The Naming of Plants — explanations and examples

by Dr. Lena Struwe

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THE GOALS OF THIS MANUAL

The purpose of this short manual is to clarify the naming of wild and cultivated plants. In particular, it provides guidance about plants that are used as source materials for commercial products. Questions that will be answered include: What are the proper ways to list plants on product labels on product labels, on websites, and in reports? Can you tell from a listed name if it is a scientific name, a cultivar, a common name, or something else? Why does the accuracy of a plant name matter, and how can you insure you are using the right name? The nomenclature of natural and cultural plant biodiversity is an ancient science that continues to be an ongoing challenge — and opportunity.

The manual aims to help botanists, herbalists, plant-derived product suppliers, naturalists, farmers, gardeners, and other users of plants and plant products to understand naming standards. Each chapter focuses on a particular issue in plant names, with in-depth, real-life case studies and examples. Along the way, I hope that you will develop a deeper curiosity and knowledge about plants.

WHY DO WE NAME THINGS?

It is a big green jungle out there: a world full of trees, grasses, orchids, with plants that are edible, or useful, or not so useful, or even toxic. From long before written and oral human history, humans have discovered, then learned, and then remembered plant species, especially those that we could eat or were dangerous. When speech evolved, we started to name the things around us to be able to talk about them, memorize them better, and share information about them using their names. These early names were everyday names that differed between languages and regions and are considered common or local names.

Names also provided opportunities for abstract organizing of objects or species in larger mental groups (think: “trees”, “edible fruits”, or “snakes!” The earliest classifications of plants were utilitarian or pragmatic and reflecting utility and mythology more than any scientific thinking. Later in civilization's history names became more formal when they were written down by hand or in print and could be shared over longer time periods and spaces outside of a face-to-face conversation.

Early written plant names are known from ancient times from ethnobotanical (mostly medical) literature in China, Egypt, Ancient Greece, and the Roman Empire, and the cultures of the Aztec and Incas. With the development of scientific discovery and literature in Europe the first floristic works were written in Latin and they often continued to use the old Greek and Roman names. Classification became a problem as the number of names grew and people needed systems for how to best divide species up in practical groups and how to best give these groups names that could be used on broader scales.

In the mid-1700s, the botanist Carl Linnaeus (1707-1778) started to use the binomial naming system for species, a system for scientific naming that is still in use today. In this system, each species has a unique two-word scientific name, where the first word indicates the genus it belongs to. This system is used for all living and extinct species on Earth. Plant families as a grouping came later, and they group genera (the plural for genus) together into larger groups. As more and more species have been discovered and described, they have all been inserted into this classification scheme of scientific names.

> *The first step in wisdom is to know the things themselves; this notion consists in having a true idea of the objects; objects are distinguished and known by classifying them methodically and giving them appropriate names. Therefore, classification and name-giving will be the foundation of our science.* *Carl Linnaeus,* Systema Naturae[1]

Without this naming system, modern scientific research and data gathering, as well as modern plant-based businesses, laws and regulations, would be chaotic and impossible to carry out. Since each species has its own unique name (with a few exceptions), we have a global, unified language for species identity. That means species information can be used in everything from scientific and popular literature to labels for DNA barcodes and plant-based ingredients in products for sale. Scientific naming follows very strict rules to keep the system stable over the long term while also allowing for science-based updates to names.

In parallel to the development of the scientific naming system, two other naming systems were also evolving. The common (folk) names were abundant, often with many names for the same plant in the same language, depending on region, use, or tradition. The same name could also be used for several different plants, so reliability of common names has always been limited. On the other hand, these are the names that people are likely to know best, and often carry an important ethnic and folkloric heritage through time.

Agricultural and horticultural breeding of plants led to another set of names. Thanks to artificial selection and domestication by farmers and gardeners, strains and varieties of plants in a given species could look quite different from one another, so these plants often got their own crop names. Such names developed into cultivar and group names whose use now follow formal rules for naming cultivated plants. There are also commercial and trade names such as patent and trademarked plant names, and they are in frequent use but have no formal status in taxonomy; their use is only for legal and commercial purposes.

Without names for objects in our lives we would not be able to have conversations reflecting over similarities and differences between things, and transfer of information to each other as well as to the next generation would be difficult. Common names are the first we learn (like spinach, apple, beans, and poison ivy), maybe followed by scientific names (such as *Citrus*, *Cocos*, and *Geranium*). Cultivar and trade names are generally used least often, except by people who have a strong interest in horticulture or agriculture. As this manual explains, the different types of plant names fill different needs for different people, and it is useful to know how to tell them apart and in what context each type is used correctly and most efficiently.

Taxonomy is the field of biological sciences that is primarily focused on organizing, describing, and discovering the enormous biodiversity of species on Earth. The naming of species (**nomenclature**), the elucidation of their evolutionary history (**phylogenetics** and **speciation**), and how we arrange them in groups (**classification**), are all topics under the general umbrella called **systematics**. It is about creating and maintaining a system that will work for us as we store and share information about millions of species; including the sources of the natural products that we have used over many millennia. First this information was stored as oral histories and in our brains, then as written or graphic information, and now, increasingly as digital information, either as text or images. But the basis for it has not changed, it is still the 400 000+ wild plant species of the world and their cultivated offspring.

NAMING IS NOT THE SAME AS IDENTIFICATION

Nomenclature, the science and rules of naming, deals with the names of species and their groups and subgroups and is focused on the question of "*What is its name*?". Another aspect, equally important, is the identification of species. First you have to identify your unknown species (*What species is this?*). Only then can you look up its proper, accurate name (*What is its correct name based on the most recent science?*). These are very different questions and processes, but they are interlinked.

You might have a perfectly correctly spelled and updated plant name on an herbal tea label, but the actual content inside the box might have been incorrectly identified. In that case, the tea actually belongs to a completely different species from the name on the label. This is then an identification problem, not a nomenclature problem (but both types represent botanical inaccuracies). Keep in mind that a correct scientific name on a product label does not mean that the product actually is that species. For that, it has to be correctly identified. It is much easier to check if a name is correct and up-to-date on a label than it is to make sure that the content of a products includes a particular species and only that species.

For herbal products and dietary supplements in the US it is the manufacturer that is responsible for providing correctly identified plant materials in their consumer products. Many manufacturers now identify their ingredient plants at the supplier stage through various scientific methods such as morphology or anatomy, DNA barcoding, and/or chemical testing.

Keep in mind that the internet is full of mislabeled photos, websites that no longer are kept up to date (or never were up to date), and that some seed and nursery companies use outdated or faulty classifications for names. There are also some excellent sources that can help you untangle such online information, and they are listed in the Resources in the back of this manual.

In this manual I will only talk about the rules for naming plant species and plant groups, not how to identify them. There are many identification tools and resources online or in print, from floras to online interactive keys, or online ID help from photos through web forums or social media. I encourage you to become familiar with botanical terminology, how to key out plants, and characteristics of major plant families, while you learn how the fantastic flowers, ferns, and other plants in this gorgeous messy mass of biodiversity get their formal and informal names.

BOTANICAL ACCURACY

Botanical inaccuracy and ambiguity in written information on labels for commercial plant products or in other public sources can take many forms. Newspaper articles or recipes might mention a common name that could be applied to several species. For commercial plant products, the wrong species could be used to make the product. The wrong species could be listed on the label. Sometimes the wrong photo is used on the label; it could show a different species than the actual source species. Typographic errors, incomplete names, wrongly formatted names, or outdated names are very common, and create problems when you try to look up additional information about the plant. The label for a product that is a mixture of plant ingredients might not include all those species; that would be a hazard for people who are allergic to the unlisted species. A basic knowledge of botanical nomenclature and potential pitfalls will help you avoid such mistakes and errors. In my blog Botanical Accuracy (www.botanicalaccuracy.com) I showcase and explain such examples of inaccuracies to help the public, non-profit and commercial companies understand botany and its naming rules better.

RULES OR RECOMMENDATIONS? THE CODES

Scientific names of **wild and naturalized plants** (and some cultivated plants) are governed by strict rules, known as the ***International Code of Nomenclature for algae, fungi, and plants*** (called the **International Code** or **ICN,** for short in this manual). These rules are maintained by the global botanical community and regularly updated on the basis of ongoing scientific research at international meetings. Common names for plants, by contrast, have no universally agreed-upon standards and rules.

Scientific names are unique to each species within ICN and form the best universal written identifier for an organism's species identity. The code functions as the law for naming wild species and their groups and hybrids worldwide. The current ICN is the 2018 Shenzhen Code, named after the Chinese city where it was developed and voted in during the summer of 2017; the previous ICN code is the Melbourne Code published in 2011.

There are **codes for other groups and organisms**, such as animals (*International Code of Zoological Nomenclature*, ICZN) and bacteria (*International Code of Nomenclature of Bacteria*, ICNB). Naming of viruses is managed under a fourth code, the *International Code of Virus Classification and Nomenclature* (ICVCN). All codes are independent of each other, so the rules can differ between codes. This means that even if a scientific name is considered unique within ICN, there are rare cases where an animal and a plant can have the exact same scientific name, since the codes are independent of each other. In the case of organisms such as some algae (diatoms, golden algae, etc.) historical natural history tradition decides which code applies to them. Some algae have traditionally have been treated in the ICN code and still are, even if we now know they are evolutionary more closely related to non-plant groups. As you will see, the codes are highly pragmatic in how they function, but conservative in their rules to create universality and stability in naming of an immense biodiversity on Earth.

EXAMPLE: EXACT SAME SCIENTIFIC NAME FOR A PLANT AND AN ANIMAL

Photos of a plant and an insect, both with the genus name *Pieris*. **Left**, a cultivated *Pieris* shrub, photo Wouter Hagens (public domain). **Right**, the butterfly *Pieris napi*, photo Estormiz (public domain).

By rare coincidence it happens that the same scientific name is used for two organisms regulated by different codes. As an example, the genus name *Pieris* is both a group of shrubs (including Japanese andromeda) in the blueberry family and a group of butterflies (the genus of the cabbage white butterfly and relatives). So the plant name is regulated by the International Code (ICN) and the butterfly name by the Zoological Code (ICZN). Such cases are completely fine, since the nomenclature of plants and animals are independent. But, be aware, it might cause potential confusion and mistakes when you deal with databases that include all types of organisms, such as EoL (Encyclopedia of Life) and iNaturalist, as well as when you google taxonomic names. Names that are identical within a code are not allowed (see later chapter on Homonyms).

For **cultivated plants**, there is another global code that regulates some non-scientific names that we give to various plants humans have bred, selected, and otherwise modified into cultivars, hybrids, etc. This code is called the ***International Code of Nomenclature for Cultivated Plants*** **(ICNCP)**; hereafter called the **Cultivated Plant Code** in this manual. The current Cultivated Plant Code is the 9th edition published in 2016. Since names regulated by the Cultivated Plant Code are largely unique, global, and follow uniform naming rules, these names are recommended to be used in global trade and information resources.

Table (below). The formal codes that regulate scientific names and the organisms they cover.

Code	Organisms:
International Code of Nomenclature for Algae, Fungi, and Plants (ICN)	ALGAE, BACTERIA (Cyanobacteria only), FUNGI, PLANTS, photosynthetic PROTISTS: Species, Subspecies, Variety, Genus, Family, Order, Classes, etc. (scientific names for all taxonomic ranks); Hybrids
International Code of Nomenclature for Cultivated Plants (ICNCP)	CULTIVATED PLANTS: Cultivars, Groups (ranks for cultivated names)
International Code of Zoological Nomenclature (ICZN)	ANIMALS, PROTISTS (except photosynthetic and some previously considered fungi): Species, Subspecies, Variety, Genus, Family, Order, Classes, etc. (scientific names for all taxonomic ranks); Hybrids
International Code of Nomenclature of Prokaryotes (ICNP)	ARCHAEA, BACTERIA (not Cyanobacteria): Species, Subspecies, Variety, Genus, Family, Order, Classes (scientific names for all taxonomic ranks)
International Code of Virus Classification and Nomenclature (ICVCN)	VIRUSES: various names and groups

Trade names are non-scientific names that are breeder's rights names, registered or unregistered trademarks, or patent names for cultivated plants. They are different from the code-ruled cultivar and group names of cultivated plants (but often confused with them), are not universal across the world's countries, and are governed by local laws and regulations.

Taxon-specific **common and folk names** in local languages are obviously not universal across the global and not regulated, but some countries have national databases that in effect function as national standards (for example SKUD and Dyntaxa in Sweden). Most countries do not have such standardized, universal lists. Therefore, it is best that common names are not used in commercial trade and commerce as plant names, except within smaller geographic areas, or when standardized names are locally available for well-known food crops or other plants.

WHAT IS A TAXON?

Scientific names are given to all biologically classified organisms and their groupings (species, genera, families, orders, classes, etc.) — these are all examples of **taxa** (**taxon** in singular), which is defined as a taxonomic grouping. When the word taxon is used, it refers to any type of group (including species and their subdivisions) that can be given a scientific name.

For example, if a taxonomist says to you "*I published a new taxon yesterday*", that could mean that she/he published a new variety, a new species, a new family, or maybe a new genus. The taxonomic levels (species, subspecies, genus, family, etc.) in classifications are called **ranks**. You won't know at what rank a taxon is unless you use clues like the ending of the word, how the word is arranged or formatted, or indications before the word, since the words taxon/taxa can be used for a classification unit at any level in a classification.

SCIENTIFIC CLASSIFICATION AND NAMES OF GROUPS

The basic unit in scientific classifications and nomenclature is the **species**. I will not enter in the centuries-long debate whether species truly exist as separate, living biological units or simply as a practical way to name things. But in taxonomy and nomenclature species do exist, as the basic unit of our scientific naming system.

Species were likely the first recognized taxon rank in history (*"Look, a lion!"*). Humans have identified and named species since our first origin, many of them still accepted today. As long as we have had languages, there has been informal and common species names in the written records such as in the earliest herbals and other literature in ancient China, Egypt, and Greece.

Species can be grouped into larger groups for convenience, especially when it comes to ease of memorization and communication. Our brains are made to categorize objects into groups of all kinds. For nature-originated things we use informal groups like "dinosaurs", "edible fruits", and "fossils", and, for human-made products we have groups such as "LEGO pieces", "Chicago blues music", and "SAAB cars".

Groupings can be completely practical and pragmatic or follow strict scientific criteria (sometimes, but not often, do they fit both criteria). The system of sorting things into groups is called **classification**. Practical groups such as "trees", "lianas", and "spring bulbs" are groups that are unaffected by evolutionary relationships. The scientific classification system in this manual is used for scientific names only, and we try to get groupings to reflect evolutionary groups, such as grasses (family Poaceae), roses (genus *Rosa*), and legumes (family Fabaceae).

Groups of scientific names follow formal rules. The International Code prescribes the naming process, but it does not lay down a rule for saying whether a particular species belongs in a particular genus, family, etc. The criteria for what species will be included in a genus are matters for biological investigations and scientific justifications, not something that can be solved by using nomenclature rules. But as soon as the botanical community has decided that a species belong in a particular grouping, then the International Code's naming rules apply.

In general, good and useful classifications to store information fit these general criteria and goals (but see below for different criteria for phylogeny-based classifications):

- Not too many, but not too few groups (our brain capacity limits the number of groups)
- Groups that are not too large (then they become unwieldy)
- Easy to use and memorize (have memorable names and characteristics)
- Groups make sense and are practical (have unifying characteristics)
- Groups are stable, don't change too much, you can easily add new items to them
- Groups are predictive, newly discovered things easily fit into existing groups

Hierarchical Ranks and Nested Classifications

Grouping species into **genera** (which is called **genus** in singular) has been done for a long time in botany, with the intent on assembling species into useful groups of similar-looking and/or related species. Many common names for groups used by the ancient Greek and Romans are still in use today as scientific names for the same groups that they identified (for example, *Quercus*, for the oak genus). Genera can further be divided up in series, and other in-between ranks can also be formed by adding super- or sub-prefixes. Genera are then grouped into families, classes and so on for increasingly larger groups. Plant **families** were not used until in the late 18th century; before then botanists often used practical but artificial groupings organized and named after the number and arrangement of stamens and styles inside the flowers (commonly known as Linnaeus' Sexual System).

The **ending of scientific names** of ranks (= taxonomic groups, see table below) above the genus level are ruled by the ICN, so by looking at an unknown name it will be possible for you to tell if it is a family, order, or tribe, etc. Other codes often use different endings, so these are specific to ICN, that is, algae, fungi, and plants.

Table (below). Endings in scientific names plants, algae, and fungi indicate different ranks.

Group (rank)	**Ending**	**Example**
Class	-opsida	Magnoliopsida
Subclass	-idae	Magnoliidae
Superorder	-anae	Magnolianae
Order	-ales	Magnoliales
Family	-aceae	Magnoliaceae
Subfamily	-oideae	Magnolioideae
Tribe	-eae	Magnolieae
Subtribe	-inae	Magnoliinae
Genus	[various]	*Magnolia*
Species	[various]	*Magnolia grandiflora*

The only exceptions to the family name-ending rule are eight families that are each allowed to have an additional historical name. If you search through older literature you will frequently encounter these alternative family names. These eight plant families are (older scientific family names in parenthesis): Apiaceae (Umbelliferae, parsley family); Arecaceae (Palmae, palm family); Asteraceae (Compositae, sunflower family); Brassicaceae (Cruciferae, mustard family); Fabaceae (Leguminosae, legume family); Lamiaceae (Labiatae, mint family); Poaceae (Graminae, grass family); Clusiaceae (Guttiferae, mangosteen family).

To remember the order of the ranks in biological nomenclature, students of botany have come up with a variety of memory phrases (mnemonics) to more easily recall the order of scientific name ranks. For animals, phylum (phyla in plural) is used, but for plants the word division is used at the same rank.

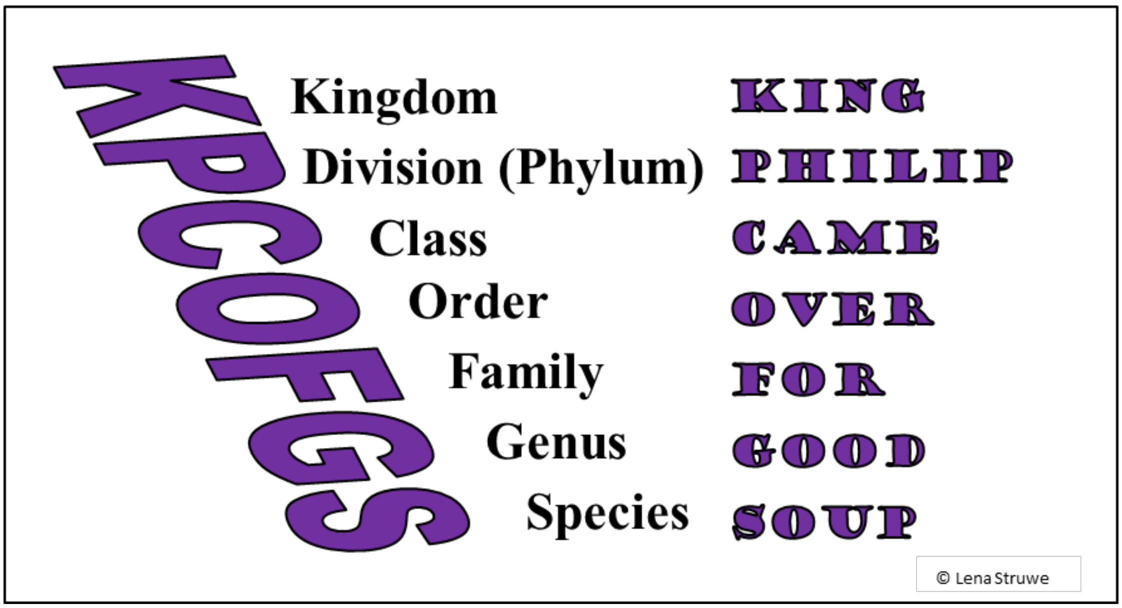


Figure (above). The ranks in botanical classification, from larger to smaller, and with a mnemonic to remember them.

In most of our everyday practical classifications of items we allow groups that overlap, for example a piece of LEGO can both belong to a group called “LEGO pieces”, as well as “toys”. Another example is when a table knife belongs to both the group “table cutlery” and “knives”. But not all knives are table cutlery and not all table cutlery are knives. In scientific nomenclature and classifications of living organisms such partial overlap is not allowed.

Instead taxonomists use a strict system where species are sorted into separate genera, then genera into separate families, and so on. A species cannot belong to two genera at the same time (unless it just recently has moved from one to the other and both a new and old classification is in current use during a transition period), and a genus cannot be part of two different families simultaneously in the same classification.

This is called **nested hierarchy** (a box-in-a-box system), and provides a clean, sleek way to sort all species into larger groups. No overlap is allowed, and you can imagine it being a set of smaller and smaller boxes, or if you go outwards to larger groups, larger and larger boxes that can fit many small boxes, but nothing can cross the box wall (see figure below). Note that this type of classification is not used for groupings and not in nomenclature for cultivated plants (see separate chapter).

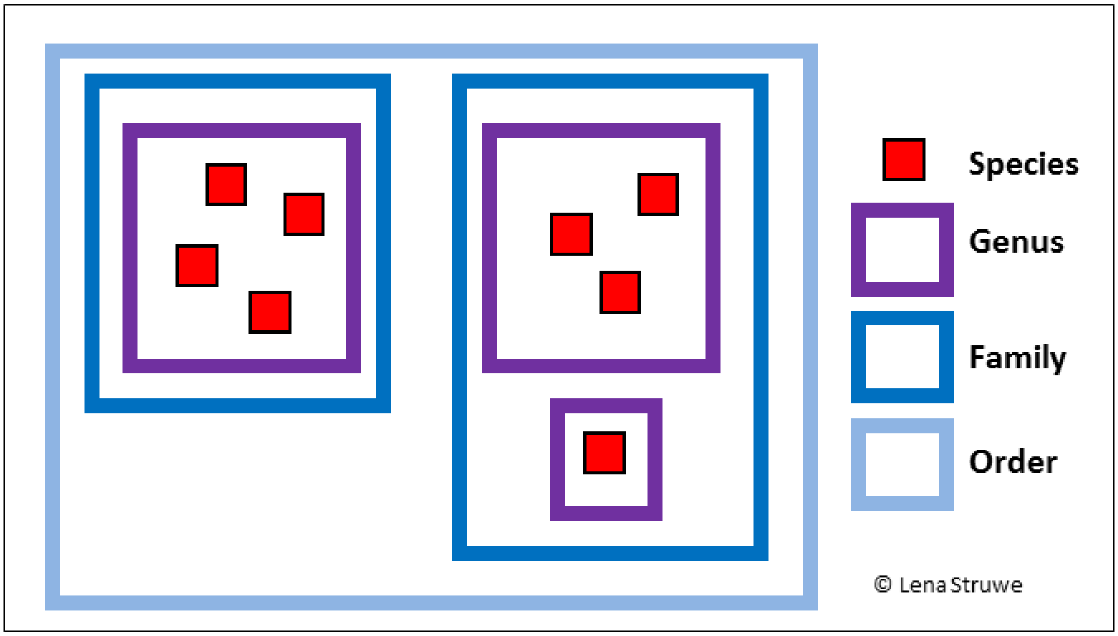


Figure (above). Schematic drawing showing how scientific classification functions as a box-in-a-box system (nested hierarchy). A species can only be member of one genus, which can only be a member of one family, but a family can have several genera within it. (Note that changes in classifications can change which genus and family a species belongs to.)

Phylogenetic Relationships and Classifications

Until recently classification groups were thought of as natural groupings of similar or related species, but it has turned out that many traditional genera and families were in fact not evolutionary groupings of the most closely related species. With the development of new phylogenetic methods based on DNA sequencing, we can now reconstruct the evolutionary relationships and histories of plants on the planet, and this has aided in getter classifications.

Scientists build phylogenetic trees (also called cladograms, clade is the word for branch) to reconstruct evolutionary history through past times using complicated mathematical methods that look for the simplest, most well-supported, or most likely tree based on the data they have gathered so far from plant species. The data can be genetic, molecular, morphological and anatomical and are used to understand not only plants' relationships based on evolution, but also their geographic distribution and morphological and chemical evolution, as well as their co-evolution with pollinators, pathogens, herbivores, and fruit and seed dispersers.

Below is a schematic figure of a simple tree showing five color-coded species alive today and how they evolved from an extinct common ancestor. The base of the tree, the oldest part, is at the root, and from there connected branches show how organismal lineages have split through time (in the order of 1, 2, 3, 4, in figure below).

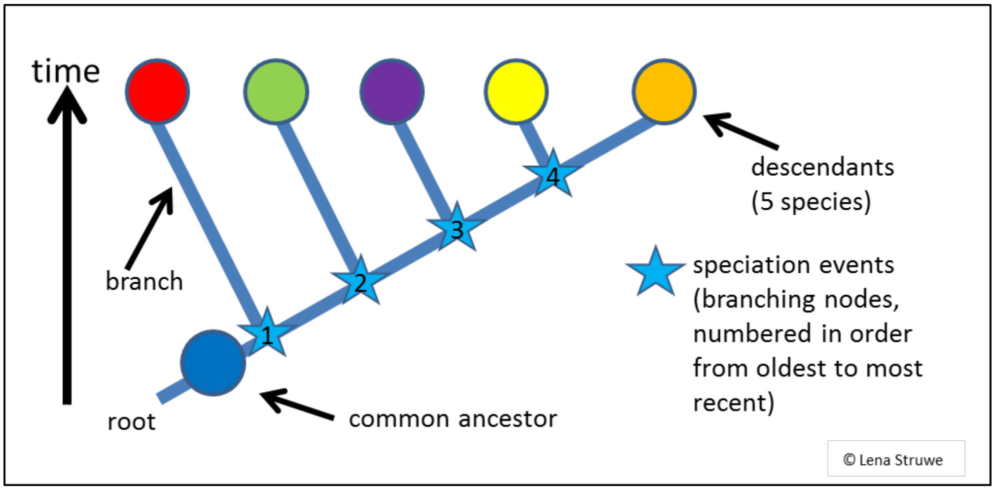


Figure (above). Schematic phylogenetic tree of 5 species (colored circles), descendants of a common ancestor (blue circle, an ancestral parent species), showing the position of the root, four speciation events as stars (=branching points, nodes) that created the five species, and their branches (=evolutionary lineages). The general timeline is shown on the left, so the closer something is to the base, the more ancient it is.

The more species you include in a phylogenetic analysis, the more possibilities there are for branching patterns. Sophisticated math algorithms and sorting methods as well as immense computing power are needed to find the best, most well-supported phylogenetic trees when large analyses are run. The published and selected best trees then represent hypotheses of evolutionary relationships, and these are the ones that form the basis for classification of species into larger groups such as genera, families, and orders.

Since scientists get more data all the time and continuously refine their methods, our understanding of relationships among plants still sometimes change, but usually more data provides more support for relationships we have already found. The exception and expected changes are mostly the placement of poorly known species or new relationships in poorly supported or complicated branching areas in the existing phylogenetic trees.

How do scientists know which branching patterns and relationships are the correct ones? If you have five species, there are many options for how those species can be related. Take a look at the figure below of various branching possibilities (also called topologies) for a tree of five species. Scientists use various criteria and methods to figure out which of the options that is the best tree (= the best supported hypothesis of relationships); this will be the tree that has the most support from the genetic and/or morphological data we can gather from plant species.

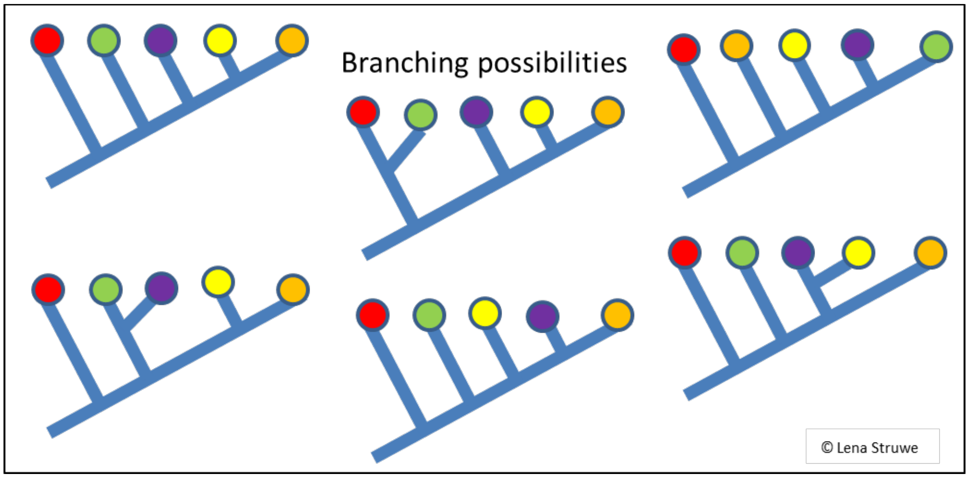


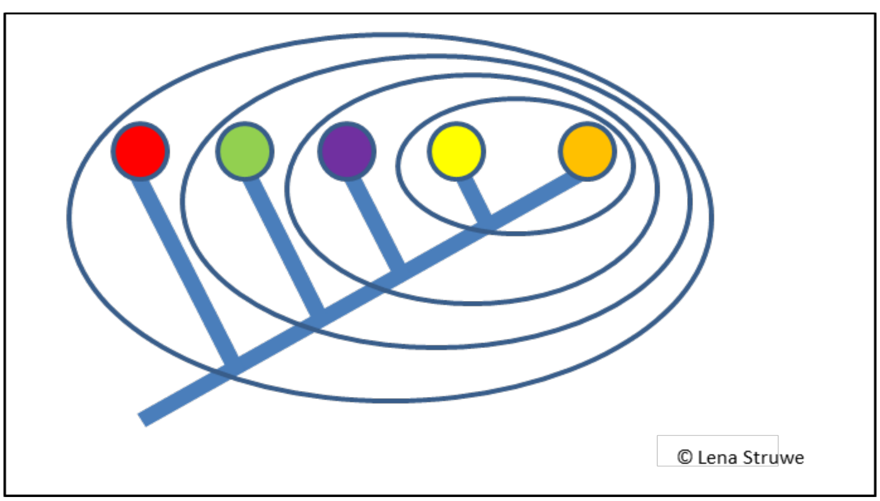
Figure (above). This figure shows six of the 105 different topologies (branching patterns) that are possible for a rooted phylogenetic tree of five species. (Each species has its own color.) The number of possible topologies increases very fast when you add more and more species.

Monophyly, Paraphyly, and Polyphyly

Today scientific groupings in botany are primarily based on evolutionary relationships, not practicality or a few selected and practical morphological characters. This newer scientific classification criterion is based on **monophyly** and the identification of monophyletic groups. The primary goal now is to have classification groups that include all living descendants (offspring species) of an ancestral species (common ancestor), and only those descendants and no other unrelated species.

To understand plant classification today you have to understand the criteria for monophyletic groups. Simply put, if you can imagine a scissor that cuts off a branch on a phylogenetic tree and you put all of the species (descendants) on that branch into a group (and no other branches with species), then you have a monophyletic group (see figure below).

Figure Definitions of paraphyly, and



(above). monophyly, polyphyly.

Figure (above). Drawing showing how a simple phylogenetic tree of five species can include four monophyletic groups - each blue circle is a group that includes all and only all species of a common ancestor.

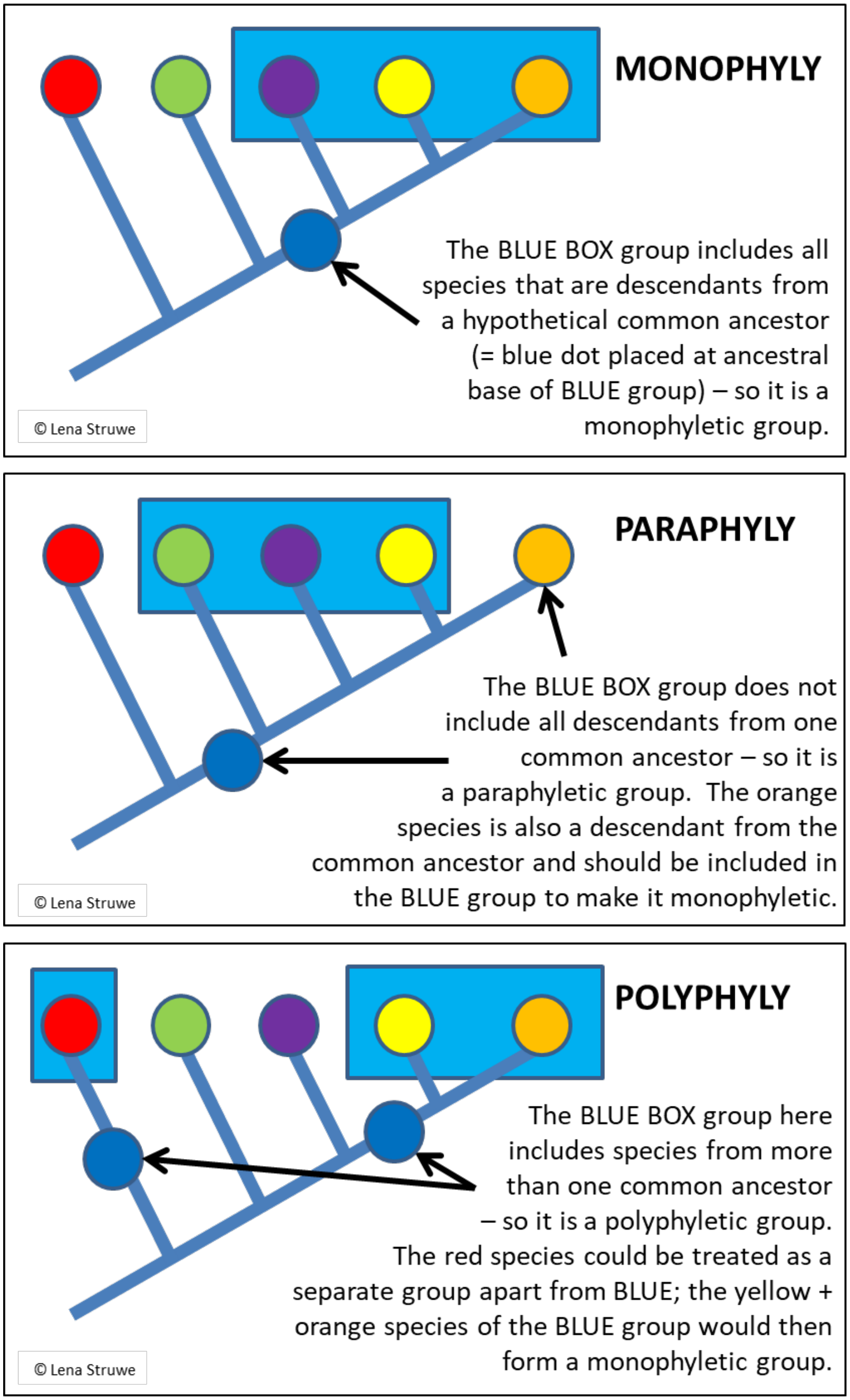


Figure (above). Definitions of monophyly, paraphyly, and polyphyly.

Why do we want monophyletic groups in our scientific classifications? Because we want our systems of naming and studying organisms to reflect genetic relationships, evolutionary histories, uniform morphological and anatomical ancestry - all of which makes more sense from a scientific viewpoint when you try to compare characters within groupings. A plant's inherited characteristics are driven by its genes, genetics, and ancestry, which have been formed by evolution over millions of years.

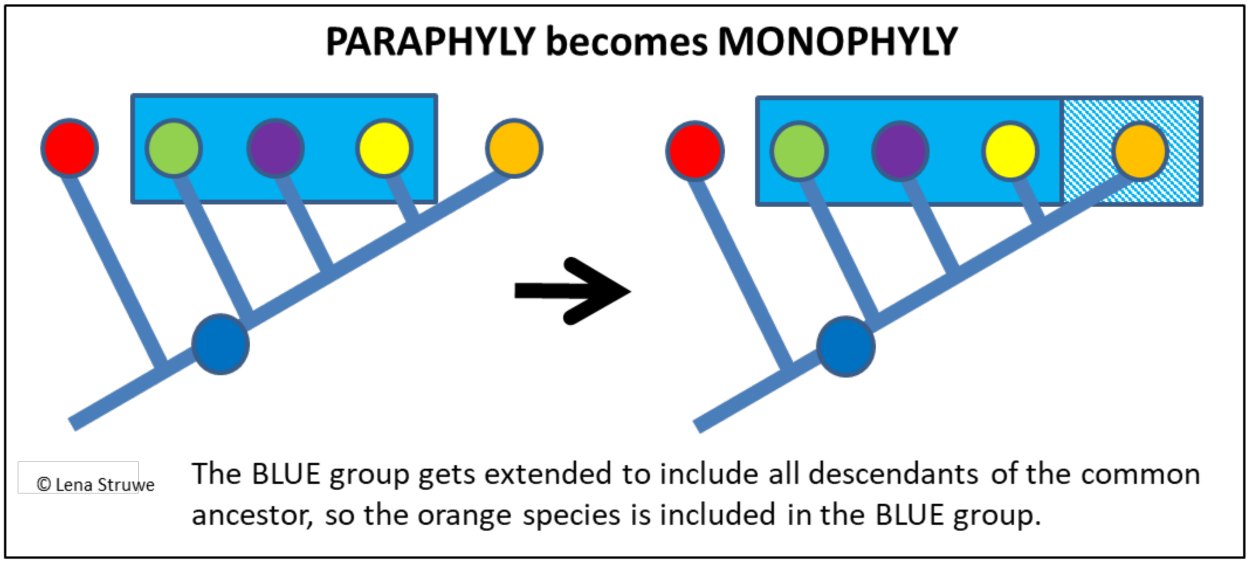
For example, you would not like to include coconuts, walnuts, pecans, and peanuts in the same group, and then compare their overall nut-like fruit anatomy. Coconut and peanuts are distantly related to each other (and are also not true nuts anatomically). If you compare walnuts with pecans, then you have a better, more logical and scientific comparison, since they are both in the walnut family and closely related.

Similarly, if you want to understand the evolution of the hazelnuts, you should compare it with the groups that are part of the closest ancestral lineages of the hazels, such as birches and oaks, not peanuts, not coconuts, not walnuts. Comparing unrelated things might give you results that are incomplete and incorrect. That is why using evolutionary relationships, instead of overall similarity, to classify species and understand their properties is the most powerful way to compare and understand the biological world.

Phylogenetic classifications have often been at odds with previous non-phylogenetic classifications, which have led to major changes in what species should be included in a particular family and genus. This has led to many recent name changes, to the frustration and consternation of people who are used to the earlier names and groupings. The biggest changes came in the last 10-20 years, as botanical research moved away from the older "natural" or phenetic [i.e., mostly based on overall morphological similarities] classifications to the new monophyly-based classifications.

There were a lot of non-monophyletic groupings in previous plant classifications, but this big upheaval in classification systems is not never-ending. In fact, we now have a rather stable family system for flowering plants (angiosperms). This classification is called the APG system, named after the Angiosperm Phylogeny Group, a global consortium of botanists that together publish and continuously refine the new classification. The most recent APG system is APG IV, published in 2016. Other plant groups, such as conifers, ferns, and mosses, also have new classifications. Both the fungi (including lichens) and algae are more complex, and the work on these two groups of organisms is ongoing, but major changes have already taken place.

When scientists discover that existing groupings are not monophyletic, but para- or polyphyletic, they try to reclassify (change) the contents of the group to make it a monophyletic group instead. The examples shown in the figure below are oversimplified but will give you the general idea how you can change the content (species) of a group. This can be done either through excluding some species into other groups (new or existing) or moving some outside species into the group (maybe even losing groups in the process). Such reclassification happens in botany whenever it is needed, and new phylogenetic results are published.



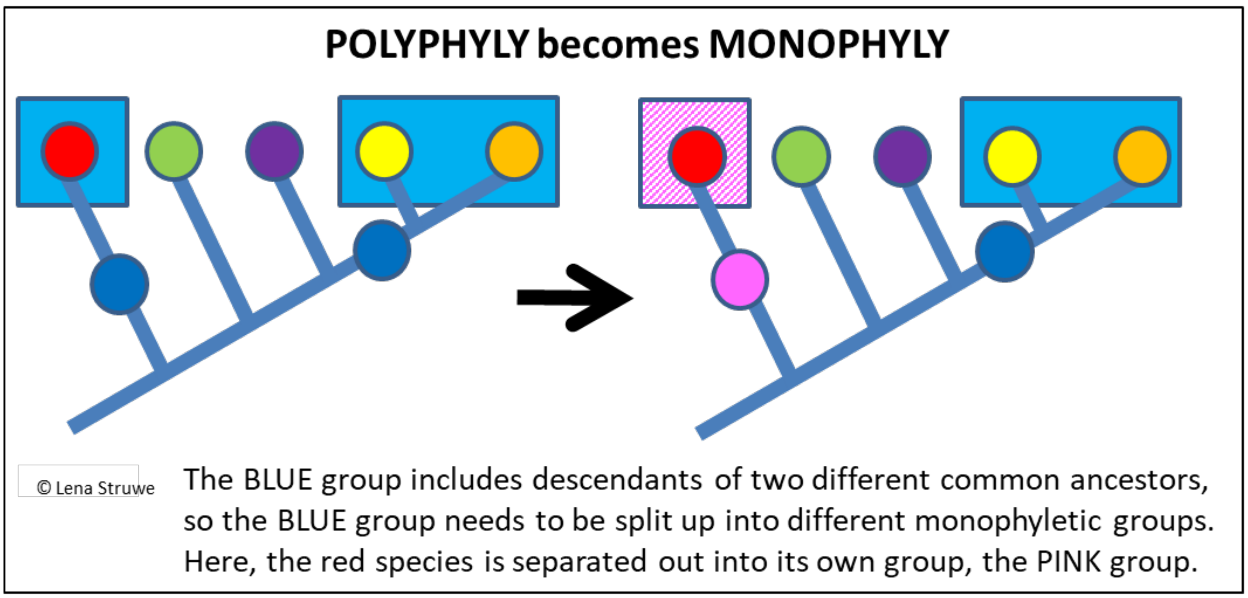


Figure (above). Schematic figures showing how paraphyletic and polyphyletic groups are treated to create monophyletic groups.

The rules of naming groups affect what names these recircumscribed groups will get in new classifications. An expanded or shrunken group may get an unfamiliar (sometimes new) name, or what you knew as a genus or family name no longer represent all the species you are used to know as members of that group.

Among the families that have had major changes in the new APG system are: Liliaceae; the two allied families, Scrophulariaceae and Plantaginaceae; and Apocynaceae/Asclepiadaceae. They represent good examples of how to deal with major classification issues due to polyphyletic and paraphyletic groups in older classifications. Many genera have changed names and circumscriptions as well, for example in the asters (*Aster* and related genera) and tomatoes (the genus *Lycopersicum* has been included in *Solanum*).

SCIENTIFIC NAMES OF PLANT SPECIES

The science of naming plants (and algae and fungi) has a long tradition stretching far back into the history of ancient science. There are many good accounts of botanical expeditions and explorers and the ways taxonomy and nomenclature developed over millennia. Thousands of plant species have been written about over the last centuries and millennia under a variety of names in a variety of languages. The scientific community had to come up with rules for deciding which names to use. The first universal code for plant nomenclature wasn't fully developed and agreed upon until 1952, after several attempts to create worldwide rules to bring some order into the nomenclature chaos. Figuring out which names and publications that follow the ICN and should be considered valid has often been done in hindsight, long after species were published.

To start with, names need to be **validly published** (publicly available) to be available for use; it is not enough to have them written in a manuscript or in a field notebook. For a taxon name to be **valid** it needs to follow the specific rules in the code, such as having a description, be in a real publication, have a type, and so on. If the name didn't follow the rules of the ICN it is an invalid scientific name and shouldn't be used. Today you have to follow the rules of the code or your species name will be invalid. There are examples of species names currently used around the world that were never described as scientific names. This creates a lot of confusion: because those horticultural names are not properly defined and published; they don't exist as real scientific names. If a name wasn't validly described, this can sometimes be corrected by publishing it again as long as nobody else has used that name for another species or has named the species something else already.

The oldest name for a particular plant species is the name that should be used (1753 onwards, see below). This is called the rule of **priority**. There is one important exception: when our classification of a species changes (as they often do), the genus name changes, but the species epithet ordinarily stays the same. Sometimes exceptions to this rule are allowed, and a younger name can get **conserved**, which means it overrules an older name.

The **starting date** for priority for all scientific names we use today for plants is a book written in Latin by Carl Linnaeus in 1753, *Species Plantarum.* Here he listed all 6000 species of plants known to him at the time with binomial genus and species names. Animal species were listed in a different book, *Systema Naturae*. Linnaeus kept publishing new editions of his books with added species as they became described. Even if Linnaeus just listed an already known species in 1753, he gets the credit and authorship.

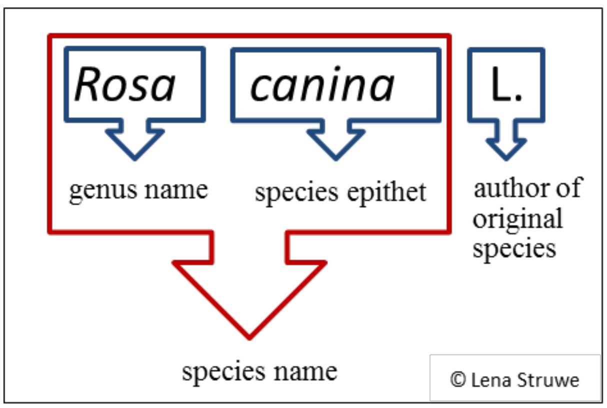
Figure 1. The title of Carl Linnaeus' 1753 book.

In the 2017 report on the *State of the World's Plants*, issued by the Royal Botanic Gardens, Kew, it is estimated that nearly 400,000 different vascular plant species are known to science and have accepted scientific names. The majority of these, about 370 000, are flowering plants. Over 2000 new plant species are described each year.

BINOMIAL NAMES FOR SPECIES

A **species name** (a **binomial** name) consists of two words, a **genus name** (first word) and a **species epithet** (second word). Names are written in Latin or Latinized versions of words from other languages (Greek is the most common, but any language is OK). The ending of the species epithet is based on the gender of the genus name or follows other rules of classical Latin grammar.

The meaning (**etymology**) of the scientific names is often of great interest and sometimes amusement and forms a subfield in itself. Can you name a plant species anything? Yes, as long as you follow the rules of the Code, and the unwritten rule of modesty: don't name something after yourself. There are species named after manmade objects, superheroes, presidents, plant collectors, and mythical creatures, but naming species after their morphological characters (flower color, leaf shape, etc.), discoverer and collector, or geographic area (country, island, mountain, river, or another place name) is more common.



Figures (above left). The species name for dog rose (*Rosa canina*) includes both the genus name *Rosa* and the species epithet *canina*. The author abbreviation is listed after the species name (this is usually optional). **(above right)** Fruits called rose hips from *Rosa canina*. Photo © Lena Struwe

An important difference between zoological and botanical nomenclature is that according to the ICN rules, the species epithet for a plant cannot be identical to its genus name. For example, the European toad is named *Bufo bufo* and the black rat is *Rattus rattus*; and such names are called **tautonyms**. For plants, algae, and fungi, tautonyms are not allowed, but they are not uncommon for animals.

WHEN A SPECIES MOVES TO ANOTHER GENUS

If a species is moved to another genus, then the genus name changes, but the species epithet stays the same. Sometimes the epithet ending might change to comply with the grammatical rules for botanical Latin, so that '*alba'* becomes '*albus'*, for example. Species can be renamed many times, move back to into an original genus, move to a third genus, and so on. A species can also change rank (become a subspecies, for example), or a subspecies or variety can be raised to species levels. The oldest published name is called a **basionym**.

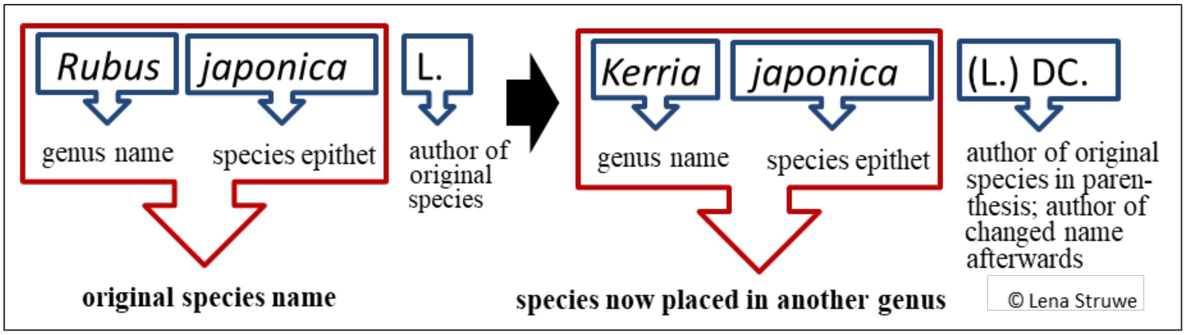


Figure (above). When the species *Rubus japonica* was moved to *Kerria*, its new name became *Kerria japonica*. The first validly published name for this species was a species described by Linnaeus (indicated as "L.") as *Rubus japonica*. De Candolle (abbreviated "DC.") moved this species from *Rubus* to *Kerria* by publishing the new name combination *Kerria japonica*.

The only exception to the rule is that the species is keeping its epithet if there already is a species in that genus with exactly that epithet, then the species that is moving in needs to get a different species epithet. This can happen since some species epithets are rather common (*campestris*, *vulgaris*, *alba*, etc.), and it is the combination with the genus name that makes the species name unique.

Authors and Publications

The **author(s)** of a taxon name, sometimes called **auctor(s)** are often listed after the scientific name, and their names are usually **abbreviated in a standardized way** in databases and floras, and usually not written out in full (so without complete first and last names). Including authors after scientific names is optional in most cases, but can be very helpful in tracking down the history and accuracy of a plant name.

In the figure above, author abbreviations are listed after the names *Rubus japonica* and *Kerria japonica*. *Rubus japonica* was originally described by Carl Linnaeus in 1771, and his authorship is indicated with the abbreviation "L." (Linnaeus was first, as well as the most famous, botanist to standardize plant names, so he gets a single letter for his name.). The botanist who moved *Rubus japonica* into *Kerria* in 1818 is indicated with DC., which stands for Augustin Pyramus de Candolle (1778-1841), a botanist from Geneva in Switzerland. In the name *Kerria japonica* (L.) DC., Linnaeus still gets credit for being the first to describe this species by having his authorship being included inside parenthesis, while de Candolle is listed after the parenthesis. This way you can see both who was first, and who made the change. (Note that zoologists do not follow this author formatting system in their code for animal nomenclature).

The early prolific authors that became the most famous often have very short abbreviations, such as "L." for Carl Linnaeus, "DC." for A. P. de Candolle, and "Lam." for J.-B. Lamarck. Today most new author names are complete last names unless the names are very long or common. For example, A.C. Smith is abbreviated "A.C. Sm.". If several botanists have the same last name, initials are used. For example, my standardized author name is Struwe (my name is Lena Struwe), because there has been no other Struwe describing species of fungi, plants, and algae before me. But if another Struwe comes along and describes a new species of a plant, algae, or fungi, then she/he will need to add their initial before the last name, to distinguish them from me.

Author abbreviations follow a global standardized list, but some editors choose to write out authors in full. If you need to look up the standardized author abbreviation for a species name or want to know who the author for a specific taxon name, use the International Plant Names Index website (ipni.org).

Authorship is important in taxonomic works since it clarifies whether the same name was used by different authors for different species (a no-no but it happens— see about homonyms below), or for the same species. It also helps sort out situations where there are botanists with the same name who published different things or at different times. For example, John Joseph Clark (born 1898) is abbreviated "Clark", and currently there are two additional active botanists named John Clark (both happen to work on Gesneriaceae, the African violet family). Their middle initials separate them and their authorships in taxonomy, as "J. L. Clark" (John Littner Clark) and "J. R. Clark" (John R. Clark). A lot of nomenclature research is figuring out who did what, when, and where when it comes to taxonomic names, so it is important to keep different authorships organized and distinctive. Who was first with a valid name publication matters a lot in plant nomenclature and might affect a species name many centuries later.

In some works, after the author and the taxon name you might find a citation of where the taxon was described, with an indication of book, article, or similar work. This includes the publication name either abbreviated or in full, and usually also includes volume and page numbers so one can find the relevant description more easily. Including a publication is not that common in everyday botany, but is often done in scientific literature about plant taxonomy, and necessary when you make a transfer of one taxon to another taxon group or changing its rank. Several abbreviation systems are in use for publications so that the complete book or journal title does not need to be listed, with the most well-known and accepted standardized abbreviation list to book titles and journal names provided on the International Plant Names Index website (ipni.org). For example, Linnaeus' *Species Plantarum* is abbreviated "Sp. Pl." and the journal *Botanical Journal of the Linnean Society* is abbreviated "Bot. J. Linn. Soc.".

Synonyms

The number of published scientific names of plants is much larger than the real number of species since sometimes several different scientific names refer to the same species. This is because, 1) a botanist was unaware of previous publications of the same species, 2) the authors had different ideas of what constituted a particular species, 3) names were published in geographically isolated regions and the species were originally assumed to be different species, but later they were shown to be the same species, or 4) two competing botanists describe the same species in different publications giving it different scientific names (it's rare, but it does happen). As a result of this, on the average, a plant species has 2 to 3 different species names (see *State of the World's Plants*, 2017), but only one of these names should be its **accepted** scientific name. The other names are considered **synonyms**, which are names for the same plant that should not be used anymore, but are often listed for reference.

"What counts as a species?" in botany is a question that does not have an exact, measurable, standardized answer in science. Any answer has to leave room for interpretations of data and observations. This can lead to disagreements among botanists on whether a set of plants should be labeled as just one species or several different ones. New data is often gathered, and/or detailed herbarium work is needed to sort out these taxonomic problems.

There are also personal scientific preferences that at times make one botanist recognize one widespread, more morphologically variable species as a single taxon (species, maybe with subspecies or varieties), while another botanist prefer to recognize this as a complex of several more narrowly defined, more distinct species. These two types of botanists go by the nicknames “lumpers” or “splitters”; in both cases, as in all science, the authors have to provide scientific data and justifications to explain their positions.

EXAMPLE: AUTUMN DWARF GENTIAN SYNONYMS

This European gentian has a long and complex taxonomic history. Over the centuries it has sometimes been considered one species, sometimes several species, and it has also moved around among the genera *Amarella*, *Gentiana*, and *Gentianella*. Below is a list of some species-level scientific names that are synonyms of the currently accepted scientific species name (*Gentianella amarella*) and the author abbreviation for each name. It was originally described by Carl Linnaeus as *Gentiana amarella* (so this is the basionym, the oldest name). *Gentiana acuta* and *Gentiana plebeja* were later described as other species by other authors, and these two were later moved into the genus *Amarella*, a genus that is not accepted today. When some species of *Gentiana* were split out to form the new genus *Gentianella*, *Gentiana amarella* turned into *Gentianella amarella*. Today, all of these listed names are the same wild species.

Photo of *Gentianella amarella.* © Bengt Hemström

Accepted name: *Gentianella amarella* (L.) Böerner*;*
Some of many synonyms:
Gentiana amarella L.
Gentiana plebeja Ledeb. ex Spreng
Amarella plebeja (Ledeb. ex Spreng.) Greene
Gentiana acuta Michx.
Amarella acuta (Michx.) Raf.
Gentianella acuta (Michx.) Hiitonen

If you are looking for information about a species in historical as well as contemporary literature or databases, it is important to search for all synonyms, not just the accepted name, since important information can be associated with any of the names. You can find currently accepted names and synonyms listed in several databases online (see Resources); be aware that they might not always agree. For example, a species accepted in *Flora of Russia* might be considered a synonym or two different species in *Flora of China*, so there are times you will have to decide which publication you will follow as your own reference for your own work (see Resources for links to databases, floras, and similar). There is not yet a global, universal database with detailed information for plant names and species, and even if it existed certain regions might decide to follow their own interpretation of scientific data. Biodiversity is a complex thing.

HOMONYMS

Sometimes two different plant species or genera are given the same scientific name by accident, when someone is using publishing a new name that has already been used for a different taxon. According to the International Code, all scientific names should be unique within all plants, fungi, and algae. The newer (younger) name for the second genus or species is called a homonym and should not be used since it would introduce confusion and breaks this rule. Scientific names should only refer to one species or genus. Homonyms were more commonly published in the past when it was harder to get access to botanical literature and we didn't have digitized databases that make it easy to search through all already existing plant names.

EXAMPLE: *TACHIA* AS A HOMONYM

The tropical gentian genus *Tachia* was described in 1775 by Jean Baptiste Christophore Fusée Aublet (1720-1778) in his book *Histoire de Plante de la Guiane Françoise* based on plant material collected in French Guiana. In 1805, Christiaan Hendrick Persoon (1761-1836) published about a genus he also called *Tachia* from French Guiana in his book *Synopsis Plantarum*, but Persoon placed *Tachia* in the legume family. Persoon's book does refer to Aublet's *Tachia*, but gentians and legumes are very different families. It is clear that Aublet and Persoon used the *Tachia* name to refer to very different groups of plants. Therefore, Persoon's *Tachia* is considered a homonym of Aublet's *Tachia*; it represents another genus but since Persoon gave it the same genus name, his Tachia name is considered a homonym now. You often see the word *non* in the explanation regarding homonyms, like this: "*Tachia* Aublet, non Persoon" (= *Tachia* according to Aublet, not according to Persoon). This is to make sure that Persoon's idea of what *Tachia* was is not included in the current meaning of the *Tachia* genus. Today Aublet's *Tachia* is an accepted name for a genus of 13 tropical gentians[2], and Persoon's *Tachia* species is renamed and his *Tachia* name is mostly forgotten (as it should be), except by botanists looking into details of botanical legume history.

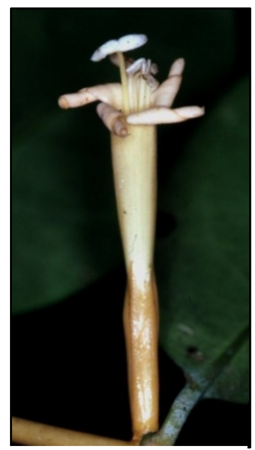


Photo of *Tachia guianensis* from French Guiana. © Carol Gracie

TYPES

How do you know what the author meant with a taxon name or what exact organism she/he described? Especially if the description is only less than a dozen words long and not very specific, as often is the case in Linnaeus' *Species Plantarum*? For this purpose, botanists use what we call **types**. A type is the core of the definition of a scientific name, the fundamental answer to the question; "*What is this species really?*" For plants, the types are generally pressed and dried herbarium specimens kept in official collections (herbaria) where they are available for researchers to visit and investigate (these days, many of them are available online). Sometimes plant types can be other objects, like rocks with fossils, or a microscope slide with planktonic algae, or dried whole mushrooms - it depends on the organism. Just as a picture is said to be worth more than a thousand words, a real specimen, even if more than 200 years old, usually contains more information than a short piece of text in a description.

Additionally, types can give information that is not present in text, photos or drawings; the physical plant can yield important information about the exact DNA, chemistry, anatomy, and micromorphology. Botanists study the morphology, anatomy, DNA and locality of the type material and other herbarium collections to make the interpretation and knowledge of each species more complete, and to research species boundaries.

Specimen-based types are used for species and within-species taxa only (subspecies, varieties, and forms), and are the most valuable specimens in scientific collections around the world. Types are irreplaceable, and it is also impossible to estimate their value in money, since they can't be collected again or seen again by the author (if she/he has died). Every herbarium sheet is a snapshot of biological diversity in time and place, and since we don't have time machines we can't go back and recollect. The type specimen is the original true biological reference point for a scientific name. There are examples of where type collections have been rescued out of buildings on fire, and other times collections burned and types were destroyed.

Herbarium collections of plants are sometimes done as **duplicates**, that is, you take several pieces from the same plant and divide them up into separate herbarium sheets. That way the same collection can exist in several herbaria, even on different continents, and become more accessible to more researchers, especially before digital imagining was possible. For smaller plants, like short herbaceous plants, botanists may instead collect several individuals from the same population and include them in the same collection. A type should preferably be a single individual plant, not a collection of different individuals of the same species.

Botanists divide up types in different categories and typification is regulated under ICN. The specimen that the author of the species saw and listed in the original publication as a type becomes the **holotype**, and its duplicates in other herbaria become **isotypes**. Duplicates of types are identified with the name **iso-** in front of the type designation. For older species names, the exact type might not have been mentioned so a type might have to be selected by later botanists from the material the original author saw in person; this is then called a **lectotype** (with isolectotypes as the duplicates). There are also **neotypes**; this is a new type that replaces lost types when there is no original material left seen by the original author.

There are also **epitypes**, which is material that is added to a type to provide additional information. For example, if the original type has no flowers, an epitype is selected flowering material from another collection that has designated to be part of the type of the species to clarify the morphology of the species.

In the early days of plant nomenclature types were not used, so types are now being determined for all names that are part of the International Code, even if the name was described long ago. Strictly speaking, a type should have been part of the material that the author who described a species actually saw in person and should be mentioned in the description (if you describe a new species today). Since it not always possible to find original material (it could have been lost or destroyed), the International Code allows for the designation of new types to define a species when needed.

Types might seem like a minor thing in systematics, but they are really the core on what scientific names stand on and the way we figure out what an author really meant in reference to the taxon name. Figuring out type problems is tedious work and often happens in rooms of herbaria and museums filled with rows of cabinets of historic specimens and bookshelves with historical floras and scientific journals. Nomenclature work, and especially typification, involves detective work skills that reach into geography of continents and expeditions, the lives and fates of botanists, world history and war, and of course, deep botanical knowledge of morphology and taxonomy.

Examples of difficulties include dealing with replacement of types lost in the destruction of the herbarium in Berlin during World War II[3] and the geographic location of types only listed as being from “Brazil”, a very large area so the original location is imprecise. Nowadays, this work is increasingly through online databases of photographed herbarium specimens available from around the world and digitized historical library collections. The internet and digitization of specimens have revolutionized taxonomic work, but still only a fraction of all specimens is available as photos online and not all types have yet been identified and checked.

There is no global database that list all known types for species names, but there are partial sources in databases on the web and in printed botanical literature (see Resources). Most users of scientific names of plants do not need to deal with or know about the types of the names, but it is important to understand their role since a correction or determination of a type for a species name sometimes causes drastic name changes or threatens well-known plant names.

Genera and families and other groupings have types too, but for these groups a taxonomic name (not actual plant material) is the type. **The type for a genus is a species name, the type for a family is a genus name, and the type for an order is a family name**— each level gets the rank ending added to the type genus name. Types at this level are important because you can only use names for groupings if the type of that name is present inside your grouping. For example, you can't call a family Poaceae (the grass family) if *Poa* (bluegrasses) is not a member of that family group, since the name Poaceae is based on the its type genus *Poa*. When genera get recircumscribed (= change species content) due to new phylogenetic studies, then the genus name always has to follow the type species for the genus. This can cause some tricky situations in classifications and you can read more about this later in the chapter on why scientific names change.

EXAMPLE: TYPIFICATION OF THE LEWIS & CLARK EXPEDITION

The Lewis and Clark Expedition crossed North America in 1804-1806 during a difficult voyage. The herbarium collections they made are at the Academy of Natural Sciences in Philadelphia (and online[4]). These collections formed the basis of Frederick Pursh’ 1813 book *Flora Americae Septentrionalis* in which 132 new plant species were described, but none were listed with types (since this was not customary at the time). Later nomenclature work by James Reveal and colleagues[5] sorted out the typifications of these species.

EXAMPLE: TYPIFICATION OF LINNAEUS' *ASTER NOVAE-ANGLIAE*

The New England aster (*Aster novae-angliae*) was described by Carl Linnaeus in his first edition of *Species Plantarum* in 1753. At the time, types were not used for scientific names. Now, one of the specimens (number BM-000647084) at the Natural History Museum in London has been designated as the lectotype ("Herb. Clifford: 408, Aster 7 novae angliae. Habitat in Nova Anglia."). The specimen came from George Clifford's collection in Holland, which Linnaeus likely had seen since he worked at Clifford's estate in 1735. As is common with old specimens, there is no detailed information on locality or collection date. Note how the cut stem of the plant is covered with a printed urn (typical of the Clifford herbarium), and the label also has an elaborate border.

Photo of New England Aster, *Aster novae-angliae* (Asteraceae) – this is the cultivar 'Barr's Pink'. CC Sandstein (Wikimedia).

Photo of lectotype of *Aster novae-angliae*, a species described by Carl Linnaeus in 1753, and this specimen is from Clifford's collection in Holland. © Herbarium BM, Natural History Museum, London.

EXAMPLE: THE NEW GENUS AND SPECIES *ARIPUANA CULLMANIORUM*

As a graduate student in the 1990s, specializing on tropical gentians, one day I was shown some unidentified plant collections stored in The York Botanical Garden (NYBG)'s cold room from a 1980s Amazonian expedition. The specimens included a strange white-flowered tree gentian that looked nothing like known species from Brazil or other countries in the New World tropics. I investigated further and it turned out to be so different that it couldn't even be placed into an existing genus. With collaborators, in 1997 I published the findings as the new genus and species *Aripuana cullmaniorum*[6], which was then only known from this single herbarium collection. There were several branches collected from this tree by the collectors during this expedition, so there were duplicates sent to several herbaria.

This plant collection by botanist C. A. Cid Ferreira and collaborators (number 5906) now is the type of the new gentian species *Aripuana cullmaniorum*, a species that is also the type for the new genus *Aripuana*. The herbarium sheet at NYBG became the isotype, while the holotype is in a Brazilian herbarium. On the photo of the herbarium collection you can see the pressed plant, the collection label with information on date, place, notes on the plant and its habitat and collector(s) names, collection numbers and project data. Also added to the herbarium sheet are labels that indicate that this is a type and of what species, a unique barcode for databasing and easy search, and a stamp noting that NYBG owns this sheet and that its digital image Is available online. The little envelope contains loose plant fragments (temporarily moved into a petri dish during photography). The removable color chart and ruler were added to the herbarium sheet when NYBG took the photograph, to aid in the scientific value of this digital photo.

Photo of type of *Aripuana cullmaniorum*, described as a new species and genus in 1997 and collected in Brazil in 1985. © C. V. Starr Virtual Herbarium, the New York Botanical Garden.

Scientific Names within Species (Infraspecific Taxa)

Botanists sometimes divide up species into within-species subgroups and give them infraspecific names. These subdivisions can be **subspecies**, **varieties**, or **forms**, and the rules for these scientific names are also ruled by the ICN.

A subspecies or variety might be named when there is group of individuals in a species that are different from the typical morphology of the species. For example, a population adapted to living on seashores instead of the normal inland meadows with slightly different morphological characteristics could be described as a separate subspecies. A subspecies can be divided up into varieties, but you do not need subspecies to be able to describe a variant. Forms are not frequently used anymore, but usually indicates a genetic variant, such as albino-like plant individuals that have white flowers.

As soon as a new subspecies is created this way, an automatic 'typical' subspecies is created for the normal population, which gets a subspecies epithet that is identical to the species (for example, *Sedum acre* ssp. *acre*, based on the figure below). Subspecies are often indicated within a scientific name with the abbreviation **ssp.** or **subsp.**, a variety is abbreviated with **var.**, and form is abbreviated with **f.**; the rank abbreviations are not italicized. Subspecies and varieties can be combined into a long name, like this made-up name: *Sedum acre* ssp. *acre* var. *oceanica* f. *alba*, but you rarely see such long taxon names.

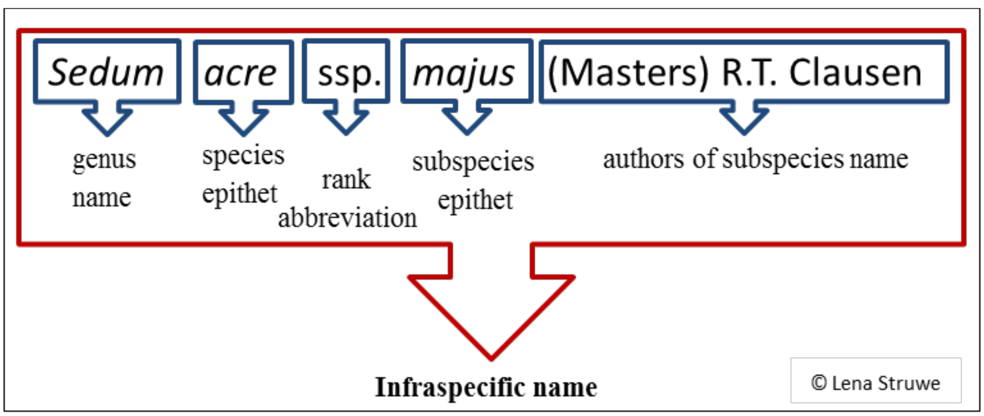


Figure (above). The infraspecific name *Sedum acre* ssp. *majus* includes both the genus name (*Sedum*), the species epithet (*acre*), and the infraspecific epithet (*majus*). The same formatting is used for varieties and forms. If both subspecies and variety needs to be listed, then subspecies comes first, then variety after the species epithet. Authors for the infraspecific name are listed at the end (this is optional), and sometimes the species author (if different) is also listed after the species epithet.

Example: infraspecific names within *Sedum acre*

The goldmoss stonecrop, *Sedum acre*, is common in Europe but has spread and become naturalized in Asia and North America. It was first described by Carl Linnaeus in 1753, but he did not divide it up into subcategories within the species. In 1878, M.T. Masters described the variety *majus* in the

Photo of *Sedum acre*. Public domain photo by Roquai (Wikimedia).

journal *The Gardeners' Chronicle & Agricultural Gazette,* to highlight a population with a particular difference from the typical populations of the species. When this was done, the name *Sedum acre* var. *acre* was automatically created for the typical species populations. In 1975, R.T. Clausen raised the rank of the *majus* variety to subspecies, publishing *Sedum acre* ssp. *majus* (Mast.) R.T. Clausen, in his book *Sedum of North America*. In the *Flora of North America* treatment the authors did not recognize any groupings within *Sedum acre* for wild and naturalized plants, but the subspecies/variety name *majus* is in use within horticulture. To complicate the story further, there is also another species using the epithet *majus*, the Chinese *Sedum majus*. It is very important to remember that, because species epithets are not unique, the same epithet might not mean the same organism; it is the combination of genus name and epithets that creates unique species names (and there can also be homonyms).

Table (below). Examples of some infraspecific names within *Sedum acre*.

Taxon	Name
Species	*Sedum acre* L.
Subspecies (ssp. or subsp.)	*Sedum acre* ssp. *acre* *Sedum acre* ssp. *majus* (Mast.) R.T.Clausen *Sedum acre* ssp. *microphyllum* (Stevanov) Bertová
Variety (var.)	*Sedum acre* var. *acre* *Sedum acre* var. *majus* Mast. *Sedum acre* var. *microphyllum* Stevanov *Sedum acre* var. *sopianae* (Priszter) Soó

Summary of Rules for Scientific Names of Plants

- **Uniqueness** — a species can only have one unique scientific name.
  - **Don't use homonyms** -— Another plant species cannot have the exact same scientific name (that creates a **homonym**).
  - **Be aware of synonyms** — A species might have a more recent name or names that were given when it was placed in other genera or other ranks (**synonyms**).
- **Priority** — the oldest (= first described, from 1753 onward) species epithet is the one that should be used.
  - **Changing genus classification?** If the original species is being moved to another genus, then the genus name changes, but the epithet stays the same (but might change its ending due to Latin grammar).
  - **Only priority within the described rank applies**. For example, if a name has been used to describe a species, it cannot have priority as a subspecies (unless it was described as a subspecies in the same publication).
- **Valid publication** — Scientific names must be validly published and legitimate. Illegitimate and/or invalidly published names violate the rules and should not be used.
- **Exceptions** — Always check the International Code for Nomenclature for details and exceptions to the rules.

NAMES OF HYBRIDS

We humans want to have information neatly categorized, but sometimes biological reality does not always fit into our practical sorting boxes. This is especially true for hybrids, a result of a cross between two different types of plants, and even more so for hybrids that are a result of horticultural or agricultural breeding. It is important to remember that sex and genetics in plants work quite differently from these processes in mammals and other animals. Among plants, hybrids are quite common, especially in the oaks, willows, sedges, and orchids. The International Code provides rules for giving valid scientific names to hybrids between species. Be aware that some hybrids developed in horticulture have been given cultigen names instead of scientific names, and that horticulturalists and farmers often use the word "hybrid" differently from plant taxonomists.

HYBRIDS BETWEEN SPECIES WITHIN SAME GENUS

The most common hybrid is a cross, natural or man-made, between two species within the same genus. There are several options using scientific nomenclature to name such a within-genus hybrid. The first option is that the name lists the two parent names with an × symbol in between ("hybrid formula"). The second option is that a new species epithet is published for the hybrid, and an × is put in front of the species epithet. Note that it is the multiplication symbol (×) that is being used, not the letter x. Hybrid species names are ruled by the International Code.

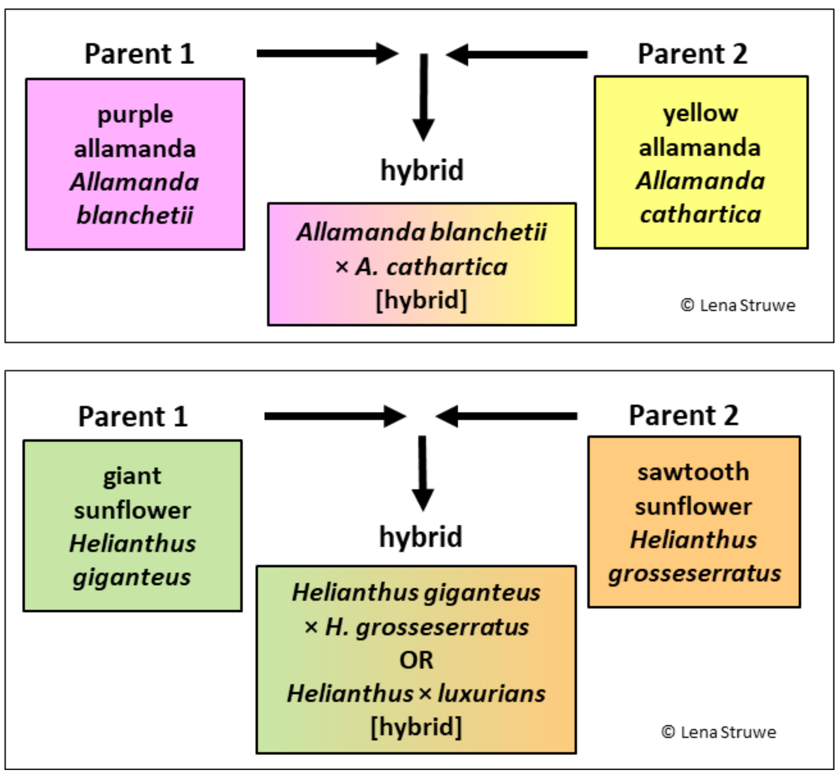


Figure (above). Diagrams showing how a hybrid between two species within the same genus (*Allamanda* or *Helianthus*, sunflowers) can get a hybrid name formed from the two parent species names or a new, unique species epithet.

Hybrids within Species

For cultivated plants, plant breeders, farmers, and horticulturalists use the word hybrid sometimes to describe crosses of different strains *within* a species. Thus, hybrids in agriculture or horticulture can be hybrids between two different parent strains, usually of the same species (for example, the tomato F1 'Sungold'). But take note: this is not how the word hybrid is used in the International Code of Nomenclature and for scientific species names, and such hybrids do not get scientific names as outlined below for between species crosses.

Hybrids between Genera

Hybrids between species from different genera are less common than between species within the same genus, but they do exist, both naturally and as artificial crosses made and propagated by humans. In this case you can't simply put an × between two parent species since they do not share the same genus name. Instead, both parents get listed with full names. In some cases, a brand-new hybrid genus name is invented and published, and this is indicated with a larger × symbol before its name. Hybrid genera like these require formal description according to the International Code. Since a hybrid genus is formed from species from two different genera it can't be monophyletic; the monophyly criterion simply can't apply to hybrid genera.

Example: Leyland Cypress

The Leyland cypress is a popular evergreen conifer in gardening and its parental origin can be traced to a hybrid cross of two species, the Monterey cypress from coastal California and the Nootka cypress from the Pacific Northwest in North America. The scientific name of the Monterey cypress is *Cupressus macrocarpa*. Conifer taxonomy has been through large upheavals and many name changes due to changing boundaries between genera. As a result, the Nootka cypress has been moved back and forth among four different genera, *Cupressus*, *Chamaecyparis*, *Callitropsis*, and *Xanthocyparis*.

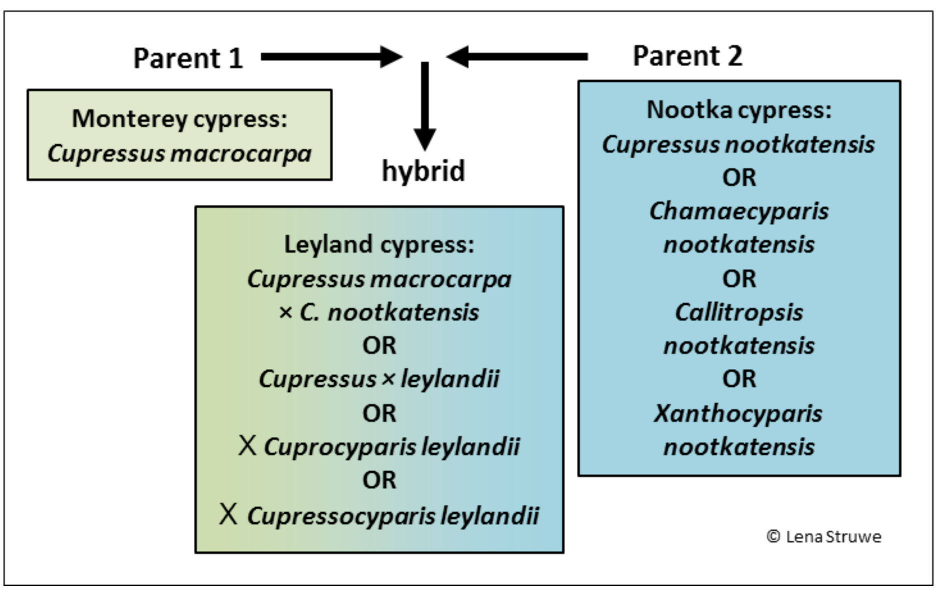


Figure (above). Diagram showing the naming of the Leyland cypress, a hybrid species between two genera.

Since the Leyland cypress is a hybrid, this has also affected its scientific name, since hybrid names are formed from parental names. When the Nootka cypress is considered a *Cupressus*, then the hybrid name would simply be *Cupressus × leylandii,* but when parent 2 was moved to *Xanthocyparis,* then the name would become a new hybrid genus name formed from *Cupressus* + *Xanthocyparis* - the X *Cuprocyparis.* This genus name (X *Cuprocyparis*) is only used for hybrids between *Xanthocyparis* and *Cupressus.* The illustration above lists the possible names for this hybrid. As you can see, the accepted name of this hybrid is dependent on what the accepted names are for the parents.

Hybrids from more than Two Parent Species or Two Parent Genera

When you have hybrids derived from more than two species (i.e., at least one of the parents is a hybrid), naming becomes complex and elaborate. It would be cumbersome to list all the species names of the all the parent as a hybrid formula. Therefore, rules have been developed for how to handle these multi-hybrid genus names (see the Cultivated Plant Code for details).

For hybrids from three parent genera, a new name can be made up as a combination of the three original genus names. For hybrids formed from four genera, a new hybrid genus name will be based on a person's name with the ending -*ara*. In orchids, which are easy to cross across generic boundaries, such hybrid mixes have been made by human-aided pollination, and here are two examples:

× *Sophrolaelicattleya* (= *Cattleya* × *Laelia* × *Sophronotis*), a manmade orchid genus

× *Beallara* (= *Brassia* × *Cochlioda* × *Miltonia* × *Odontoglossum*), a manmade orchid genus

WHY DO SCIENTIFIC NAMES AND GROUPINGS CHANGE?

Scientific names are based on the most current and updated scientific research of the world's biodiversity. That means new data is added all the time: every year thousands of new species are discovered or described for the first time and our phylogenetic analyses and classifications of species into genera and families (etc.) are continuously refined and a work in progress.

However, thanks to the use of DNA for clarifying phylogenetic evolution, relationships of species, and techniques for classifying species into natural, monophyletic units, our taxonomic classifications are becoming more and more stable. A lot of reorganization of plant families in the last 20 years have been a correction and update of old classifications that lumped unrelated plants together. The new APG family classification is proving to be highly stable, and we expect only relatively small family changes to it in the future. For species names, in general the scientific name for a species does not change if classified into a new family or other higher rank. But the name will change if the species is changing genus.

Scientific plant names can change for many reasons. Some of these reasons are outlined with examples below, and are summarized here:

- The species is reclassified into another genus (and species epithet stays the same, but its ending can change).

- It turns out that the species is actually two different species that should be separated. One of the species will keep the old name (following the original description and type material), the other will have another name (which can be new or old, depending on what names are already available for that part of the species.)
- Two species get lumped together into one species, and then the younger species name will become a synonym to the older name, following priority.
- An older species epithet that hasn't been in current use is found in the literature for a species, so due to the rule of priority, the oldest name should be used. (But see conservation of names below, an exception.)
- A new species is found and described, and individual plants get identified as this new species (instead of an already known species).
- Names of groupings of species (genera) can also change due to new phylogenetic results, which lead to a recircumscription of the species content of that group. When such changes happen, the oldest name that can be applied to the group should be followed (priority applies).
- Family recircumscriptions can lead to a change in family names, since the oldest name available for the species in the group should be used (priority applies, again). What names that are available depends on if family names have been published earlier based on the genera present in the group. If no family name is available, then a new family name must be published.

Species Changes

Example: *Symbolanthus calygonus* teased apart

Taxonomists look carefully at plant materials from large areas to clarify how the species should be defined and what they should be named. In my scientific work with ring gentians (*Symbolanthus*) from South America, it was clear that what had been considered one large, widespread species with gorgeous and large white, green, pink or red flowers actually was several species with distinct leaf and sepal morphologies, as well as distinct flower colors.

Photo of *Symbolanthus alboarenicola.*
© Paul Maas.

The circumscription of *Symbolanthus calygonus*, the oldest name in the genus, needed to be redefined, so what was recently considered a widespread species now became a species endemic to central Peru[7]. The rest of the plants that used to be considered *Symbolanthus calygonus* needed new names. If there was a synonym available representing one of the species that was split out, then that could be used. For example, *Symbolanthus brittonianus* from the Andes of Bolivia had already been described over 100 years ago, thus was resurrected. Another species from lowland white sand areas of Peru had just been discovered, and was new to science, so it was published as *Symbolanthus alboarenicola*.

Over time, the scientific data and opinions might change, so it does happen that previously accepted species that were sunk into one species might get resurrected a hundred years later. As with families, the scientific names of the species and genera follow the best scientific understanding based on the total amount of data we have gathered so far.

Example: the merger of two ring gentian species into one species

When scientists make detailed studies (called revisions or monographs) of the taxonomy of a plant group, taxonomic changes are common. In our revision of Andean ring-gentians (*Symbolanthus*)[8], it turned out that what had been considered two species (*S. mathewsii* and *S. macranthus*), occurring in the same area, actually were the same species, sharing the same morphology and distinctive characters. We therefore joined the two species into one, and the name that now is used for this species is the oldest species epithet, *mathewsii*, which has priority. However, *S. mathewsii* was initially described in a different genus, *Lisianthus*, and both species had previously also been placed in *Helia*, and the first species epithet to get moved into *Symbolanthus* was *macranthus,* not *mathewsii* (see table below). That doesn't matter, priority trumps everything, now this species is *Symbolanthus mathewsii*.

1838	Grisebach describes ***Lisianthus mathewsii***, based on a type specimen from Peru.	
1844		Bentham describes ***Lisianthus macranthus*** based on a type specimen from Ecuador.
1891	Kuntze moves *Lisianthus mathewsii* to *Helia*, new name is ***Helia mathewsii***	Kuntze moves *Lisianthus macranthus* to *Helia*, new name is ***Helia macrantha***
1947		Moldenke moves *Lisianthus macranthus* to *Symbolanthus*, new name is ***Symbolanthus macranthus***
1952	Ewan moves *Lisianthus mathewsii* to *Symbolanthus*, new name is ***Symbolanthus mathewsii***	
now	Currently the plants from these two names are considered the same *Symbolanthus* species in nature, so the accepted name for this species is: ***Symbolanthus mathewsii*** (=current genus plus oldest species epithet). All other listed names are synonyms.	

Table (above). The taxonomic histories of *Symbolanthus mathewsii* and *Symbolanthus macranthus*, showing the timeline and taxonomic changes for the two names before their merger.

Photo (above). These gorgeous Ecuadorian flowers are from the species that used to be called *Symbolanthus macranthus*, but now they belong to *Symbolanthus mathewsii*, since *S. macranthus* was sunk into *S. mathewsii* in 2008 (see left). © Jason R. Grant.

Name Changes in Genera and Families

Today when a species changes its genus or family designation, it is nearly always a result of new evolutionary insights that show that the grouping (family or genus) a species used to belong to was not a monophyletic group, that is, not a natural, evolutionary lineage. To fix this, taxonomists reclassify species and groups to make them monophyletic, so that all closely related species are in the same group, not in different ones. With the tools of DNA and molecular analyses, botanists have been able to fix a multitude of such problems over the last few decades, so we are now seeing an increasingly stable family and genus classification for vascular plants like angiosperms, ferns, conifers, and clubmosses after some big changes.

There is still work to be done on the generic levels, but major family reorganizations have mostly been completed for flowering plants. The most up-to-date APG family classification is what generally should be followed for the most accurate family groups for flowering plants, since it provides a global standardized list based on monophyletic groups. There are also updated family classifications for conifers, mosses, ferns, lichens, algae, and fungi.

Table (below). Some examples of major changes in family organizations of flowering plant species.

Traditionally used family names	Current classification (APG)
Aceraceae (maples)	Included in Sapindaceae
Asclepiadaceae	Included in Apocynaceae
Bombacaceae	Included in Malvaceae
Caesalpiniaceae	Included in Fabaceae
Cornaceae	Only two genera left in family, the rest in other families (Nyssaceae, Alangiaceae)
Dipsacaceae	Included in Caprifoliaceae
Liliaceae	Major split-up, only a small part left in Liliaceae, the rest now placed in other families
Loganiaceae	Major reclassification, less than half of genera left in family, rest moved to other families (Gelsemiaceae, Gentianaceae, Buddlejaceae, Gesneriaceae, etc.)
Myrsinaceae	Included in Primulaceae
Pyrolaceae	Included in Ericaceae
Scrophulariaceae	Major reclassification, resulted in just a few genera left in Scrophulariaceae, the rest placed in other families (Plantaginaceae, Orobanchaceae, etc.)
Sterculiaceae	Included in Malvaceae
Tiliaceae	Included in Malvaceae
Verbenaceae	Some genera moved to Lamiaceae

EXAMPLE: RECLASSIFICATION OF A POLYPHYLETIC LOGANIACEAE

The taxonomic history of Loganiaceae[9] (the strychnine family) is a good case study in how molecular data can help solve classification problems and improve plant family naming. A few decades ago when I started my PhD studies, Loganiaceae included 29 genera, but there were no character states that united them, instead the plants in the family were united by *not* having the specialized characters of other families in the order Gentianales. This order included four-five families then, Apocynaceae/ Asclepiadaceae, Gentianaceae, Loganiaceae, and Rubiaceae. The coffee family (Rubiaceae) has interpetiolar stipules and inferior ovaries, Apocynaceae (now incl. Asclepiadaceae) has latex and specialized structures in the sexual parts of the flowers. Gentians (Gentianaceae) are generally herbaceous with capsular fruits with parietal placentation (however, this is not uniform), but they have specialized chemical compounds. DNA sequencing and phylogenetic analysis in the 1990s showed that some Loganiaceae members didn't even belong in the Gentianales; their closest relatives were in other orders, so they were excluded and moved away from Loganiaceae[10].

When the analysis was run for only Gentianales, the remaining genera of Loganiaceae were placed in three separate clades (see figure below), showing that Loganiaceae was polyphyletic within the order[11]. To fix this in a reclassification, the clade that contained *Logania*, the type genus for Loganiaceae, became the new Loganiaceae. The clade with *Gelsemium* and *Mostuea* were described as a new family, the Gelsemiaceae. The final group, three genera with trees with leathery berries (*Anthocleista*, *Fagraea*, and *Potalia*), was moved into Gentianaceae. With these two changes, all families in Gentianales became monophyletic. Further research showed that the three tree-like genera had been suggested to be gentians nearly 150 years earlier in a forgotten French PhD thesis based on comparison of wood anatomy of plants in this group. Molecular data analysis rarely results in completely unexpected relationships, instead it helps sort out and select between competing theories of relationships.

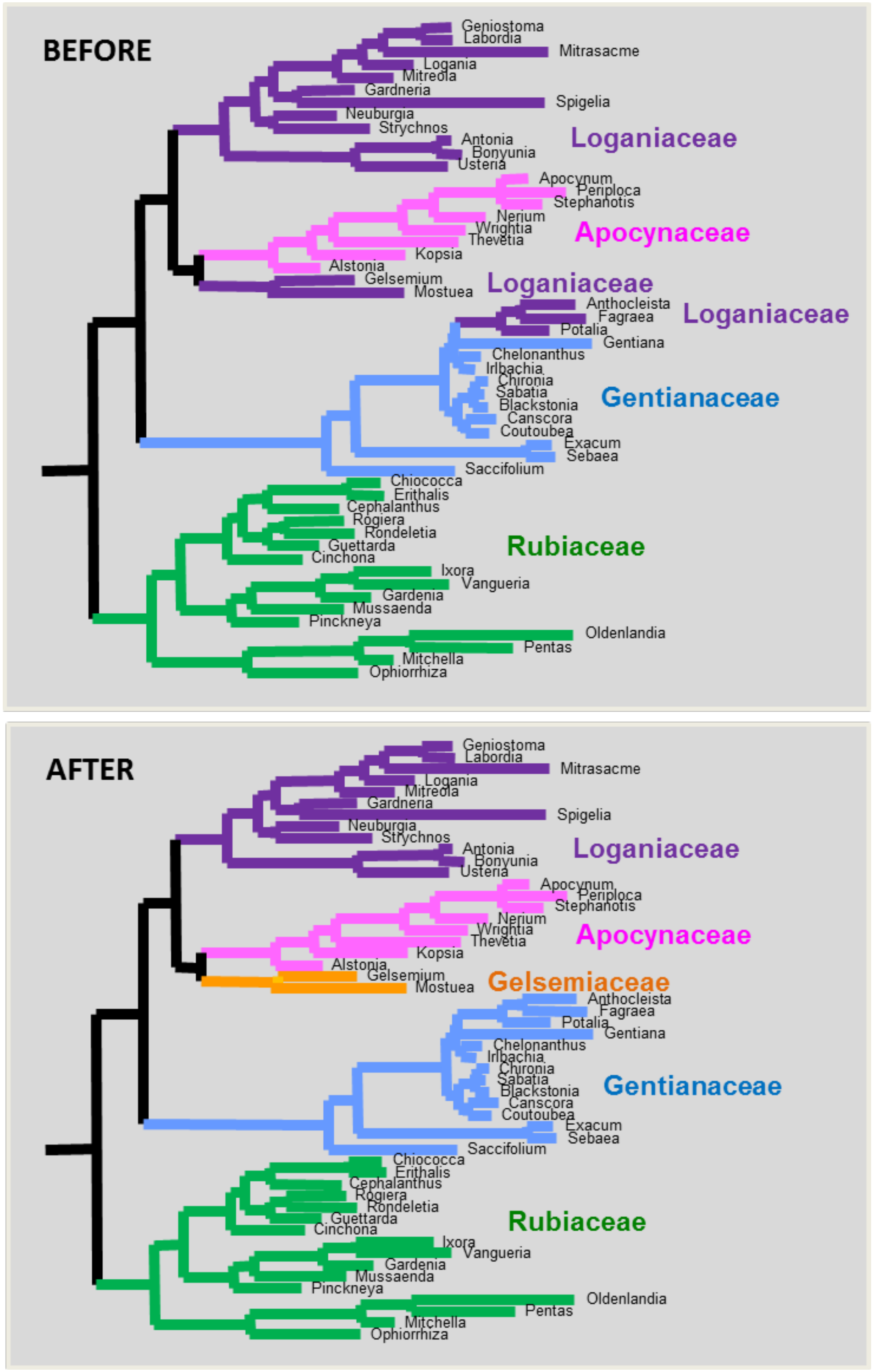


Figure (above). Reclassification of Loganiaceae based on a phylogenetic analysis of molecular (DNA) data, showing the formation of Gelsemiaceae and the moving of three Loganiaceae genera into Gentianaceae, so that all families are monophyletic. (Redrawn after research published by Lena Struwe; © Lena Struwe)

COMMON NAMES

Common names of plants are the names we use in everyday, local languages; these are also called vernacular names. Examples of such names in English are oak, red oak, tulip, tulip tree, Brussel sprouts, snake root, moss, and fireweed. These names are often not unique to a particular species and are often different in different countries and/or regions (even if several regions speaks English, for example). Sometimes a species has many common names. Sometimes a single name is used for many species.

Because common names are in the vernacular language of a region, they are easy for local people to learn and pass along by word of mouth. These common names often reflect a particular culture's historical, folkloric, mythological, botanical, or ethnobotanical heritage; for example, "pao de cobra" ('snake stick') for a plant used against snake bites in the Amazon, and "jimsonweed" for a plant that is associated with the settlement of Jamestown, Virginia, in colonial North America.

Interesting and familiar as common names may be, they present big problems in practice. Many plants level lack common names especially if are very small, have no human use, or are hard to recognize at the species; this is especially true for mosses, lichens, and smaller tropical plants. Common names also do not tell you if you are referring to a genus, species, or informal group of plants.

The use of a common name can often create confusion and uncertainty in both scientific and non-scientific contexts; you can't to be sure about which exact species the local name refers to. Common names are only based on what name is (or was) used in the local language for that species at that a particular time and region. For example, the same species can have a different English name in the United Kingdom and another in the United States, or different names within different parts of the UK and the US. Within the same region, different names can also come from different ethnic heritages of the local human population.

As plants and humans move around, common names keep changing. Sometimes names are created for plants that did not have them. Sometimes names that might be offensive or taxonomically misleading are deliberately changed on official lists and avoided in future use. There was and is no global authority for accepted common names to be used on a worldwide scale. Even when a country tries to provide standardized lists of common names that are unique, only one per species, and follow certain rules (for example in Sweden and its DYNTAXA and SKUD databases), there is usually no strict legal rule that you have to follow those recommended names unless you follow specific local policies.

Common plant names are often used in trade and commerce, arts and literature, as recipe ingredients, as well as in popular and scientific writing. The names of plants included in food products are often defined on a country level, for example in the US, to help consumers, the Food and Drug Administration specifies which common plant names can be used in food ingredient lists and on labels. Similarly, the names of the plants in personal care products and medicinal plants in commercial herbal preparations are often required to follow a particular pharmacopeia or other standardized, published work, especially if the common name is used instead of its scientific name. In the case of personal care products, the worldwide data base is called INCI, and run by the Personal Care Product Council.

There are various works that list common names, such as the USDA's PLANTS database in the US, national pharmacopeias, local or national floras, garden and seed catalogs, or herbal books. You can choose to follow a preferred reference in your own use of common names (if so, make sure you provide the citation of your reference work), but be aware that others might use the same common name for another species, or use other common names for the species you mean. Generally speaking, common names are problematic on larger geographic scales and can often introduce confusion and uncertainty. This is true even for everyday names like "orange", "sage", "basil", "yam", and "cinnamon", names that each can refer to several different plants.

Photo of White snakeroot, *Ageratina altissima*. © Lena Struwe

EXAMPLE: SAME COMMON NAME FOR SEVERAL SPECIES

Many species have or have had the common name snakeroot in English. Sometimes the name snakeroot is used with descriptive or geographic modifiers to help tell species apart. Since the name snakeroot has been used for many different species from many different plant families and from many different geographic regions, this illustrates the problem with using a common name as the only listed name of a plant or plant product source very well. If a product label just gives the common name, snakeroot in this case, you have no way to be sure exactly what plant species is in the product.

Table (below). Examples of different plants that have the same common name in English, snakeroot.

Common names	Scientific name	Plant family	Geographic origin
black snakeroot	*Actaea racemosa*	Ranunculaceae (buttercup family)	North America
white snakeroot	*Ageratina altissima*	Asteraceae (sunflower family)	North America
Virginia snakeroot	*Aristolochia serpentaria*	Aristolochiaceae (birthwort family)	North America
Canadian snakeroot	*Asarum canadense*	Aristolochiaceae (birthwort family)	North America
snakeroot	*Eryngium cuneifolium*	Apiaceae (parsley family)	North America
snakeroot	*Liatris punctata*	Asteraceae (sunflower family)	North America
snakeroot	*Mitreola petiolata*	Loganiaceae (strychnine family)	Widespread, tropics
snakeroot	*Persicaria bistorta* (formerly *Polygonum bistorta*)	Polygonaceae (knotweed family)	Europe & Asia
snakeroot	*Plantago major*	Plantaginaceae (plantain family)	Widespread
Seneca snakeroot	*Polygala senega*	Polygalaceae (milkwort family)	North America
Indian snakeroot	*Rauvolfia serpentina*	Apocynaceae (dogbane family)	Asia
clustered black snakeroot	*Sanicula gregaria*	Apiaceae (parsley family)	North America
snakeroot	*Senecio aureus*	Asteraceae (sunflower family)	North America

EXAMPLE: SEVERAL COMMON NAMES FOR THE SAME PLANT

The plant known as *Chamerion angustifolium* (previously called *Epilobium angustifolium* or *Chamaenerion angustifolium*) is a widespread herb used by people in many countries for many purposes. It is known across USA and Canada as fireweed, but it has also been called willowherb and other names. A Native American tribe called it spukWu'say (Twana, in the Pacific Northwest). In Europe it also has many names. In the United Kingdom alone it has been called blood vine, blooming Sally, bomb weed, flowering willow, French willow, great willowherb, Persian willow, purple rocket, and rosebay willowherb. In Sweden, it is rallarros (= railroad track builder's rose) and mjölkört (= milk herb), or mjölke (= milkie). It is 柳 兰 (liu lan) in Chinese. The scientific name provides a unique, global identifier to this widespread, often beloved, species, while the common names are numerous and local. Note that there are also at least five other plant species called fireweed in English around the world.

Photo of *Chamerion angustifolium* (Onagraceae). © Lena Struwe.

CULTIVATED PLANT NAMES

For plants that people have changed through breeding, hybridization, domestication, and artificial selection for particular human uses into stable types of cultivated plants, the formal naming is governed by the *International Code of Nomenclature for Cultivated Plants* (ICNCP), called the **Cultivated Plant Code** in this manual. Such types of human-bred plants are informally called **cultigens.** The Cultivated Plant Code rules only over names that belong to **cultivars** and groups of cultivars (the latter is conveniently called **Groups**). There are also **graft-chimaeras** used within the cultivated Plant Code (a result of grafting of several species together).

Cultivar and Group names are only allowed for plants that fulfill these criteria; they 1) have been selected from wild plants or changed through various types of breeding and artificial selection by humans; 2) are now stable in their characteristics through propagation; and 3) are distinct enough from other kinds of plants to merit recognition.

Included in the global system of cultigen naming is a diverse array of plants grown by humans. Some of these plants are a result of ancient domestication, while others are older or newly formed hybrids, genetically modified organisms, and still others are accidentally or purposefully developed mutations. Many chemical and morphological crop and horticultural plant features are part of such breeding, from beauty and fragrance, edibility and nutrition, fibers, medicinal phytochemicals, and other desirable traits. Most cultivated plants are the result of deliberate selections by humans from what was originally wild species.

Be aware that the words **variety** and **varieties** should not be used as names of cultivated plants, unless they refer to a variety as a scientific name. Varieties are not used in the Cultivated Plant Code. Variety is a *within-species-rank* used officially only in scientific names ruled by the International Code of Nomenclature (scientific names can of course be used on garden labels and in catalogs with cultivated species). Wild-sourced plant species that are purposefully grown in gardens and as agricultural crops can have names that are regulated by the International Code of Nomenclature without additional cultivar and Group names.

The Cultivated Plant Code deals with the complexity of the results of human plant breeding and selections. The names of scientific species and their groups (genera, families, etc.) in the International Code are nested hierarchies, a clean, well-organized system of boxes within boxes (see previous chapters). Since cultivars are often a result of extensive hybridization between different species and sometimes different genera, the principles of nested hierarchy and monophyly do not work as criteria for cultivated plant naming.

The Cultivated Plant Code methods for naming cultivated plants does not try to present evolutionary accurate groups and names. The Cultivated Plant Code instead provides a highly practical way of naming a taxonomically complex organism created by humans. It accepts groupings that are not formed by only the most closely related plants, so it is strictly practical.

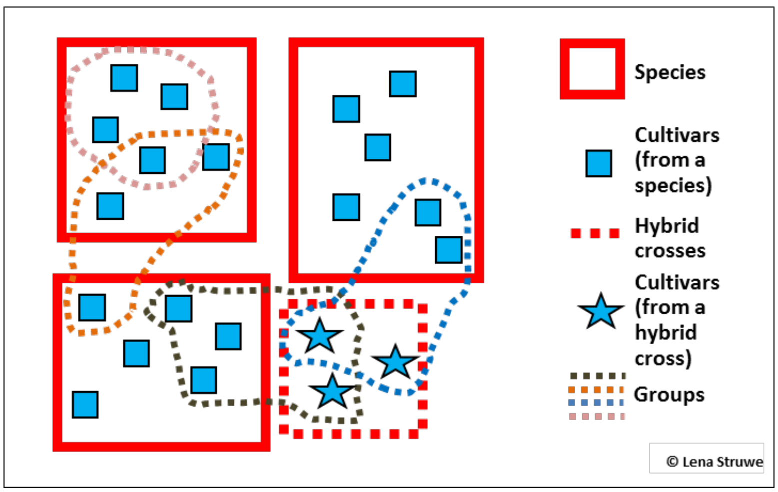


Figure (above). Wild species (in red boxes, scientific names) are bred and selected and then named as cultivars (blue small boxes). A thick red dotted line shows hybrids (either wild or developed by humans), with its named cultivars (blue stars). Cultivars are grouped into Groups (thin colored dotted lines) based on selected characteristics, and a Group can include cultivars from several species and hybrids.

As you can see in the diagram above, Groups can be overlapping, some cultivars do not have to belong to Groups, and cultivars can be a result of artificial selection both within a species and between species. Cultivated hybrids can include characteristics and ancestry from one or more species. Groups can include variation and ancestry from several species as well. This means that monophyly is not relevant for Group names.

It is important to note that there are many examples of horticultural and agricultural databases, books, and online sources that are not properly following the nomenclature rules of cultivated plants (not scientific names), so there is a lot of confusion when it comes to cultivated plant names. Cultivar and Group names are not registered trade names or patent names and they are not legally protected, but they are often used in commerce (commercial names are explained in the next chapter).

CULTIVARS

The word cultivar comes from 'cultivated variety'. Often the cultivar name is listed after the scientific name, but cultivar names can also be used only with the genus name, without the species epithet (unless the same cultivar name is used for cultivars from closely related species within the same genus, which then would create ambiguity and confusion). Cultivar names are placed in **single quotes** and start with a capital letter; they are **not italicized** and do not follow botanical Latin grammar rules (a feature reserved for scientific names).

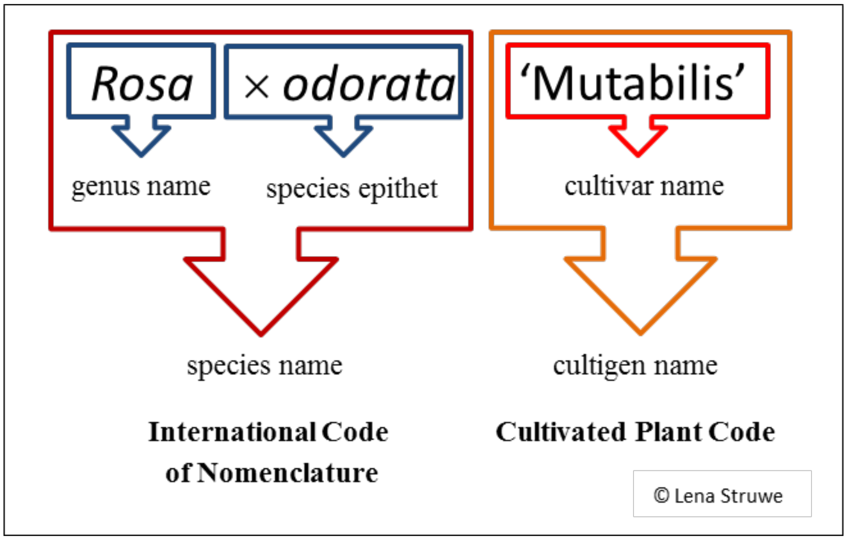


Figure (above). Cultivar names are added onto the scientific name, here exemplified by the cultivar 'Mutabilis' of the hybrid *Rosa* × *odorata*. The International Code of Nomenclature includes regulations for the scientific name, while the Cultivated Plant Code regulates cultivar and Group names of cultivated plants.

EXAMPLE: ROSE CULTIVAR NAMES

Roses (*Rosa*) are a delightful group of plants that have been bred and hybridized since ancient times, and as a result, many cultivated roses cannot (and should not) be attributed to a particular scientific species. They are often identified by their cultivar names instead and these may be arranged into groups (such as Floribunda Group, Hybrid Tea Group, and Polyantha Group). Cultivar names can be registered, and registry (ICRA) of roses are handled by the American Rose Society, which recently published a new classification of cultivated roses, dividing up all roses in three major types: Wild Roses (naturally occurring species), Old Garden Roses (bred before 1867), and Modern Roses (developed after 1867)[12].

Photos of cultivated roses (*Rosa*). (c) Lena Struwe

Many cultivars are well-known, for example, *Rosa* 'Queen Elizabeth'; however, some are better known by their trade names. For example, the famous Peace rose has the cultivar name 'Madame A. Meilland', but is better known in horticulture by its trade name *Rosa* PEACE.

EXAMPLE: A DOGWOOD HYBRID AND ITS CULTIVARS

An artificial plant hybrid can receive several names: several cultivar names, associated trade names, and a scientific hybrid name (this last is less common). This recently happened to a popular garden tree that is the hybrid between *Cornus kousa* (Kousa dogwood) and *Cornus florida* (flowering dogwood).

The first-generation (F1) cross between *Cornus kousa* and *C. florida* led to a selection of cultivars (listed inside quotation marks) that were also patented (trade names in SMALL CAPS, followed by the appropriate trade name symbol). The hybrid itself recently received a scientific hybrid name through the publication of the name *Cornus* × *rutgersensis* (named after Rutgers University, NJ, US, where the crosses where made) many years after the first hybrids were made[13]. This provides a unifying scientific name for this between-species cross and encompasses all known F1 hybrids between these species and their cultivars. Note how the registered trade names are the exciting ones, whereas the cultivar names are less interesting — this is not always the case. Here it was simply the dogwood breeders' choice when the cultivars were named, and the patent applications filed.

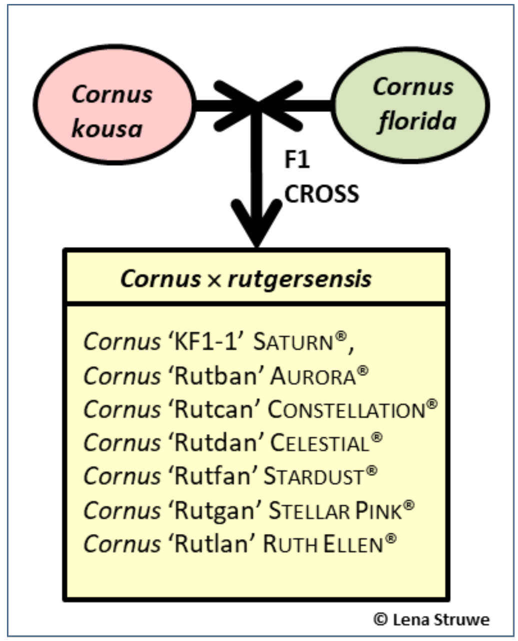


Figure (above). The crosses between two dogwood species resulted in several different selections, which has been given cultivar names (in single quotes) and commercial trade names.

GRAFT-CHIMAERAS

Graft-chimaeras are the result of a mechanical and cellular fusion of plants from at least two different taxa (different or same species) through grafting. These are formed when a shoot develops from the grafting zone and the shoot contains a mixture of two species (or cultivars). It is not a regular biological hybrid, but a plant with two separate types of cells co-existing simultaneously. This shoot then be propagated clonally and sold under its own new name following naming rules in the Cultivated Plant Code.

If the parents of the chimaera are from the same genus, then the name will be a cultivar name within that genus, without a species epithet. Graft-chimaera names are in italics and with an initial capital letter. If the chimaera is from two different genera it may receive a new name that starts with a + sign (for example, +*Laburnocytisus* is formed from the legume genera *Laburnum* and *Cytisus*), sometimes also with a new cultivar name after the newly formed genus name.

GROUPS

Groups in the sense of the Cultivated Plant Code are pragmatically grouped cultivars (see previous figure above). Some cultivated plant species or genera contain many well-known groups of cultivars, such as the roses, cabbages, citrus fruits, and wheats. Groups can be overlapping, a cultivar may belong to more than one group, not all cultivars need to be part of Groups, and Groups do not need to reflect genetic relationships, only overall similarities. So Groups can be very confusing in cultivated plant taxonomy.

Group names are not in quotes, not italicized, and do not follow botanical Latin grammar rules (they can be based on English or Latin or other languages). The name of a Group is always capitalized and includes the word 'Group' at the end (for example: *Citrus* Grapefruit Group).

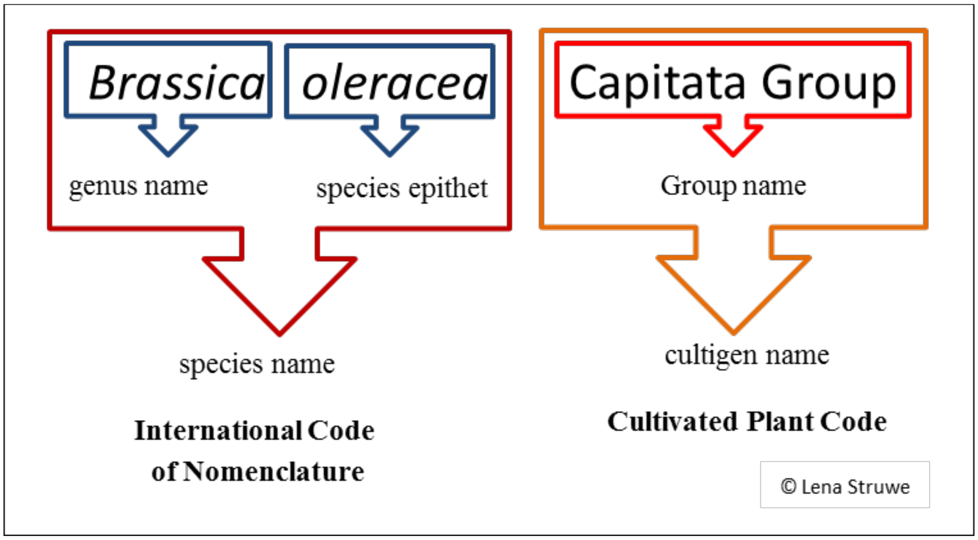


Figure (above). The white and red cabbages belong to the *Brassica oleracea* Capitata group, a plant name that is formed by the combination of a scientific name and a cultigen name.

Note, in cultivated orchids a grouping type called **grex** (greges or grexes in plural) is sometimes used due to the cultivated orchids' extremely complex breeding histories; please see the orchid literature for this special case.

EXAMPLE: CABBAGE GROUPS

The European coastal species *Brassica oleracea* (wild cabbage) has been domesticated and bred for a long time into a wide variety of edible cultivars. These crops are commonly known by their common names that most of us recognize from the supermarket and vegetable garden: broccoli, white and red cabbage, kale, collards, cauliflower, Brussel sprouts, kohlrabi, broccolini, and more.

Photo of cooked broccolini. This plant is a natural hybrid between two cabbage cultivars, broccoli and gai lan, so it is a hybrid between two groups, the Botrytis Group and the Alboglabra Group. © Lena

The cultivated cabbages are assembled into Groups, and some of the group names indicate the morphological part of the plant that has been bred into new non-wild characteristics. For example, the Acephala Group (= headless) includes the extra-leafy kale and collards, the Botrytis Group is formed by the broccolis and cauliflowers, which have compact flowering parts (chlorophyll-less in white cauliflower), and the Gemmifera Group includes Brussel sprouts, which has large axillary buds in the leaf axils.

EXAMPLE: NAMES OF CULTIVATED *CITRUS*

The *Citrus* genus (lemons, oranges, grapefruits, etc.) has a very complex history that involves many wild species, their wild and domesticated hybrids, and cultigens selected by humans from these. This has led to an extremely complex and still not fully understood genetic history of our cultivated citrus fruits.

Table (below). Examples of cultigen names from citrus fruits. You can see how commercial citrus fruits are represented by either a scientific species name, a cultivar name, a hybrid name, or a Group name, or combinations of these types of names.

Complete Name	**Scientific name**	**Cultigen name**	**Common name**
Citrus japonica	*Citrus japonica* (species)	None	kumquat
Citrus medica 'Fingered'	*Citrus medica* (species)	'Fingered' (cultivar)	Buddha's hand
Citrus × *aurantiifolia*	*Citrus* × *aurantiifolia* (hybrid species)	None	lime
Citrus Grapefruit Group	*Citrus* (genus only)	Grapefruit Group (group)	grapefruits
Citrus Grapefruit Group 'Star Ruby'	*Citrus* (genus only)	Grapefruit Group 'Star Ruby' (cultivar)	pink grapefruit
Citrus 'Star Ruby'	*Citrus* (genus only)	'Star Ruby' (cultivar)	pink grapefruit

SUMMARY OF RULES FOR CULTIGEN NAMES OF CULTIVATED PLANTS

- Formal and global non-legal names for cultivated plants are either cultivar or Group names (plus grexes for orchids).
- Cultivar and Group names are in addition to scientific names or unambiguous common names (common names that can't be misunderstood or are standardized).
- Descriptions and use of cultigen names need to follow the rules of the Cultivated Plant Code.
- Trade and patent names, and other commercial plant names, are not cultigen names and should not be used as permanent, global names.

COMMERCIAL NAMES (TRADE AND PATENT NAMES)

Trade names (or trade designations or brand names) are commercial names for cultivated plants that are not regulated by the Cultivated Plant Code, and include **trademarked names** and **patented names**. Trade names can be **non-registered**, **trademarked** (indicated with ™), or **registered** (indicated with ®).

A patent provides legal protection and establishes rules for who can sell and grow a particular patented plant type. Patent names are often an abbreviation or number, but not always; they can take many forms. Patent names have no special formatting. There is also a process to provide Plant Variety Certification (PVP) for selected plants, which is another way to protect intellectual property and allow the inventor or breeder to have some control over the original material of a newly developed cultivated plant.

Trade names should also be distinguished from cultivar and Group names in how they are written. Trade names are typically written in small capital letters or in a different font. They are not placed inside single quotation marks and not written in italics (examples: *Rosa* PEACE and *Cornus* SCARLET FIRE®).

The registration of a trademark provides legal protection against infringement and stealing of names and strains that belong to a certain breeder or company. Patenting of plants can also lead to royalty income when such plants are licensed out for propagation by nurseries and seed companies.

Trade names are usually different between countries, and laws and regulations for trade names usually also differ across borders. Separate trade names for the exact same cultivar may exist in different countries, or the same name might have been patented for different plants in different countries. Yes, it is inconsistent and a bit confusing; it is a bit like the Wild West when it comes to naming rules and customs in the cultivated plant world.

The reason trade names and patents are used so frequently used in commerce is that they protect the intellectual property of plant breeders and plant nurseries through patenting or registration of newly developed plants with special characteristics. It is mostly an economic decision, not to ensure that the plant has a name (since a cultivar name is equally possible, and cultivars provide stable names).

Please note, in trade designations, **variety** is sometimes used as a legal term, but that usage represents a definition and set of criteria very different from the International Code of Nomenclature's 'variety', i.e., the scientific rank term for a unit within a species. Trade varieties have no taxonomic standing and are not following the standards for varieties according to the ICN, and therefore are not recommended for use, since they are not stable, global names.

Similarly, the grouping called **series** is sometimes used in marketing of plants, but it is not the same as the scientific taxon rank called series. A genus can be divided up in several series according to the International Code of Nomenclature. Series used in commercial naming is unrelated to scientific nomenclature. As an example, there is a scientific taxon called *Carex* series *Lupulinae* (a group of sedges) in scientific nomenclature, and Syngenta sells a "*Geranium* Freestyle™ series", which is not a scientific taxon.

There are examples of popular cultivated plants that never got a cultigen name and are now known only by their trade name, as well as vice versa. If a name is protected legally, other sellers cannot sell those plants without permission from the trademark or patent owner (unless the patent has expired). Note that some historical heirloom plants cannot be patented or trademarked, they are in the public domain of plant commerce. This is a very complicated and often confused area of plant naming, and I highly recommend Tony Avent's blog post on the topic (see References).

Trade names are not recommended to be used on commercial plant products except when the actual living plant (as bulbs, potted plant, seeds, etc.) is being sold for horticultural and agricultural purposes, since they are not regulated by any of the Codes for plant nomenclature and have no global authorities. One exception is in the horticultural and agricultural literature, including seed catalogs, where trade names are common for obvious reasons.

RECOMMENDATIONS FOR USE OF BOTANICAL NAMES IN COMMERCE

DO:

- Follow the legal rules for your country, but if you are allowed to include more specific (scientific) names, that is always recommended.
- Follow the highest standards for your field (food, herbals, personal skin care products, horticulture, textiles, crafts, etc.) in content labeling.
- Use globally available names that are listed in global databases of scientific or cultivated plant names.
- Include complete scientific species names on all products if possible.
- Cultigen names are preferred over trade names.
- Common names can be included in addition to scientific and cultigen names
- For some products including only the local common name is allowed (foods and spices, etc.), but beware of the possibility of several plants having the same common name.
- Format all names properly check capitalization, italicization, punctuation, font, and symbols.
- Make sure you know the true species and/or cultigen identity of the plant product you are selling. Make sure your suppliers know what they are collecting and selling.
- Be aware that horticultural labels and names in past and current literature might be wrong or outdated. Check all names against updated sources.
- Always spell out the genus name, do not abbreviate it.
- Family names are not needed.
- Spell check your scientific and cultigen names.
- If you are the buyer of plant products, require proper labeling and identification of plant species in ingredient list and the source materials. Ask the seller how plant species were identified and which taxonomy and standardized classification they are following.

DON'T:

- Do not abbreviate generic names for species; if you do the names become uncertain or ambiguous.
- Do not use common names unless you refer to a standardized, national list (which is available in some countries for herbals, crops, and spices; see local regulations).
- There is no need to include authors for scientific names on product labels.
- Do not use trade names; they are not universal, not global, and not consistent. They might also be trademarked and unavailable for your use.

HOW TO FORMAT AND WRITE PLANT NAMES

Overview of recommended formatting of plant names. Abbreviations of kinds of names follows: COM: Common names; CULT: Cultivated; SCI: Scientific, TRADE: Tradenames; OTHER.

Name type	Name category	Example	Special Formatting (recommended or required)
SCI	Family	Lamiaceae	Capitalized first letter, not italics
SCI	Genus	*Monarda*	Italicized; capitalized first letter
SCI	Species	*Monarda citriodora*	Italicized; genus capitalized first letter, species epithet not capitalized
SCI	Species, subspecies	*Monarda citriodora* ssp. *austromontana;* *Monarda citriodora* subsp. *austromontana*	Italicized (except ssp. or subsp.); genus capitalized first letter, species epithet and subspecies not capitalized
SCI	Species, variety	*Monarda citriodora* var. *parva*	Italicized (except var.); genus capitalized first letter, species epithet and variety not capitalized
SCI	Species, form	*Monarda fistulosa* f. *albescens*	Italicized (except f.); genus capitalized first letter, species epithet and variety not capitalized
SCI	Species, subspecies, variety, form	*Monarda citriodora* ssp. *austromontana* var. *parva* f. *albescens*	Italicized (except ssp., var., and f.); genus capitalized first letter, species epithet and variety not capitalized
SCI	Hybrid species	*Monarda* × *medioides*; *M. fistulosa* × *M. media*	Several options: List parent names with × in between; list new hybrid epithet after × (note, not x, but ×).
COM	Common name	Lemon bee balm	Capitalized or not, not in italics
COM + CULT	Common name with cultivar	bee balm 'Acrade'	Common name in non-italics; cultivar name not italicized, in single quotes, capitalized first letter
SCI+CULT	Genus, cultivar	*Monarda* 'Elsie's Lavender'	Genus name in italics; Cultivar name in single quotes, capitalized first letter, not italicized
SCI+CULT	Species, cultivar	*Monarda punctata* 'Bee Bop'	Species name in italics; Cultivar name in single quotes, capitalized, not italicized;
CULT	Genus, Cultivar Group	*Citrus* Grapefruit Group	Genus name in italics; Group name in non-italics, capitalized first letter of all words
CULT	Graft-chimaera	+ *Crataegomespilus*	Graft-chimaera name starts with '+' sign, in italics, capitalized first letter
SCI + TRADE	Genus, trade name	*Rosa* HIGH HOPES	Genus name in italics; list trade name in small caps
SCI + TRADE	Genus, trademarked name	*Spiraea* LIMEMOUND®	Genus name in italics; list trade name in small caps, include ® after name
SCI + CULT + TRADE	Species, cultivar name, registered trademark name	*Lagerstroemia indica* 'Whit II' DYNAMITE®	Species name in italics, cultivar name in single quotes (not italics); list trade name in small caps, include ® after registered trade name
SCI+TRADE	Trade name, non-registered trademark name	*Rosa* BURGUNDY ICEBERG ™	Use ™ symbol for trademarked names; use ® for registered trademarked
SCI + CULT + TRADE	Genus, cultivar, patent name	*Spiraea* 'Monhub' PP5834	Genus name in italics; Cultivar name in single quotes, capitalized, not italicized; Patent name or number in non-italicized font, no quotes

ABBREVIATIONS AND CATEGORIES

auct.	author of a scientific name
cult.	cultivar [cultigen name]
cv.	cultivar, sometimes used for unknown cultivars too [cultigen name]
cvs.	cultivars (plural) [cultigen name]
f.	form [scientific name]
fo.	form [scientific name]
group	Group [cultigen name]
gx	grex [cultigen name]
non	not (in Latin)
sp.	species (one, singular) [scientific name]
spp.	species (several, plural) [scientific name]
ssp.	subspecies [scientific name]
subg.	subgenus [scientific name]
subsp.	subspecies [scientific name]
syn.	synonym [scientific name]
var.	variety [scientific name]

SYMBOLS

×	symbol indicating hybrid [scientific name]
+	symbol indicating graft-chimaera
™	trademarked name
®	registered trademarked name

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Botanicus Digital Library, Missouri Botanical Garden: http://www.botanicus.org/ [historic botanical literature]

Index Nominum Genericorum (ING), Smithsonian Institution: http://botany.si.edu/ing/ [generic names published for plants, fungi, and algae]

International Plant Names Index (IPNI): http://www.ipni.org [database of published scientific names of vascular plants, botanical authors, and standardized abbreviations of botanical journals and books]

The Linnaean Plant Name Typification Project: http://www.nhm.ac.uk/our-science/data/linnaean-typification/databasehome.html [typification of the scientific names described by Linnaeus]

Organizations:

American Society of Plant Taxonomists (ASPT): https://aspt.net/ [USA]

International Association of Plant Taxonomists (IAPT): http://www.iapt-taxon.org/ [global]

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International Society for Horticultural Science (ISHS): https://www.ishs.org/ [global]
Royal Horticultural Society (RHS): https://www.rhs.org.uk/ [United Kingdom]
American Horticultural Society: http://ahsgardening.org/ [USA]
Floricode: http://www.floricode.com/en-us/home.aspx [Dutch]

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Plants of the World Online (POWO), Royal Botanic Gardens, Kew: http://plantsoftheworldonline.org/

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TROPICOS, Missouri Botanical Garden: http://www.tropicos.org/ [database of taxonomic and other information of wild plants, primarily from North America, South and Central America, China and Madagascar]

World Checklist of Selected Plant families (WCSP): http://wcsp.science.kew.org/home.do [200 seed plant families]

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African Plants Database, Geneva Botanical Garden: http://www.ville-ge.ch/musinfo/bd/cjb/africa/recherche.php

The Australian Plant Census (APC): https://biodiversity.org.au [Australian database of currently accepted vascular plant species]

The Australian Plant Name Index (APNI): https://biodiversity.org.au [Australian vascular plant database of wild plant names]

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