

Binomial nomenclature

Binomial nomenclature (also called **binominal nomenclature** or **binary nomenclature**) is a formal system of naming species of living things by giving each a name composed of two parts, both of which use Latin grammatical forms, although they can be based on words from other languages. Such a name is called a **binomial name** (which may be shortened to just "binomial"), a **binomen** or a **scientific name**; more informally it is also called a **Latin name**. The first part of the name identifies the genus to which the species belongs; the second part identifies the species within the genus. For example, humans belong to the genus *Homo* and within this genus to the species *Homo sapiens*. The introduction of this system of naming species is credited to Linnaeus, effectively beginning with his work *Species Plantarum* in 1753.^[1] Linnaeus called his two-part name a **trivial name** (*nomen triviale*) as opposed to the much longer names then used.

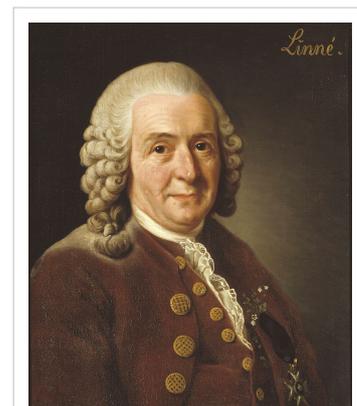
The application of binomial nomenclature is now governed by various internationally agreed codes of rules, of which the two most important are the *International Code of Zoological Nomenclature (ICZN)* for animals and the *International Code of Botanical Nomenclature (ICBN)* for plants. Although the general principles underlying binomial nomenclature are common to these two codes, there are some differences, both in the terminology they use and in their precise rules.

In modern usage, in writing the first letter of the first part of the name, the genus, is always capitalized, while that of the second part is not, even when derived from a proper noun such as the name of a person or place. Both parts are italicized. Thus the binomial name of the annual phlox is now written as *Phlox drummondii*.

In scientific works, the "authority" for a binomial name is usually given, at least when it is first mentioned. Thus zoologists will give the name of a particular sea snail species as "*Patella vulgata* Linnaeus, 1758". The name "Linnaeus" tells the reader who it was that named the species; 1758 is the date of the publication in which the original description can be found, in this case the 10th edition of the book *Systema Naturae*. (Botanists are not required to give the date).

History

Prior to the adoption of the modern binomial system of naming species, those who wrote about animals and plants either used their common names in various languages or adopted more-or-less standardized descriptions. In medieval Europe these descriptions were typically in Latin, which was then the language of science. Such "polynomial names" may sometimes look like binomials, but are significantly different. For example, Gerard's herbal describes various kinds of spiderwort: "The first is called *phalangium ramosum*, Branched Spiderwort; the second, *phalangium non ramosum*, Unbranched Spiderwort. The other ... is aptly termed *phalangium ephemereum virginianum*, Soone Fading Spiderwort of Virginia".^[2] The Latin phrases are short descriptions, rather than identifying labels. The problem was that as new species were discovered, their descriptions needed to become ever longer in order to distinguish them from existing species. For example, the tomato had the polynomial *Solanum caule inermi herbaceo, foliis pinnatis incisiss*, meaning "the smooth-stemmed herbaceous solanum with incised pinnate leaves".^[1]



Carolus Linnaeus (1707–1778), a Swedish botanist, invented the modern system of binomial nomenclature.

The Bauhins, in particular Caspar Bauhin (1560–1624), took some important steps towards the binomial system, by pruning the Latin descriptions, in many cases to two words.^[3] The adoption by biologists of a system of strictly binomial nomenclature is due to Swedish botanist and physician Carl von Linné, more commonly known by his Latinized name Carolus Linnaeus (1707–1778). It has been said that the spread of two-part names was in some sense

an accident.^[1] Linnaeus attempted to describe and classify the entire known natural world. He continued to use polynomial names, but in his *Species Plantarum* (1753) and later in the 10th edition of *Systema Naturae* (1758), he supplemented these by what he called a "trivial name" (*nomen triviale*). The Bauhins' genus names were used in many of these, but the descriptive part was always reduced to a single word.

Linnaeus's trivial names introduced an important new idea, namely that the function of a name could simply be to give a species a unique label. This meant that the name did not need to be descriptive; for example both parts could be derived from the names of people. Thus Gerard's *phalangium ephemerum virginianum* became *Tradescantia virginiana*, where the genus name honoured John Tradescant the younger,^[4] an English botanist and gardener.^[5] A bird in the parrot family was named *Psittacus alexandri*, meaning "Alexander's parrot", after Alexander the Great whose armies introduced eastern parakeets to Greece.^[6] Linnaeus' trivial names were much easier to remember and use than the parallel polynomial names and eventually replaced them.^[1]

Value

The value of the binomial nomenclature system derives primarily from its economy, its widespread use, and the uniqueness and stability of names it generally favors:

- **Economy.** Compared to the polynomial system which it replaced, a binomial name is shorter and easier to remember.^[1] It corresponds to the widespread system of family name plus given name(s) used to name people in many cultures.^[3]
- **Widespread use.** The binomial system of nomenclature is governed by international codes and is used by biologists worldwide.^[7]
- **Clarity.** Binomial names avoid the confusion that can be created when attempting to use common names to refer to a species.^[8] Common names often differ even from one part of a country to another, and certainly vary from one country to another. In English-speaking parts of Europe, the bird called a "robin" is *Erithacus rubecula*. In English-speaking North America, a "robin" is *Turdus migratorius*. In contrast, the scientific name can be used all over the world, in all languages, avoiding confusion and difficulties of translation.^[9] ^[10]
- **Uniqueness.** Provided that taxonomists agree as to the limits of a species, there can only be one name for it that is correct under the various nomenclature codes, generally the earliest published if two or more names are accidentally assigned to a species.^[10] However, establishing that two names actually refer to the same species and then determining which has priority can be a difficult task, particularly if the species were named by biologists from different countries, so that in reality, a species may have more than one regularly used name (these are "synonyms").^[11]
- **Stability.** Although stability is far from absolute, the procedures associated with establishing binomial names tend to favor stability.^[8] For example, when species are transferred between genera (as not uncommonly happens as a result of new knowledge), if possible the second part of the binomial is kept the same. Thus there is disagreement among botanists as to whether the genera *Chionodoxa* and *Scilla* are sufficiently different to be kept separate. Those who keep them separate give the plant commonly grown in gardens in Europe the name *Chionodoxa siehei*; those who do not give it the name *Scilla siehei*.^[12] The *siehei* element is constant. Similarly if what were previously thought to be two distinct species are demoted to a lower rank, such as subspecies, the second part of the binomial name is, where possible, retained as the third part of the new name. Thus the Tenerife robin may be treated as a different species from the European robin, in which case its name is *Erithacus superbus*, or as only a subspecies, in which case its name is *Erithacus rubecula superbus*.^[13] The *superbus* element of the name is constant. Since taxonomists can legitimately disagree as to whether two genera or two species are distinct or not, more than one name can be in use.^[14]

Relationship to classification and taxonomy

Nomenclature (including binomial nomenclature) is not the same as classification, although the two are related. Classification is the ordering of items into groups based on similarities and/or differences; in biological classification, species are one of the kinds of item to be classified.^[15] In principle, the names given to species could be completely independent of their classification. This is not the case for binomial names, since the first part of a binomial is the name of the genus into which the species is placed. Above the rank of genus, binomial nomenclature and classification are partly independent; for example, a species retains its binomial name if it is moved from one family to another or from one order to another. The independence is only partial since the names of families and other higher taxa are usually based on genera.

Taxonomy includes both nomenclature and classification. Its first stages (sometimes called "alpha taxonomy") are concerned with finding, describing and naming species of living or fossil organisms.^[16] Binomial nomenclature is thus an important part of taxonomy as it is the system by which species are named. Taxonomists are also concerned with classification, including its principles, procedures and rules.^[17]

Derivation of binomial names

A complete binomial name is always treated grammatically as if it were a phrase in the Latin language (hence the common use of the term "Latin name" for a binomial name). However, the two parts of a binomial name can each be derived from a number of different sources, of which Latin is only one. These include:

- Latin, either classical or medieval. Thus both parts of the binomial name *Homo sapiens* are Latin words, meaning "wise" (*sapiens*) "human/man" (*Homo*).
- Classical Greek. The genus *Rhododendron* was named by Linnaeus from the Greek word ῥοδόδενδρον, itself derived from *rhodos*, rose, and *dendron*, tree.^[18] Greek words are often converted to a Latinized form. Thus coca (the plant from which cocaine is obtained) has the name *Erythroxylum coca*. *Erythroxylum* is derived from the Greek words *erythros*, red, and *xylon*, wood.^[19] The Greek neuter ending -ov (-on) is converted to the Latin neuter ending -um.
- Other languages. The second part of the name *Erythroxylum coca* is derived from the name of the plant in the Quechua language.^[20]
- Names of people (often naturalists or biologists). The name *Magnolia campbellii* commemorates two people: Pierre Magnol, a French botanist, and Archibald Campbell, a doctor in British India.^[21]
- Names of places. The lone star tick, *Amblyomma americanum* is widespread in the United States.^[22]
- Other sources. Some binominal names have been constructed from anagrams or other re-orderings of existing names. Thus the name of the genus *Muilla* is derived by reversing the name *Allium*.^[23] Names may also be derived from jokes or puns. For example, Ratcliffe described a number of species of Rhinoceros beetle, including *Cyclocephala nodanotherwon*.^[24]

The first part of the name, which identifies the genus, must be a word which can be treated as a Latin singular noun in the nominative case. It must be unique within each kingdom, but can be repeated between kingdoms. Thus *Huia recurvata* is an extinct species of plant, found as fossils in Yunnan, China,^[25] whereas *Huia masonii* is a species of frog found in Java, Indonesia.^[26]

The second part of the name, which identifies the species within the genus, is also treated grammatically as a Latin word. It can have one of a number of different forms.

- The second part of a binomial may be an adjective. The adjective modifies the genus name, and must agree with it in gender. Latin has three genders, masculine, feminine and neuter, shown by different endings to nouns and adjectives. The house sparrow has the binomial name *Passer domesticus*. Here *domesticus* ("domestic") simply means "associated with the house". The sacred bamboo is *Nandina domestica*^[27] rather than *Nandina domesticus*, since *Nandina* is feminine whereas *Passer* is masculine. The tropical fruit langsat is a product of the plant

Lansium domesticum, since *Lansium* is neuter. Some common endings for Latin adjectives in the three genders (masculine, feminine, neuter) are *-us*, *-a*, *-um* (as in the previous example of *domesticus*); *-is*, *-is*, *-e* (e.g. *tristis*, meaning "sad"); and *-or*, *-or*, *-us* (e.g. *minor*, meaning "smaller"). For further information, see Latin_declension#Adjectives.^[28]

- The second part of a binomial may be a noun in the nominative case. An example is the binomial name of the lion, which is *Panthera leo*. Grammatically the noun is said to be in apposition to the genus name and the two nouns do not have to agree in gender; in this case, *Panthera* is feminine and *leo* is masculine.
- The second part of a binomial may be a noun in the genitive (possessive) case. The genitive case is constructed in a number of different ways in Latin, depending on the declension of the noun. Common endings for masculine and neuter nouns are *-ii* or *-i* in the singular and *-orum* in the plural, and for feminine nouns *-ae* in the singular and *-arum* in the plural. The noun may be part of a person's name, often the surname, as in the Tibetan antelope *Pantholops hodgsonii*, the shrub *Magnolia hodgsonii*, or the Olive-backed Pipit *Anthus hodgsoni*. The meaning is "of the person named", so that *Magnolia hodgsonii* means "Hodgson's magnolia". The *-ii* or *-i* endings show that in each case Hodgson was a (different) man; had Hodgson been a woman, *hodgsonae* would have been used. The person commemorated in the binomial name is not usually (if ever) the person who created the name; for example *Anthus hodgsoni* was named by Charles Wallace Richmond, in honour of Hodgson. Rather than a person, the noun may be related to a place, as with *Latimeria chalumnae*, meaning "of the Chalumna River". A different example of a genitive noun used as the second part of a binomial name is the name of the bacterium *Escherichia coli*, where *coli* means "of the colon". This formation is common in parasites, as in *Xenos vesparum*, where *vesparum* means "of the wasps", since *Xenos vesparum* is a parasite of wasps.

Whereas the first part of a binomial name must be unique within a kingdom, the second part is quite commonly used in two or more different genera (as is shown by examples of *hodgsonii* above). The full binomial name must be unique within a kingdom.

Codes

From the mid nineteenth century onwards it became ever more apparent that a body of rules was necessary to govern scientific names. In the course of time these became nomenclature codes. The *International Code of Zoological Nomenclature (ICZN)* governs the naming of animals,^[29] the *International Code of Botanical Nomenclature (ICBN)* that of plants (including fungi and cyanobacteria), and the *International Code of Nomenclature of Bacteria (ICNB)* that of bacteria (including Archaea). Virus names are governed by the *International Committee on Taxonomy of Viruses (ICTV)*, a taxonomic code, which determines taxa as well as names. These codes differ in certain ways, e.g.:

- "Binomial nomenclature" is the correct term for botany,^[30] although it is also used by zoologists.^[31] Since 1953, "binominal nomenclature" is the technically correct term in zoology.^[32]
- Both codes agree in calling the first part of the two-part name for a species the "genus name". However in zoological nomenclature the second part is called the "species name", whereas in botanical nomenclature the second part is called the "species epithet", and the term "species name" should only be used for the whole name, i.e. the combination of the two parts.
- The *ICBN*, the plant *Code*, does not allow the two parts of a binomial name to be the same (such a name is called a tautonym), whereas the *ICZN*, the animal *Code*, does. Thus the American bison has the binomial *Bison bison*; a name of this kind would not be allowed for a plant.
- The starting points, the time from which these codes are in effect (retroactively), vary from group to group. In botany the starting point will often be in 1753 (the year Carl Linnaeus first published *Species Plantarum*). In zoology the starting point is 1758 (1 January 1758 is considered the date of the publication of Linnaeus's *Systema Naturae*, 10th Edition, and also Clerck's *Aranei Svecici*). Bacteriology started anew, with a starting point on 1 January 1980.^[33]

Unifying the different codes into a single code, the "*BioCode*", has been suggested, although implementation is not in sight. (There is also a code in development for a different system of classification which does not use ranks, but instead names clades. This is called the *PhyloCode*.)

Writing binomial names

The binomial names of species are usually typeset in italics; for example, *Homo sapiens*.^[34] Generally the binomial should be printed in a font different from that used in the normal text; for example, "*Several more Homo sapiens fossils were discovered.*" When handwritten, each part of a binomial name should be underlined; for example, Homo sapiens.^[35]

The first part of the binomial, the genus name, is *always* written with an initial capital letter. In current usage, the second part is *never* written with an initial capital.^{[36] [37]} Older sources, particularly botanical works published before the 1950s, use a different convention. If the second part of the name is derived from a proper noun, e.g. the name of a person or place, a capital letter was used. Thus the modern form *Berberis darwinii* was written as *Berberis Darwinii*. A capital was also used when the name is formed by two nouns in apposition, e.g. *Panthera Leo* or *Centaurea Cyanus*.^{[38] [39]}

When used with a common name, the scientific name often follows in parentheses, although this varies with publication.^[40] For example "The house sparrow (*Passer domesticus*) is decreasing in Europe."

The binomial name should generally be written in full. The exception to this is when several species from the same genus are being listed or discussed in the same paper or report, or the same species is mentioned repeatedly; in which case the genus is written in full when it is first used, but may then be abbreviated to an initial (and a period/full stop).^[41] For example, a list of members of the genus *Canis* might be written as "*Canis lupus*, *C. aureus*, *C. simensis*". In rare cases, this abbreviated form has spread to more general use; for example, the bacterium *Escherichia coli* is often referred to as just *E. coli*, and *Tyrannosaurus rex* is perhaps even better known simply as *T. rex*, these two both often appearing in this form in popular writing even where the full genus name has not already been given.

The abbreviation "sp." is used when the actual specific name cannot or need not be specified. The abbreviation "spp." (plural) indicates "several species". These abbreviations are not italicised (or underlined).^[42] For example: "*Canis* sp." means "an unspecified species of the genus *Canis*", while "*Canis* spp." means "two or more species of the genus *Canis*". (The abbreviations "sp." and "spp." can easily be confused with the abbreviations "ssp." (zoology) or "subsp." (botany), plurals "sspp." or "subssp.", referring to one or more subspecies. See trinomen (zoology) and infraspecific name (botany).)

The abbreviation "cf." is used when the identification is not confirmed.^[43] For example "*Corvus* cf. *splendens*" indicates "a bird similar to the house crow but not certainly identified as this species".

Authority

In scholarly texts, at least the first or main use of the binomial name is usually followed by the "authority" – a way of designating the scientist(s) who first published the name. The authority is written in slightly different ways in zoology and botany: under the *ICZN* the surname is written in full together with the date (usually only the year) of publication, whereas under the *ICBN* the name is generally abbreviated and the date omitted. Historically, abbreviations were used in zoology too.

When the original name is changed, e.g. the species is moved to a different genus, both *Codes* use parentheses around the original authority; the *ICBN* also requires the person who made the change to be given. Some examples:

- (plant) *Amaranthus retroflexus* L. – "L." is the standard abbreviation for "Linnaeus"; the absence of parentheses shows that this is his original name.

- (plant) *Hyacinthoides italica* (L.) Rothm. – Linnaeus first named the Italian bluebell *Scilla italica*; Rothmaler transferred it to the genus *Hyacinthoides*.
- (animal) *Passer domesticus* (Linnaeus, 1758) – the original name given by Linnaeus was *Fringilla domestica*; unlike the *ICBN*, the *ICZN* does not require the name of the person who changed the genus to be given.

Other ranks

Binomial nomenclature, as described here, is a system for naming species. Implicitly it includes a system for naming genera, since the first part of the name of the species is a genus name. In a classification system based on ranks there are also ways of naming ranks above the level of genus and below the level of species. Ranks above genus (e.g. family, order, class) receive one part names which are conventionally not written in italics. Thus the house sparrow, *Passer domesticus*, belongs to the family Passeridae. Family names are normally based on genus names, although the endings used differ between zoology and botany.

Ranks below species receive three part names, conventionally written in italics like the names of species. There are significant differences between the *ICZN* and the *ICBN*. In zoology, the only rank below species is subspecies and the name is written simply as three parts. Thus one of the subspecies of the olive-backed pipit is *Anthus hodgsoni berezowskii*. In botany, there are many ranks below species and although the name itself is written in three parts, a "connecting term" (not part of the name) is needed to show the rank. Thus the American black elder is *Sambucus nigra* subsp. *canadensis*; the white-flowered form of the ivy-leaved cyclamen is *Cyclamen hederifolium* f. *albiflorum*.

Notes and references

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- [39] The modern notation was resisted by some, partly because writing names like *Centaurea cyanus* can suggest that *cyanus* is an adjective which should agree with *Centaurea*, i.e. that the name should be *Centaurea cyana*, whereas *Cyanus* is derived from the Greek name for the cornflower. See Gilbert-Carter, H. (1955), *Glossary of the British Flora* (2nd ed.), Cambridge University Press, OCLC 559413416, p. xix.
- [40] "Writing Guide" (<http://www.gse.mq.edu.au/resources/guide/format.htm>). Macquarie University. . Retrieved June 20, 2011.
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External links

- Curiosities of Biological Nomenclature (<http://www.curiooustaxonomy.net/index.html>)
 - The Language of Horticulture (<http://www.hcs.ohio-state.edu/hcs/TMI/HORT234/Nomenclature.html>)
 - Crinan, Alexander, ed. (2007), *Plant Names : A Guide for Horticulturists, Nurserymen, Gardeners and Students* (<http://www.hortax.org.uk/plantnames/pdf/booklet.pdf>), Horticultural Taxonomy Group, Royal Botanic Garden Edinburgh, retrieved 2011-06-04
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