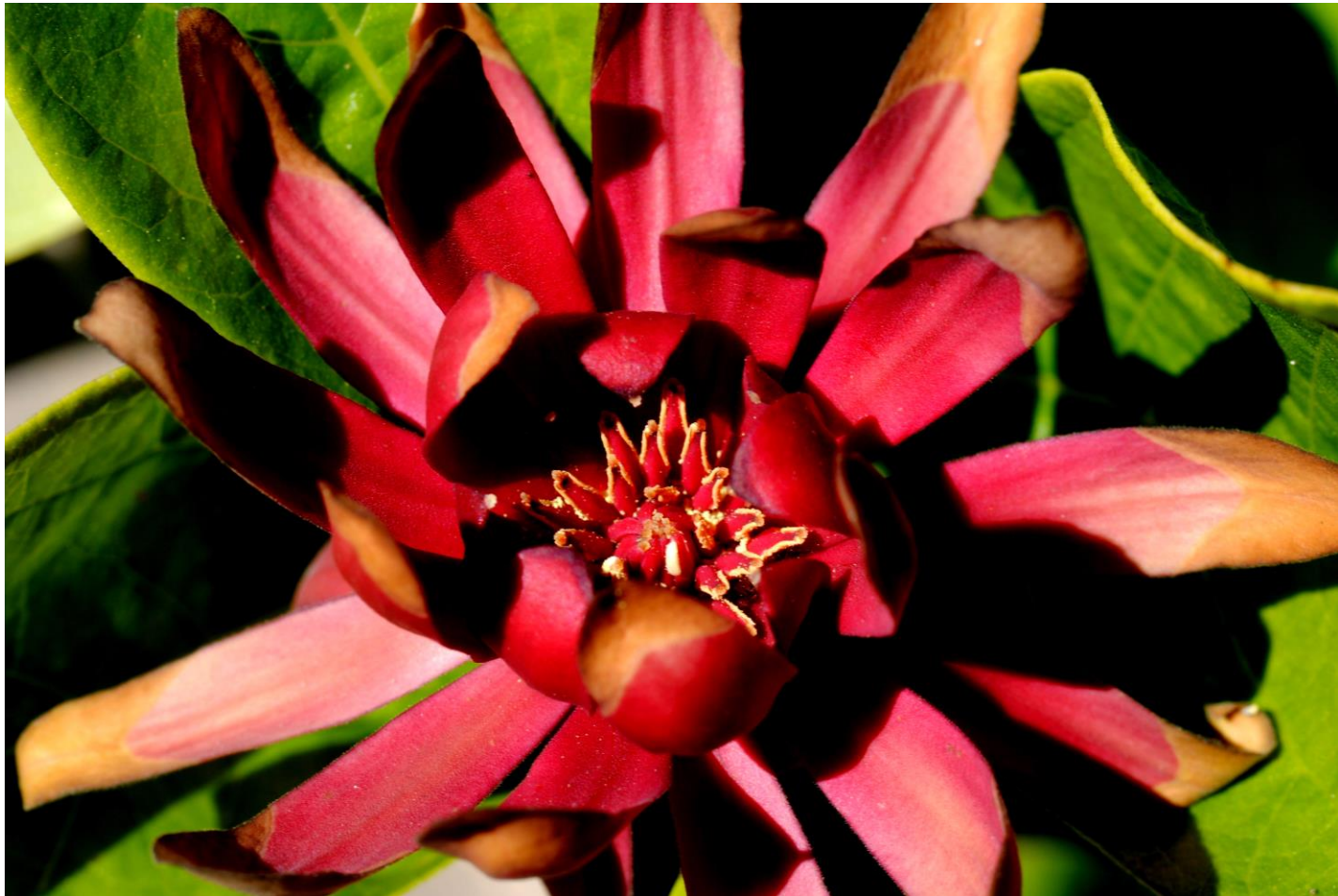
Helianthus annuus, the annual sunflower, is actually one of a few other annual species, and because they can grow to over 6 feet, may be difficult to determine as an annual. The sunflower part of the name refers to the flowers turning towards the sun.



Physocarpus capitatus, the ninebark, is well named: on the left the headlike clusters of flowers, on the right the inflated seed pods



The western spicebush, *Calycanthus occidentalis* is named for the multiple sepals (= calyx) around the outside of the flower (anthus)



Most of the binomials mentioned give some information about the plant or where it grows

- But there are no rules about whether the scientific name is meaningful or appropriate, so we end up sometimes with names like...
- *Eschscholzia californica* (California poppy), a plant from California named to honor Mr. Escholz
- *Cassiope mertensiana* (white-heather) named for a goddess and honoring Mr. Mertens
- *Dudleya brittonii* (Britton's dudleya) honoring both Mr. Dudley and Mr. Britton
- Names like these are hardly descriptive of the plants, making it much harder to memorize the names
- A great number of specific epithets honor explorers and collectors such as Brewer, Menzies, Douglas, and Kellogg

The beautiful alpine white-heather, *Cassiope mertensiana*, has a fanciful genus name and a botanists's specific epithet but neither of these says much about the appearance of the plant



The state flower, *Eschscholzia californica*, doesn't help identify the plant but there are plenty of traits that could be used for a more appropriate name



The desert shrub known as jojoba, *Simmondsia chinensis*, seems like a botanical joke. Name for a Mr. Simmonds and implying it comes from China, nothing could be farther from the truth as this shrub is only native to our desert southwest. Unfortunately, once a botanical name has been created, it cannot be changed because people don't like it!



Finally, in the nomenclature system, we have to account for variation within species and other special categories

- As mentioned previously, variable species are often given subspecific or varietal names. In this case, the varietal name is also italicized and starts with a lower case letter, but always follows the specific epithet
- An example of how this works is with the Garry oak, *Quercus garryana*, a tree common in Northern California
- However, there is a shrub version of the same oak, and so it's distinguished by adding the varietal name, giving you *Quercus garryana breweri*.

Here is the full-sized “typical” *Quercus garryana* a full-sized oak tree with a crown similar to other California oaks



Here in the left-hand corner is a stand of the dwarf Brewer's oak, *Q. garryana breweri*, similar to its tree sister except for size



Remember that cultivated varieties or cultivars are not the same as botanical varieties and so the rules for naming cultivars is different

- Cultivar names are not italicized, are written inside single quotes, and should *not* be in Latin although many break this rule
- Cultivar names can often be two or three words long and usually describe some feature for which they're named
- For example, *Arctostaphylos pajaroensis* 'Paradise' is a particularly beautiful form of the species.
- You will also often see a label with the genus named followed by a cultivar, without the specific epithet, such as *Ceanothus* 'Dark Star' This is often because the parentage of some cultivars is not known

Ceanothus 'Dark Star' is a great garden cultivar because it blooms long, has deep blue flowers, and doesn't grow very tall. Although there's no specific epithet, the species that at least entered this cultivar is *C. impressus*



Arctostaphylos pajaroensis 'Paradise' is garden worthy because it's a moderate-sized shrub with pink tinted flowers and bronze new leaves.



This brings us to another important category in horticulture, hybrids

- Technically, hybrids are genetic crosses between two different individuals, sometimes within the same species, but most often between two closely related species
- Many hybrids may have “hybrid vigor” but fail to produce viable seed
- The more distantly related the two parents, the less likely a hybrid will succeed
- There are a few cases in which two genera have been hybridized, as in \times *Chiranthofremontia lenzii*. This hybrid is between the Mexican monkey hand tree (*Chiranthodendron pentadactylon* and the flannel bush or fremontia, *Fremontodendron*.
- The orchids also have been widely hybridized between genera because in the wild, the parents are isolated by using different pollinators

California oaks sometimes hybridize where the habitats overlap. In this example, a black oak (*Quercus kelloggii*) has crossed with a coast live oak (*Q. agrifolia*) to produce a hybrid that combines features from both species—coast live oak is evergreen, black oak is deciduous, and the hybrid is *half deciduous*!



Here is one of the parents of our bigeneric hybrid, the Mexican monkey hand tree with its cup-shaped dark red flowers and fingerlike stamens. The leaves are similar to fremontias.



By contrast, the California fremontias have saucer-shaped yellow-orange flowers with much less prominent stamens



And here is the hybrid, x *Chiranthofremontia lenzii*. The flower shape recalls the Mexican relative but the color the California genus. Even the size of the plant is intermediate.



What's the rule for naming hybrids? The unchanging rule is an x is placed in front of the specific epithet if it's a hybrid between two species of the same genus but

- If the hybrid is between two genera, the x goes in front of the genus name
- In the case of our bigeneric hybrid we just looked at, the genus name combines parts of the names of the two parents involved, while the specific epithet honors a man involved in making the hybrid
- However, there are many hybrids where the parentage is not indicated by the hybrid name, as, for example, often happens in cultivars of hybrid origin
- So just remember the x is the important part of a hybrid name