The Naming of Plants — explanations and examples

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Botanical ACCURACY

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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

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

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)

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).

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.

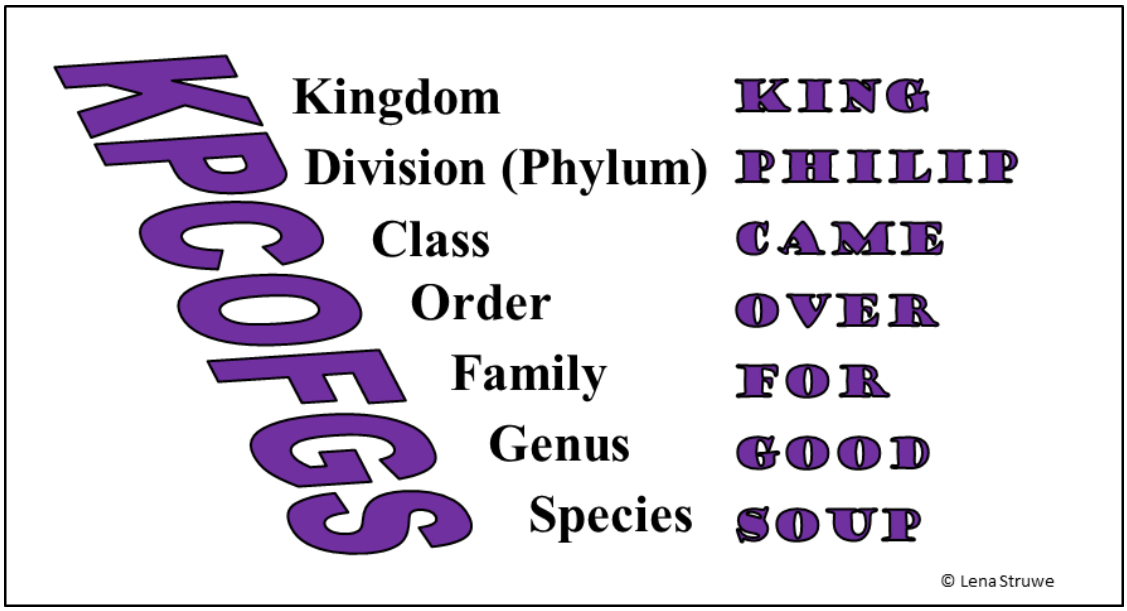


Figure (above). The ranks in botanical classification, from larger to smaller, and with a mnemonic to remember them.

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).

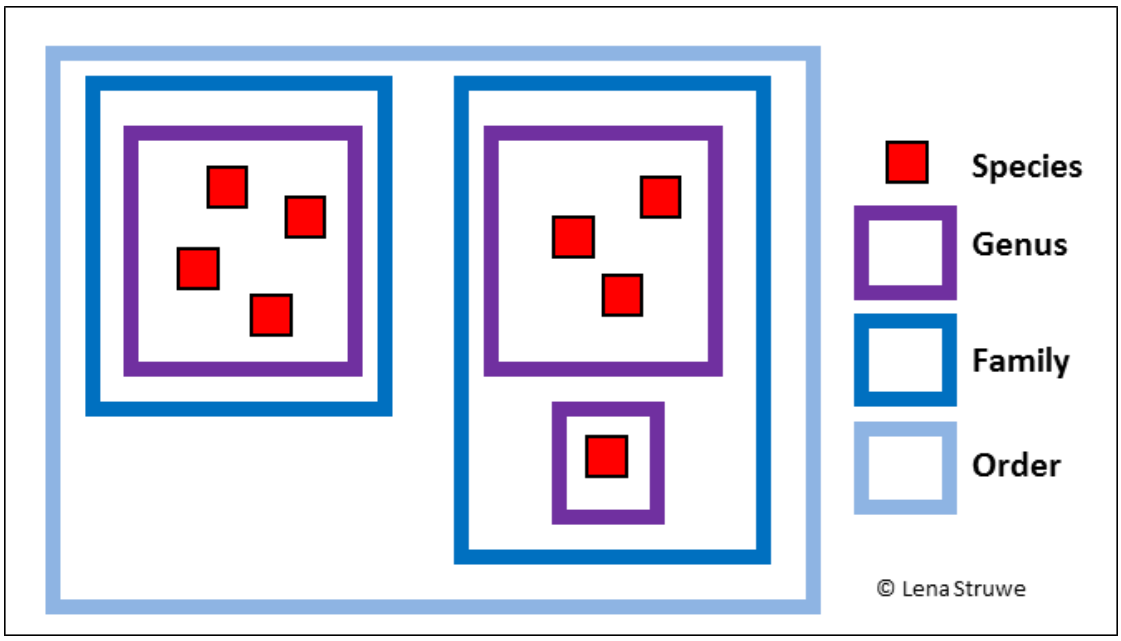


Figure (above). Schematic drawing showing how scientific classification functions as a box-in-a-box system (nested hierarchy). A species can only be member of one genus, which can only be a member of one family, but a family can have several genera within it. (Note that changes in classifications can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

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.


CAROLI LINNÆI
S:Æ R:GIÆ M:TIS SVECIÆ ARCHIATRI; MEDIC. & BOTAN.
PROFESS. UPSAL; EQUITIS AUR. DE STELLA POLARI;
nec non ACAD. IMPER. MONSPEL. BEROL. TOLOS.
UPSAL. STOCKH. SOC. & PARIS. CORESP.
SPECIES
PLANTARUM,

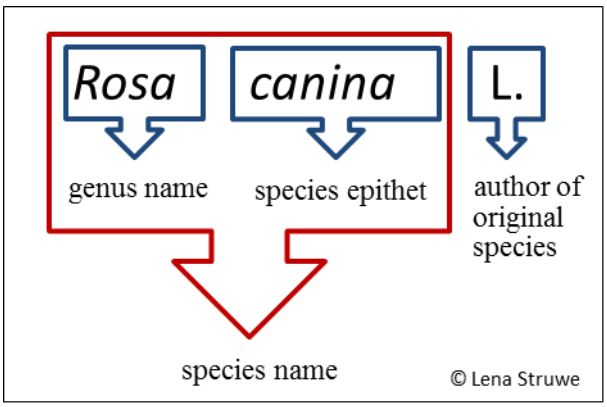
Figure 1. The title of Carl Linnaeus' 1753 book.

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**.

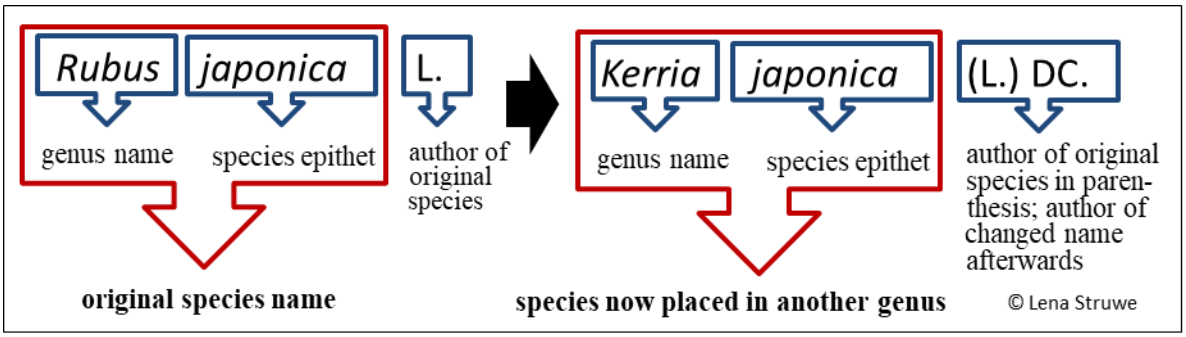


Figure (above). When the species *Rubus japonica* was moved to *Kerria*, its new name became *Kerria japonica*. The first validly published name for this species was a species described by Linnaeus (indicated as "L.") as *Rubus japonica*. De Candolle (abbreviated "DC.") moved this species from *Rubus*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

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'S *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, *Symphyotrichum 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.

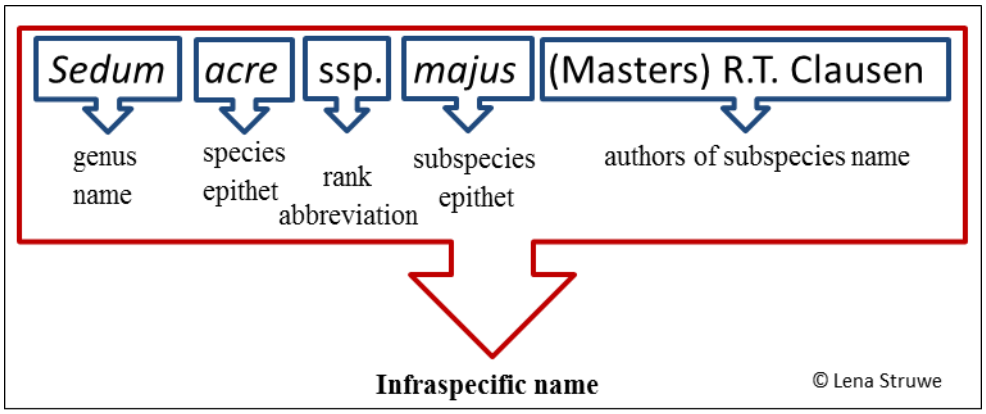


Figure (above). The infraspecific name *Sedum acre* ssp. *majus* includes both the genus name (*Sedum*), the species epithet (*acre*), and the infraspecific epithet (*majus*). The same formatting is used for varieties and forms. If both subspecies and variety needs to be listed, then subspecies comes 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.

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*.

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.

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.

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.

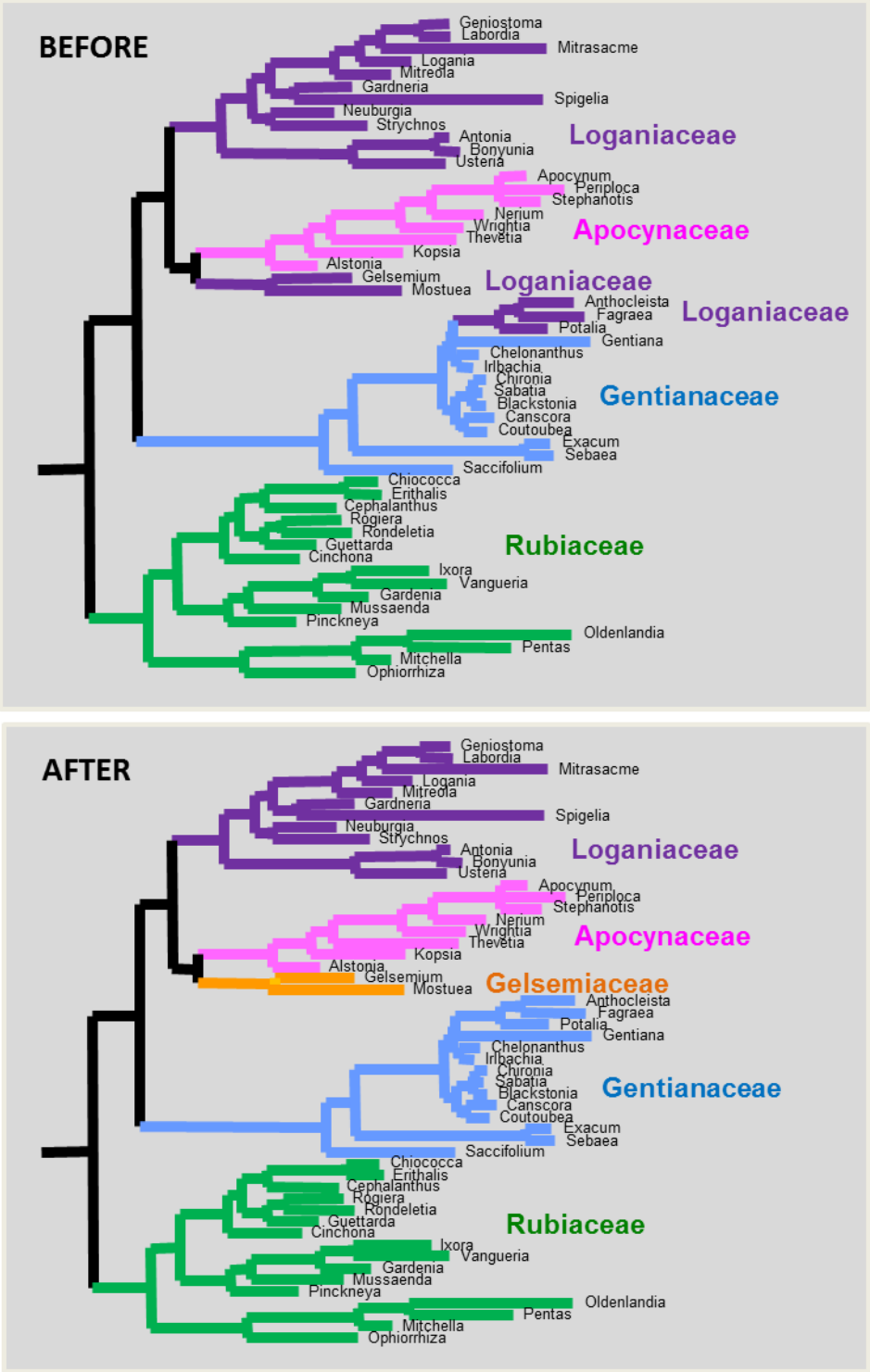


Figure (above). Reclassification of Loganiaceae based on a phylogenetic analysis of molecular (DNA) data, showing the formation of Gelsemiaceae and the moving of three Loganiaceae genera into Gentianaceae, so that all families are monophyletic. (Redrawn after research published by Lena Struwe; © Lena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

HOW TO FORMAT AND WRITE PLANT NAMES

Overview of recommended formatting of plant names. Abbreviations of kinds of names follows: COM: Common names; SCI: Scientific

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

SELECTED REFERENCES AND SOURCES

BOTANICAL NOMENCLATURE AND HISTORY

Literature:

Australia's Virtual Herbarium. (2010) **Plant Names – a basic introduction**: https://www.anbg.gov.au/chah/avh/help/names/index.html

Judd WS, Campbell CS, Kellogg EA, Stevens PF, Donoghue MJ. (2015) **Plant Systematics – a Phylogenetic Approach**, ed. 4. Sinauer Associates.

Simpson MG. (2018 [in press]) **Plant Systematics**, ed. 3. Academic Press.

Spencer R, Cross R, Lumley P. (2007). Plant names – a guide to botanical nomenclature, ed 3. CSIRO Publishing, Collingwood.

Stuessy TF, Crawford DJ, Soltis DE & Soltis PS. (2014) **Plant Systematics: The origin, interpretation, and ordering of plant biodiversity.** Reg. Veg. Vol. 156. Koeltz Scientific Books, Königstein.

Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber W-H, Li D-Z, Marhold K, May TW, McNeill J, Monro AM, Prado J, Price MJ & Smith GF (eds.). (2018) **International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code)** adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile, vol. 159. Koeltz Botanical Books, Glashütten.

Turland NJ. (2013) **The Code Decoded**. A User's Guide to the International Code of Nomenclature for Algae, Fungi, and Plants. Regnum Vegetabile, vol. 155. Koeltz Scientific Books, Königstein.

Databases and Websites:

Biodiversity Heritage Library (BHL): https://www.biodiversitylibrary.org/ [historic botanical literature]

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]

The Linnean Society : https://www.linnean.org/the-society [UK/global]

ETYMOLOGY AND BOTANICAL LATIN

Literature:

Stearn WT. (2002) **Stearn's Dictionary of Plant Names for Gardeners**: A Handbook on the Origin and Meaning of the Botanical Names of Some Cultivated Plants. Timber Press, Portland.

Stearn WT. (2004) **Botanical Latin**, ed. 4. Timber Press, Portland.

Databases and Websites:

A Grammatical Dictionary of Botanical Latin, Missouri Botanical Garden: http://www.mobot.org/mobot/LatinDict/search.aspx

ENDNOTES (REFERENCES FOR EXAMPLES)

[1] Linnaeus, C. in *Systema Naturae* (1735), original in Latin, translated by M. S. J. Engel-Ledeboer and H. Engel (1964: page 19).

[2] Struwe, L. & M. Kinkade. 2013. Revision of *Tachia* (Gentianaceae: Helieae). *Systematic Botany* 38(4):1142-1159.

[3] The Berlin Negatives, The Field Museum: http://emuweb.fieldmuseum.org/botany/search_berlin.php

[4] Lewis and Clark Herbarium at The Academy of Natural Sciences, Philadelphia, USA. http://ansp.org/exhibits/online-exhibits/stories/lewis-and-clark-herbarium/

[5] Reveal, J. L., G. E. Moulton & A. E. Schuyler. 1999. The Lewis and Clark Collections of Vascular Plants: Names, Types, and Comments. *Proceedings of the Academy of Natural Sciences of Philadelphia* 149 (9): 1-64.

[6] Struwe, L., P. J. M. Maas, & V. A. Albert. 1997. *Aripuana cullmaniorum*, a new genus and species of Gentianaceae from white sands of southeastern Amazonas, Brazil. *Harvard Papers in Botany* 2: 235-253.

[7] Molina, J. & L. Struwe. 2008. Revision of ring-gentians (*Symbolanthus*, Gentianaceae) from Bolivia, Ecuador and Peru, with a first assessment of conservation status. *Systematics & Biodiversity* 6: 477-501.

[8] Molina, J. & L. Struwe. 2008. Revision of ring-gentians (*Symbolanthus*, Gentianaceae) from Bolivia, Ecuador and Peru, with a first assessment of conservation status. *Systematics & Biodiversity* 6: 477-501.

[9] Struwe, L. K. Gibbons, B. Conn, & T. Motley. 2018. Loganiaceae (including Antoniaceae, Geniostomaceae, Spigeliaceae, and Strychnaceae). In: *Families and Genera of Flowering Plants*, vol. Asteridae-Gentianales, Springer Verlag, Berlin.

[10] Bremer, B. & L. Struwe. 1992. Phylogeny of the Rubiaceae and the Loganiaceae: congruence or conflict between morphological and molecular data? American Journal of Botany 79: 1171-1184.

[11] Struwe, L., V. A. Albert, & B. Bremer. 1994. Cladistics and family level classification of the Gentianales. Cladistics 10: 175-206.

[12] American Rose Society. 2018. Rose classifications. Blog on ARS website: https://www.rose.org/single-post/2018/06/11/Rose-Classifications

[13] Mattera, R., T. Molnar, & L. Struwe. 2015. *Cornus* × *elwinortonii* and *Cornus* × *rutgersensis* (Cornaceae), new names for two artificially produced hybrids of big-bracted dogwoods. PhytoKeys 55: 93-111. doi: 10.3897/phytokeys.55.9112, http://phytokeys.pensoft.net/articles.php?id=5829