SPECPOSIUM

A Guide to Realistic Taxonomy

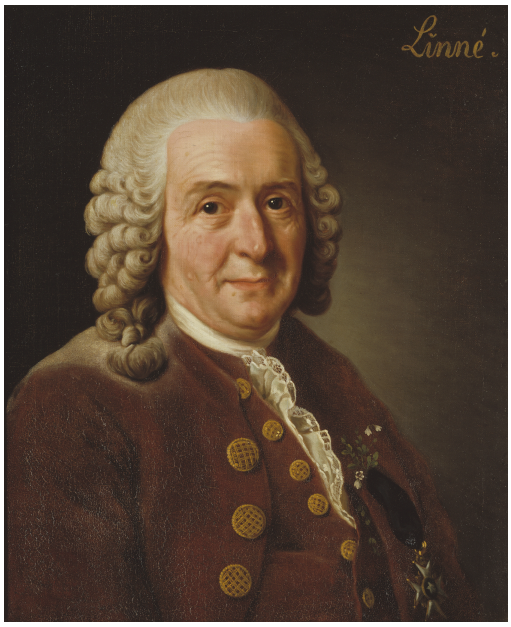
By Henry Thomas

Introduction

This document provides a guide on how to devise plausible scientific names for species and groups of organisms. A lot of it focuses on the naming of binomial names (genus and species), but we will also be touching on higher-level clades and phylogenetic relationships. Although geared towards speculative evolution and other works of fiction, we hope that it will also be a useful resource for understanding how taxonomy works in general.

What is Taxonomy?

In the context of biology, **taxonomy** is the classification of organisms. This system of biological classification was first introduced in 1735 by Carl Linnaeus with the first edition of his work *Systema Naturae* (Linnaeus 1735). At the time it was merely a system of organization for the natural world - Linnaeus's classifications weren't necessarily intended to represent natural groups[1] (and explicitly *weren't* in the case of plants[2]), and he also included a taxonomy of rocks and minerals that nobody uses anymore. But since then, especially following the publication of Charles Darwin's *On the Origin of Species*, taxonomy has been integrated with hypotheses about evolutionary relationships between organisms.



Portrait of Carl Linnaeus, the man we have to thank for all this. Painted by Alexander Roslin in 1775, now in the National Portrait Gallery of Sweden.

Ranked taxonomy vs. cladistics

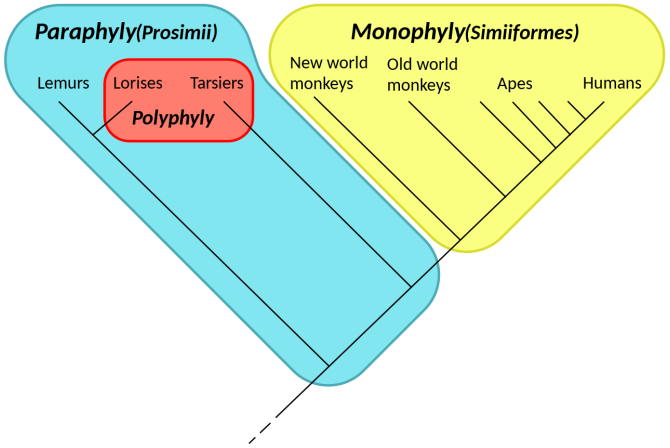
Traditional taxonomy (**Linnaean taxonomy**) is done using a hierarchical system. Organisms are placed in various groups, known as **taxa** (singular **taxon**), that are given different ranks, each bigger than the last. This makes for a simple and practical system of classification. Taxonomy can be based on one of two things: phenetics or systematics. **Phenetics** classifies organisms based on overall similarity (and this is how things were done for many years, starting with Linnaeus). **Systematics**, or **phylogenetics**, is the study of evolutionary relationships between organisms. Phenetics has largely been abandoned, and the idea nowadays is that taxonomic classification should accurately reflect these relationships.

[1] Linnaeus was a creationist; he's quoted as having said "God created, Linnaeus organized".
[2] Linnaeus actually did provide a more naturally-oriented classification of plants in *Philosophia Botanica* (Linnaeus 1751) and *Species Plantarum* (Linnaeus 1753)

The classic eight ranks[3] are, in order from largest to smallest: **domain**, **kingdom**, **phylum**, **class**, **order**, **family**, **genus**, and **species**. Additional ranks can be made by taking a rank and adding prefixes. The prefix **super-** can be used for the rank just above, and the prefixes **sub-** and **infra**- can be used for the ranks just below and two below, respectively. For example, a superorder is bigger than an order, which is bigger than a suborder, which is bigger than an infraorder. There's also a pretty commonly used ninth rank, **tribe**, between family and genus, and botanists sometimes use the additional divisions **section** (between genus and species) and **variety** (below species). Virus taxonomy uses the name **realm** instead of **domain**, and plant taxonomy uses the name **division** instead of **phylum**.

As the study of systematics took off, some problems with classical, ranked and phenetics-based taxonomy became apparent:

- It turned out that a lot of traditional taxa were not **monophyletic**: that is, they didn't include all of the descendants of a common ancestor. Ergo, they didn't represent complete evolutionary lineages. Either some descendant taxa were arbitrarily excluded (**paraphyletic**), or the group consisted of a bunch of taxa without their common ancestor (**polyphyletic**).
- Because of this, we now know that certain groups formerly at the same rank actually nest within each other.
  Example: The class Aves (birds) is now known to nest within class Reptilia (reptiles).
- Taxa of the same rank could vary wildly in terms of size and evolutionary history, due to the subjectivity in assigning ranks.
  Example: Frogs are all classified in the order Anura, and sea cows are all classified in the order Sirenia. There are over 5,000 living species of frogs, and they've been around for over 200



An illustration of monophyly, paraphyly, and polyphyly on the family tree of primates. By Chiswick Chap on Wikimedia Commons.

[3] *Systema Naturae* only used kingdom, class, order, genus, and species. The family rank was introduced by Pierre André Latreille in 1796. The phylum rank was introduced by Ernst Haeckel in 1866. The domain rank was introduced by Carl Woese, Otto Kandler, and Mark Wheelis in 1990.

million years. In contrast, there are a little over 50 sirenian species known at all, and they've only been around for about 55 million years.

Because of this, in recent years **cladistics** and **phylogenetic taxonomy** have taken favor among biologists instead of Linnaean taxonomy. In cladistics, genus and species are still used, but higher-level taxa are all in the form of "clades". Clades are unranked - it doesn't matter if there's one within the other, since there isn't an implied "size" to them. Clades are also explicitly defined based on evolutionary relationships, so that they are always monophyletic. The practice of naming clades is called **phylogenetic nomenclature**.

Jurisdiction of taxonomy

There are four major **nomenclatural codes** that govern real-world taxonomy, each applying to a different group of organisms:

- **International Code of Zoological Nomenclature (ICZN):** covers animals. Published by the International Commission on Zoological Nomenclature.
- **International Code of Nomenclature for algae, fungi, and plants (ICN):** covers plants, algae, fungi, and cyanobacteria (i.e., botany's traditional coverage). Published by the International Botanical Congress.
- **International Code of Nomenclature for Prokaryotes (ICNP):** covers bacteria and archaeans. Published by the International Committee on the Systematics of Prokaryotes.
- **International Code of Virus Classification and Nomenclature (ICVCN):** covers viruses, viroids, viriforms, and satellites. Published by the International Committee on Taxonomy of Viruses.

There's also an **International Code on Nomenclature for Cultivated Plants (ICNCP)**, published by the International Journal for Horticultural Science, that works in tandem with the ICN and applies only to plants that have been cultivated (i.e. deliberately altered) by humans. We won't be talking about it here, but it might be worth looking into as a model if your project involves artificial selection or genetic engineering.

Further reading: Nomenclatural codes

The full texts of all nomenclatural codes are available to read online for free:

ICZN
ICN
ICNP
ICVCN
ICNCP
PhyloCode

Each of these codes has different "starting points" for their taxonomic systems. The ICZN adopts the 10th edition of *Systema Naturae* (Linnaeus 1758) as the starting point, with the sole exception of spiders named in Carl Alexander Clerck's 1757 work *Svenska Spindlar*. The ICN adopts *Species Plantarum* (Linnaeus 1753) as the starting point. The ICNP wiped the slate clean and started fresh in 1980 with an approved list of names (Skerman et al. 1980). The ICVCN manually approves all virus taxonomy, so virus taxonomy started with its first report in 1971 (Kuhn 2021).

There are a bunch of single-celled eukaryotes ("protists") for whom the rules are unclear; they aren't particularly animal-like (and thus be covered by the ICZN), nor do they fall under the traditional realm of botany (and thus be covered by the ICN). They're known as **ambiregnal protists**. The rule of thumb that most protist workers use is that *photosynthetic* protists are covered by the ICN, and that *non-photosynthetic* protists are covered by the ICZN, with an exception: slime molds (Mixomycetes) and pseudofungi are covered by the ICN, as they used to be classified with fungi (Ronikier and Halamski 2018). It may seem weird, but stability's the goal in taxonomy. However, some have argued that protists should be covered by both codes because of this ambiguity, and at least one guy has proposed a separate code entirely for them (Corliss 1992), though this hasn't taken off. Also, cyanobacteria are covered by both the ICN and the ICNP, and there's disagreement over which one (if not both) applies (Oren and Ventura 2017).

The rule of thumb is that these nomenclatural codes only apply to naturally evolved Earthly lifeforms. The ICZN accepts domesticated animals, but does not cover hybrids, genetically engineered organisms, teratological specimens, or hypothetical taxa (International Commission on Zoological Nomenclature, n.d.). The ICN has specifications for hybrids[4], but plant cultivars are covered by the ICNCP. The ICVCN rejects lab-created viruses (ICVCN 3.5). There does not exist a code for trace fossils, though some (e.g., Sarjeant and Kennedy 1973, Bertling et al. 2003, 2007) have proposed that one should be made. The ICZN

Taxonomic codes for unearthly life

Certainly, many speculative evolution projects involve organisms that aren't related to Earth life. This hasn't been discussed yet by real-world scientists because the ICZN doesn't deal with hypothetical taxa (International Commission on Zoological Nomenclature, n.d.). So it's up to you. Maybe researchers in your setting would consider animal-like aliens "animals" and use the ICZN for them, or maybe they would create their own code (International Code for Extraterrestrial Nomenclature, perhaps?). This also applies to speculative "kingdoms" of Earth life. Your choice on how to deal with them.

[4] Place an x before the hybrid's name (ICN 3.1). Names given to plant hybrids are called **nothotaxa**.

itself lays claim to trace fossil taxonomy (International Commission on Zoological Nomenclature, n.d.). Artificially created organisms are a gray area that hasn't been tackled by real-world taxonomy, and if your project incorporates these, that could be an interesting avenue to explore.

Historically, clades have sort of been the wild west; for a long time there was no code governing them. The **International Code of Phylogenetic Nomenclature (PhyloCode)**, published by the International Society for Phylogenetic Nomenclature, went into effect in 2020, but it's received its share of criticism and has not been globally accepted. I've heard from many that the guidelines for clade stability are nice, but they have objections to the other requirements for clade establishment.

For the purposes of this document, all of the guidelines for the genus and species level, as well as Linnaean taxonomy, will follow the ICZN unless stated otherwise. Assume that plants, fungi, slime molds, algae, pseudofungi, and photosynthetic protists are covered by the ICN, all other eukaryotes are covered by the ICZN, and all prokaryotes are covered by the ICNP. The guidelines for clades will follow the PhyloCode regulations worth following in this context.

Binomial Names

Binomial names are the names given to individual species. A binomial always consists of a genus name, which is always capitalized, and a species name, which is always lowercase. The binomial name is always written in italics. Examples of correctly formulated scientific names are *Eublepharis macularis*, *Quetzalcoatlus northropi*, *Zostera marina*, and *Escherichia coli*.

A species name can never stand on its own; it must always be paired with a genus name. There can be multiple species within a genus, but a species cannot be in more than one genus; because of this, the same species name can be found in different genera. *Velociraptor mongoliensis*, *Psittacosaurus mongoliensis*, and *Andrewsarchus mongoliensis* are very different animals. If you want to shorten a binomial, you can reduce the genus name to an initial, e.g. *V. mongoliensis*. You should always introduce the genus name first, though, so people know what you're talking about[5].

Every genus has a **type species**: the species that the genus name is rooted on. That species can *never* be moved from the genus. For example, the type species of *Dicynodon* is *D. lacerticeps*. Over 100 different species of dicynodont have been assigned to *Dicynodon* over the years. All except two have been either moved elsewhere (e.g. *D. amalitzkii*, which is now *Peramodon*) or demonstrated to be invalid[6]. But *D. lacerticeps* can never be moved out of *Dicynodon*. If a type species is found to be invalid, then the genus is *also* invalidated and can't be used anymore. Any other species that are still valid would need a new genus name.

Subspecies and varieties

For living organisms, sometimes **subspecies** can be named. These are below the rank of species. The idea, at least nowadays, is that subspecies are separate populations, sometimes with notable physical differences, but can successfully interbreed. For example, there are up to 16 living subspecies of brown bear (*Ursus arctos*) spread across Eurasia and North America. They're separated geographically,

[5] Unless you're talking about *C. elegans*, *E. coli*, or *T. rex*. Those are so widely known the genus needs no introduction.

[6] "Invalid" can mean the species is either synonymous with something else (junior synonym) or lacks the evidence to support its distinctiveness (*nomen dubium*)

and they vary in size and coat color, but you could introduce a European brown bear (*Ursus arctos arctos*) to a Kodiak bear (*Ursus arctos middendorffi*) and they could theoretically produce fertile offspring. It's the only rank below species covered by the ICZN. If a subspecies is included, the full scientific name is called the **trinomial name**.

In plants, **varieties** and **forms** can also be named below the species or subspecies level, if there's still noteworthy morphological difference to identify. These are denoted by the prefixes var. and f., respectively. To take just one example, the common cabbage is known as *Brassica oleracea* var. *capitata* f. *alba*.

Some notation that you might see

Abbreviations

- **sp.** Means you're referring to any species in a genus or higher taxon.
  Example: *Psittacosaurus* sp. refers to a member of the genus *Psittacosaurus*, but the exact species is unknown.
- **ssp.** (ICZN) and **subsp.** (ICN) are like sp. but for subspecies.
- **spp.** Means you're referring to multiple species.
  Example: *Psittacosaurus* spp. refers to more than one species of *Psittacosaurus*.
- **sspp.** (ICZN) and **subspp.** (ICN) are like spp. but for subspecies.
- **cf.** Means that this organism is similar to this other one, but we can't be certain that it is the same.
  Example: cf. *Psittacosaurus* refers to something that's similar to *Psittacosaurus* but for some reason we can't say with confidence that it actually is *Psittacosaurus*
- **aff.** Means that this organism is similar to this other one, but we think it's probably a new species.
  Example: aff. *Psittacosaurus* refers to a probable new species that is similar or closely related to *Psittacosaurus*

Although all of the examples here use genera, these abbreviations can be used alongside any taxon higher than species. For example, Eurypterida spp. would refer to multiple species of eurypterid. cf. and aff. can also be placed before a full binomial, or between a genus and species, to refer to that particular species. For example, *Psittacosaurus* cf. *mongoliensis* would refer to a *Psittacosaurus* that is similar to *P. mongoliensis*, but we can't say for sure that it *is P. mongoliensis*.

Hybrids

Hybrids between two species are denoted by putting a cross (×) between the two. A liger, for example, would be known as *Panthera leo* × *Panthera tigris*, or *Panthera leo* × *tigris*. Unless you have an entire population that forms through hybrid speciation, hybrids do not get their own species name except in plants (ICN 3.1).

Dagger of death

You can put a dagger (†) before or after a taxon name to indicate that it's extinct, but this isn't always mandatory.

How to formulate a name

As you probably know, scientific names are coined using one or more root words. There are a couple basic ground rules to follow:

- Genus names should be treatable as a noun in Latin, but species names can be phrased as either adjectives or nouns
- All names *must* be limited to the 26 characters of the basic Latin alphabet. No diacritics, super/subscript, non-Latin letters, extra spaces, or special characters[7] are allowed. Names with any diacritics have to be amended (ICZN 32.5).
  Example: *Pterodaustro guiñazui* had to be amended to *P. guinazui* (Hanson 2004)
- The name cannot be offensive in any way

Root words

Traditionally, all scientific names were based in either Latin or Ancient Greek converted to a Latinized form, following Linnaeus's lead. Oftentimes they're put together in the same name (e.g. *Tyrannosaurus* is Greek for "tyrant lizard", *rex* is Latin for "king"). However, a scientific name can be based on any language. Examples of non-Latin/Greek-based genus names include *Kembawacela* (Bemba), *Incakujira* (Japanese), *Guanlong* (Chinese), *Beesiiwo* (Arapaho), *Dearc* (Scots Gaelic), *Tiktaalik* (Inuktitut), *Ypupiara* (Old Tupi), *Tsaagan* (Mongolian), and *Azhdarcho* (Uzbek). Mark

[7] Hyphens are acceptable in species names under the ICN in specific circumstances (ICN 23.3, 60.11, 60.13). They are *only* allowed by the ICZN if the first element is a letter and it's used as part of a description of the animal (ICZN 32.5.2.4.3).

Isaak has compiled a pretty long list of languages that have been incorporated here. It's becoming increasingly popular to incorporate languages indigenous to the area that the organism is found in. Depending on your project's lore, you could even get away with using an in-universe conlang in certain instances.

Scientific names are *supposed* to be a description of the organism in question, traditionally its physical features. The idea back in Linnaeus's day was that the binomial was like any name given to an animal, but in Latin, and animal names tend to be descriptive (little pied cormorant, for instance). Things like color, size, anatomical features, the habitat it lives in, and lifestyle are commonly used. But this isn't universal by any means. Other things that scientific names can be based on include:

- The location where it is found
  Example: *Zalophus californianus*, the California sea lion
- The organism's habitat (or, for parasites, hosts)
  Example: *Aloe arenicola*, so named because it grows in sand
- Names of people[8]
  Example: *Morturneria* is named for the late geologist Mort Turner

And, much less commonly...

- Mythological figures
  Example: *Wonambi*, named for the Rainbow Serpent in Aboriginal Australian folklore
- Onomatopoeia
  Example: *Gekko gecko*; the word "gecko" is an imitation of the Tokay gecko's sound
- The circumstances of its discovery
  Example: *Latenivenatrix* means "hidden hunter" because it wasn't recognized as a distinct species for almost 50 years
- Acronyms
  Example: *Unescoceratops*, found at a UNESCO World Heritage Site
- Pop culture references
  Example: *Ikrandraco*, named in reference to the creatures from the movie *Avatar*
- Puns
  Example: *Mini scule*, a very small frog
- Anagrams of other names
  Example: *Cramauchenia*, named as an anagram of the closely related *Macrauchenia*

Further reading: CuriousTaxonomy.net
Mark Isaak's website *Curiosities of Biological Nomenclature* compiles many examples of interesting scientific names. Unusual or humorous etymologies, puns and wordplay, pop cultural references, and more. It's a fun read.

[8] Historically, these mostly honored scientists, collectors, and curators. Nowadays more variety is for better or for worse common, including benefactors, celebrities, and the namer's family/partners.

- Random combinations of letters
  Example: *Blamada*, which explicitly means nothing
- Whatever you want
  Example: *Grant* was named in honor of academic grants

Generally, the less that a name has to do with the organism in question, the more people may be disappointed in it. Pop culture references are frowned upon if used too frequently, and don't use random combinations of letters unless you're a really bored insect taxonomist.

I'm slowly putting together a dictionary, in the form of a spreadsheet, of root words that may be used in scientific names **here**. There are several other lists online; here, here, and here are the three examples that the linked spreadsheet is using as a base (note the latter two include only Greek and Latin words). Simply search for the word you want and look up its translation. If you want to use a word and you can't find it in any of these lists, you'll have to look up the translation yourself. I recommend searching your word on Wiktionary and looking at the available translations; this tends to be more accurate than Google Translate.

Lastly, binomial names should ideally be easy to pronounce. All four nomenclatural codes call for names to be euphonious[9] (ICZN Recommendation 25C, ICN Recommendation 20A, ICNP Recommendation 6, ICVCN 3.12). So the exact root words can be tweaked a little bit if it flows off the tongue better. Not doing so can make them sound clunky (e.g. *Thanatosdrakon*, which I would have named *Thanatodrakon*).

Tautonyms

A **tautonym** is when the genus and the species name are the same. Examples include *Vulpes vulpes* and *Gorilla gorilla*. The ICN forbids tautonyms, but the ICZN allows them. So you can do them with animals but not plants or fungi. The ICNP and ICVCN say nothing about tautonyms, so they're probably allowed for prokaryotes and viruses.

[9] "Easy to pronounce", if you aren't familiar with the word

Naming a species after a person or place

When naming a species after a proper noun (i.e., a person or place), what you do is you take the name and add specific suffixes to it. The idea is that the proper name is converted to the Latin genitive (possessive) case, which acts as an adjective to describe the organism.

For species named after people (**eponyms**), the suffix depends on the person's gender and how many there are. The same standard suffixes are used by the ICZN, ICN, and ICNP, and while the ICVCN doesn't have any specific guidelines, in practice the same standards are used there. The suffixes are outlined in this table:

	Male[10]	**Female**
One person	*-i* or *-ii*[11]	*-ae*
Multiple people with one name	*-orum*[12]	*-arum*

These forms also apply when naming a species after a mythological figure, fictional character, or really anything phrased as a possessive[13]. *-orum* or *-arum* can be used for any group of people, from a pair of siblings (e.g. *Buitreraptor gonzalezorum*, named for Fabian and Jorge Gonzalez) to an entire culture (e.g. *Europejara olcadesorum*, named for the Olcades tribe).

It should be noted that the ICZN has *no* guidelines for what happens when you name a species after multiple people with *different* names. The ICZN treats these instances as arbitrary combinations of letters. While I would personally recommend using *-orum*/*-arum*, there have certainly been instances that don't (e.g. *Utahraptor ostrommaysi*, *Tianchisaurus nedegoapeferima*). It is not *illegal* to name a species after yourself, but it is highly frowned upon.

For naming species after a place, take the place name and add one of the three following suffixes: *-ensis*, *-anus*, or *-icus*. I don't think there's a particular standard for

[10] The Latin format is the same for masculine and neuter genders, so I suppose you should follow this for nonbinary people that don't lean feminine.

[11] *-ii* was more common historically. Technically, the name should be converted to a Latin form (*-ius*/*-ia*), and then be modified to the genitive case; doing this to a masculine name would result in *-ii*. Nowadays fewer people care about this technicality, so you see a lot of *-i* around.

[12] If the group of people includes at least one guy, it's gendered masculine.

[13] **Example**: *Xenos vesparum* is a parasite of wasps. *vesparum* is the genitive form of *vespa* "wasp", making its species name "of the wasps"

which one to use; choose whichever one sounds the best. There are a few pre-existing Latin adjectives that can be used instead (e.g. *africanus* “African”), but if one of those doesn’t already exist, don’t make one; use the -ensis form.

It should be noted that the above guidelines only apply to *species* names. Naming a genus after a person or place can be done by combining it with another root word (e.g. *Perucetus*), a simple Latinizing ending like *-ia* (e.g. *Gastonia*), or sometimes just using the name without modification (e.g. *Carlito*, *Luangwa*).

Gender rules

Binomial names follow the grammatical rules of Latin, and therefore there are three grammatical genders: **masculine**, **feminine**, and **neuter**. Grammatical gender is determined by the root words that end a genus or species name. For Latin, Greek, or any other language with grammatical gender, the gender of the name follows the gender of the root word that *ends* it. The following table identifies Latin/Greek gendered endings as they would be formatted in scientific names; follow these if you want to convert a name to a different gender (e.g. making feminine *saura* from masculine *saurus*).

Masculine	Neuter	Feminine
-us	-um/-on	-a
-is	-e	-is
-er	-rium	-re
-or	-rum	-rix
-i	-i	-ae
-orum	-orum	-arum
-ensis	-ense	-ensis
-anus	-anum	-ana
-icus	-icum	-ica

If the taxon is named for a person or mythological figure in the Latin genitive case (*-i*, *-ae*, *-orum*, *-arum*), then their gender determines the grammatical gender of the name. There are also special cases:

- Some Latin words (e.g. *cola*, "dweller", *-fer* "bearer") are considered to be of "common" gender; they could apply to any gender. They should be treated as masculine unless the author indicates otherwise
  Example: *Rupicola peruvianus*, the Andean cock-of-the-rock
- Names that end in *-es* should be treated as masculine unless the author indicates otherwise
- Names that end in *-ps* or *-ax*[14] are always treated as masculine

If the word is *not* derived from Greek or Latin, including things named after people but *not* in the genitive case (e.g., *Morturneria*), things are different (ICZN 30.2). If the author explicitly states a grammatical gender, that should be followed.[15] If the base language genders that word, follow that. But if no grammatical gender is specified, indicated, or inferable from the rules of the original language, then:[16]

- If the name ends with *-a*, it should be treated as feminine
- If the name ends with *-um*, *-on*, or *-u*, it should be treated as neuter
- Otherwise, it should be treated as masculine

The grammatical genders of the genus and the species must be the same if the species name is in the form of an *adjective* - think of it as if it's *describing* the genus name (in Romance languages like Latin, the adjective's gender has to agree with the noun's). If the species name is a noun itself (e.g. *Equus zebra*) or named after a person (e.g. *Maiasaura peeblesorum*), it does not need to match the genus name's gender.

Regulation of binomial names

Homonymy

All nomenclatural codes forbid **homonymy**: there cannot be two genera with the same name, and there cannot be two species in a genus with the same name. If two

[14] Or *-ex*, or *-ox*
[15] The ICZN recommends that authors declare the grammatical gender of a name if isn't immediately obvious from the spelling
[16] I've heard opinions that non-Greek/Latin words should be treated as neuter by default, but the ICZN indicates otherwise (ICZN 30.2.4).

genera or two congeneric species have the same name, **the first one to be named gets to keep it**, and the later-named one has to be changed. Since names from speculative evolution projects will never be formally established, this means that **you always have to defer to real taxa**. To avoid homonymy, you should search for the genus name you want to use to see if it's already been taken. A difference of even a single letter can be enough to prevent homonymy. For example, *Kentrosaurus* and *Centrosaurus* are based on the same root words and mean the same thing, but the single different letter is enough to keep them from being homonyms.

However, where nomenclatural codes do not overlap, this does not apply. The ICZN, ICN, ICNP, and ICVCN have no restrictions on homonymy with a genus covered by one of the other codes. Two identical names covered by different codes are known as **hemihomonyms**, and over 1,000 are known to exist (Shipunov, 2011). An animal can have the same name as a plant or fungus, but a plant cannot have the same name as a fungus since they're both covered by the ICN.

Synonymy

If two names are given for the same taxon, then they are considered **synonyms.** The ICZN, ICN, and ICNP operate on the principle of priority: the oldest name (**senior synonym**) is the valid one[17], and all succeeding names are **junior synonyms**. This is to prevent things from constantly being renamed willy-nilly - again, stability's the goal in taxonomy. Exceptions can be made under the ICZN and ICN:

- If a name hasn't been used by the scientific community since 1899, it can be labeled a ***nomen oblitum*** and rejected in favor of a newer name for the same organism (now the ***nomen protectum***)

  Example: *Crotalus atrox*, the western diamondback rattlesnake, was named in 1853. *Crotalus cinereous*, named in 1852, predates it, and therefore would usually be the senior synonym. However, nobody actually used *Crotalus cinereous* since 1899, so it has been deemed a *nomen oblitum*, in favor of *Crotalus atrox*.
- If a younger name is far, far more commonly used (or if a name that's commonly used otherwise violates the rules), then you can petition the Commission for it to be deemed a ***nomen conservandum***. If the Commission approves, then the other name is labeled a ***nomen rejiciendum*** and rejected.

[17] If two things named in the same work are found to be the same, it is up to the researcher who pointed it out to choose which one stands. "Page priority" does not exist (ICZN 24.2).

Example: *Procynosuchus* Broom, 1937 is a junior synonym of *Cyrbasiodon* Broom, 1931. *Cyrbasiodon* was extremely rarely used after the 1930s, while *Procynosuchus* became the dominant name in the literature. In 2010, the ICZN ruled that *Procynosuchus* was a *nomen conservandum*, so now, even though it's younger, it's the valid name.

Meanwhile, the ICVCN doesn't have any priority principle: older names can be forgotten if a newer name becomes widely used (ICVCN 3.10).

Typos

If there's evidence that a name was accidentally misspelled or misprinted in initial publication, it can be deemed a **lapsus calami** and corrected to what the name was intended to be (ICZN 32.5.1). For example, the pterosaur *Vesperopterylus* was inadvertently named *Versperopterylus*; this was soon corrected by the authors (Lü et al. 2017).

Higher-Level Taxa and Clades

Most modern biologists have abandoned the ranked taxonomic system in favor of cladistics, although its adoption is less universal in certain branches of the field. I'll provide guidelines on how to handle both here. Ranks of family and below are regulated by the ICZN, and most ranked taxa are regulated by the ICN, ICNP, and ICVCN. For the purposes of this document, **higher-level taxa** and **clades** refer to any group larger than a genus, and will be used interchangeably.

Unlike genera and species, names of higher-level taxa are only italicized for viruses (ICVCN 3.27) and by hardcore PhyloCode adherents (PhyloCode Recommendation 6.1A).

Ranked taxa

Back in the day, taxonomists would take pains to make sure *all* of the major taxonomic ranks were named. Please don't do that. Then you end up with a bunch of redundant taxa with identical content. Modern biologists[18] don't make new ranked taxa when they aren't necessary. The kingdom Protista was abolished when it became clear it was wildly paraphyletic with regard to animals, plants, and fungi, and now there are a bunch of eukaryote phyla that aren't assigned to a kingdom. Bacteria taxonomy doesn't use kingdoms at all. Nobody names monotypic[19] families anymore.

[18] *Most* of them. There are a few ornithologists I have a bone to pick with about this

[19] A ranked taxon that only contains one thing in it. The mammal order Tubulidentata is monotypic because it contains a single family, Orycteropodidae. Monotypic clades cannot exist, as they're defined to include *all* members of a lineage, not just the taxa that we know from it.

Standardized endings

An easy way that ranked clades are named is to take a specific genus within it (the **type genus**) and add a suffix to it. For example, animal families are often made by modifying a genus name with the suffix *-idae*. The ICZN only provides standardized suffixes at the superfamily level and below:

Rank	Suffix (ICZN)
Superfamily	-oidea
Family	-idae
Subfamily	-inae
Tribe	-ini
Subtribe	-ina

There are no standardized suffixes for animal ranks above the level of superfamily. However, *-iformes* is a commonly used suffix for orders, and certain other groups (most notably mammals) may also use *-morpha* as an order-level suffix. Apparently protozoologists like using *-ida* as a suffix for protist orders.

The ICN, ICNP, and ICVCN, on the other hand, have pretty stringent suffix standards:

Rank	Plants (ICN)	Algae (ICN)	Fungi (ICN)	Prokaryotes (ICNP)
Phylum (or division)	-phyta	-phyta	-mycota	-ota
Subphylum (or subdivision)	-phytina	-phytina	-mycotina	
Class	-opsida	-phyceae	-mycetes	-ia
Subclass	-idae	-phycidae	-mycetidae	-idae
Superorder	-anae	-anae	-anae	
Order	-ales	-ales	-ales	-ales

Suborder	-ineae	-ineae	-ineae	-ineae
Infraorder	-aria	-aria	-aria	
Superfamily	-acea	-acea	-acea	
Family	-aceae	-aceae	-aceae	-aceae
Subfamily	-oideae	-oideae	-oideae	-oideae
Tribe	-eae	-eae	-eae	-eae
Subtribe	-inae	-inae	-inae	-inae

Rank	Viruses (ICVCN)	Viroids (ICVCN)	Viriforms (ICVCN)	Satellites (ICVCN)
Realm	-viria	-viroidia	-viriformia	-satellitia
Subrealm	-vira	-viroida	-viriforma	-satellita
Kingdom	-virae	-viroidae	-viriformae	-satellitae
Subkingom	-virites	-viroidites	-viriformites	-satellitites
Phylum	-viricota	-viroidicota	-viriformicota	-satellicota
Subphylum	-viricotina	-viroidicotina	-viriformicotina	-satellicotina
Class	-viricetes	-viroidicetes	-viriformicetes	-satellictes
Subclass	-viricetidae	-viroidicetidae	-viriformicetidae	-satellicetidae
Order	-virales	-viroidales	-viriformales	-satellitales
Suborder	-virineae	-viroidineae	-viriformineae	-satelltineae
Family	-viridae	-viroidae	-viriformidae	-satellitidae
Subfamily	-virinae	-viroidinae	-viriforminae	-satellitinae
Genus	-virus	-viroid	-viriform	-satellite
Subgenus	-virus	-viroid	-viriform	-satellite

It should be noted that family-rank and below taxa **cannot** be formed any other way except using a type genus. To take an example, a family of pterosaurs was once named Asiaticognathidae. This was rejected because it did not contain an *Asiaticognathus*; that genus does not exist (Kellner et al. 2010).

Clades

Clade names are like ranked taxa, in that they can be either based on a type genus or not. The classical ranked taxon suffixes can be used in clade names, but most biologists try not to nest ranks that are still governed by a nomenclatural code (family and below for animals, most of them for plants, fungi, bacteria, and viruses) - so, while the PhyloCode would allow for a "family-level" *-idae* clade to fall within another one, many biologists would rather avoid that if possible.

Clades are always defined using **specifiers** - specific species that should be either included or excluded from the clade. This way, if the exact content of the clade changes with newer analyses, it can still be used in the way it was originally intended. The PhyloCode outlines some easy rules for defining clades. All clade definitions follow one of three formats:

- **Node-based clades:** The most recent common ancestors of species X and species Y, plus all of its descendants. Can also be phrased as "The least inclusive clade containing X and Y". Shorthand: X + Y
- **Stem-based clades:** The most recent ancestor of species X that is not also an ancestor of species Y, plus all of its descendants. Can also be phrased as "The most inclusive clade containing X but not Y". Shorthand: X > Y
- **Apomorphy-based clades:** The oldest species with trait A homologous to its presence in species X, plus all of its descendants. Not very commonly used and I'd personally avoid them

Although the above templates for node- and stem-based clades include two **specifiers**, a node-based clade can have multiple **internal specifiers** (e.g. V + W + X + Y + Z) and a stem-based clade can have multiple **external specifiers** (e.g. X > V, W, Y, Z).

Clade names can be based on three things: the name of a genus it contains, a repurposed ranked taxon (this is called a **converted clade name**), or a new name that is usually descriptive of the organisms it contains. The PhyloCode mandates that, if a

clade name is based on a specific genus, the clade definition *must* include that genus as an internal specifier. For a hypothetical example, if Dromornithidae did not include *Dromornis* as an internal specifier, there would be a chance that *Dromornis* could fall outside Dromornithidae. Most[20] clade names that aren't converted ranked names end with *-a*, *-ia*, or *-es*. Clades follow similar rules of synonymy and homonymy to the ICZN, and likewise clade names only allow the 26 letters of the basic Latin alphabet (with the exception of pan-clades and apo-clades, which allow hyphens).

Pan-clades and Apo-clades

A **crown group** is the least inclusive clade containing all living members of a certain group. For example, crown-Aves includes all living birds, but excludes *Ichthyornis*, *Hesperornis*, etc. A **total group**, denoted by the prefix *Pan-*, includes the crown group and all extinct things more closely related to the crown group than any other living species. Pan-Aves includes everything that's more closely related to birds than the next closest living relative to birds (crocodilians): this means all Mesozoic dinosaurs, pterosaurs, and aphanosaurs. Collectively, that assemblage of extinct species is known as the **stem group.** *Brontosaurus* is a stem-bird. The PhyloCode allows for **pan-clades** to be defined to correspond to total groups. The names are pretty much that of the crown clade plus the prefix *Pan-* (including hyphen).

The PhyloCode also allows for **apo-clades**, distinguished by the prefix *Apo-* (including hyphen). This is used to include all organisms that share a major derived trait of the crown clade it's based from. For example, the clade Gnathostomata refers to the crown group of vertebrates with jaws, and Pan-Gnathostomata is the corresponding total group. Apo-Gnathostomata, meanwhile, would be only those members of Pan-Gnathostomata that actually had jaws (Downs 2020). There are extinct jawless fish more closely related to Gnathostomata than to living hagfish or lampreys; these would be members of Pan-Gnathostomata, but not Apo-Gnathostomata.

[20] Some "protist" clades like SAR are mavericks. I wouldn't follow their example.

Works Cited

Bertling, M.; Braddy, S.J.; Bromley, R.G.; Demathieu, G.R.; Genise, J.; Mikuláš, R.; Nielsen, J.K.; Nielsen, K.S.S.; Rindsberg, A.K.; Schlirf, M.; Uchman, A. (2003). "Draft proposal to emend the Code with respect to trace fossils: request for comments". *Bulletin of Zoological Nomenclature* 60(2): 141-2.

Bertling, M.; Braddy, S.J.; Bromley, R.G.; Demathieu, G.R.; Genise, J.; Mikuláš, R.; Nielsen, J.K.; Nielsen, K.S.S.; Rindsberg, A.K.; Schlirf, M.; Uchman, A. (2007). "Names for trace fossils: a uniform approach". *Lethaia* 39(3): 265-86.

Corliss, J.O. (1992). "Should there be a separate code of nomenclature for the protists?" *Biosystems* 28(1-3): 1-14.

Downs, J.P. (2020). "Apo-Gnathostomata". In: de Queiroz, K.; Cantino, P.D.; Gauthier, J.A. (eds.). *Phylonyms: A Companion to the PhyloCode*. CRC Press, Boca Raton.

Hanson, M. (2004). "The Pterosaur Species List". *Archosauria.org*.

International Botanical Congress (2018). *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code)*.

International Commission on Zoological Nomenclature (2000). *International Code of Zoological Nomenclature, Fourth Edition*.

International Commission on Zoological Nomenclature (n.d.). "Frequently Asked Questions". *International Commission on Zoological Nomenclature*.

International Committee on Taxonomy of Viruses (2021). *The International Code of Virus Classification and Nomenclature (ICVCN)*.

International Society for Phylogenetic Nomenclature (2019). *International Code of Phylogenetic Nomenclature (PhyloCode) Version 6*.

Kellner, A.W.A.; Wang, X.; Tischlinger, H.; Campos, D.A.; Hone, D.W.E.; Meng, X. (2010). "The soft tissue of *Jeholopterus* (Pterosauria, Anurognathidae, Batrachognathinae) and the structure of the pterosaur wing membrane". *Proceedings of the Royal Society B* 277(1679): 321-329.

Kuhn, J.H. (2021). "Virus Taxonomy". In: Bamford, D.H.; Zuckerman, M. (eds.). *Encyclopedia of Virology, Fourth Edition*, 1: 28-37.

Linnaeus, C. (1735). *Systema naturæ, sive regna tria naturæ systematice proposita per classes, ordines, genera, & species* [*Systema Naturae*, first edition]. Lugduni Batavorum, Leiden.

Linnaeus, C. (1751). *Philosophia botanica in qua explicantur fundamenta botanica cum definitionibus partium, exemplis terminorum, observationibus rariorum, adlectis figuris aeneis* [*Philosophia Botanica*, first edition]. R. Kiesewetter, Stockholm.

Linnaeus, C. (1753). *Species plantarum, exhibentes plantas rite cognitas, ad genera relatas, cum differentiis specificus, nominibus trivialibus, synonymis selectis, locis natalibus, secundum systema sexuale digestas* [*Species Plantarum*, first edition]. Impensis Laurentii Salvii, Stockholm.

Linnaeus, C. (1758). *Systema naturæ per regna tria naturæ, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis* [*Systema Naturae*, 10th edition]. Holmiæ, Stockholm.

Lü, J.; Meng, Q.; Wang, B.; Liu, D.; Shen, C.; Zhang, Y. (2017). "Short note on a new anurognathid pterosaur with evidence of perching behavior from Jianchang of Liaoning Province, China". *Geological Society, London, Special Publications* 455: 95-104.

Oren, A.; Arahal, D.R.; Göker, M.; Moore, E.R.B.; Rossello-Mora, R.; Sutcliffe, I.C. (2022). "International Code of Nomenclature of Prokaryotes. Prokaryotic Code (2022 Revision)". *International Journal of Systematic and Evolutionary Microbiology* 73: 005585.

Oren, A.; Ventura, S. (2017). "The current status of cyanobacterial nomenclature under the "prokaryotic" and the "botanical" code". *Antoine van Leeuwenhoek* 110: 1257-69.

Ronikier, A.; Halamski, A.T. (2018). "Is Myxomycetes (Amoebozoa) a Truly Ambiregnal Group? A Major Issue in Protist Nomenclature". *Protist* 169(4): 484-93.

Sarjeant, W.A.S.; Kennedy, W.J. (1973). "Proposal of a Code for the Nomenclature of Trace-Fossils". *Canadian Journal of Earth Sciences* 10(4): 460-75.

Shipunov, A. (2011). "The problem of hemihomonyms and the on-line hemihomonyms database (*HHDB*)". *Bionomina* 4: 65-72.

Skerman, V.B.D.; McGowan, V.; Sneath, P.H.A. (1980). "Approved Lists of Bacterial Names". *International Journal of Systematic and Evolutionary Microbiology* 30(1): 225-420.