Scientific classification

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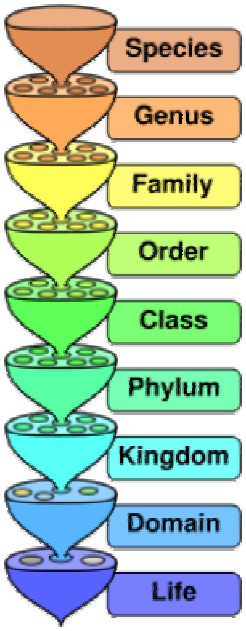

Scientific classification or **biological classification** is a method by which biologists group and categorize species of organisms. Scientific classification also can be called scientific taxonomy, but should be distinguished from folk taxonomy, which lacks scientific basis. Modern classification has its root in the work of Carolus Linnaeus, who grouped species according to shared physical characteristics. These groupings since have been revised to improve consistency with the Darwinian principle of common descent. Molecular systematics, which uses DNA sequences as data, has driven many recent revisions and is likely to continue to do so. Scientific classification belongs to the science of taxonomy or biological systematics.

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Early systems

Ancient through medieval

Current systems of classifying forms of life descend from the thought presented by the Greek philosopher Aristotle, who published in his metaphysical and logical works the first known classification of everything whatsoever, or "being". This is the scheme that gave moderns such words as substance, species and genus and was retained in modified and less general form by Linnaeus.

Aristotle also studied animals and classified them according to method of reproduction, as did Linnaeus later with plants. Aristotle's animal classification was soon made obsolete by additional knowledge and was forgotten.

The philosophical classification is in brief as follows.[1] Primary substance is the individual being; for example, Peter, Paul, etc. Secondary substance is a predicate that can properly or characteristically be said of a class of primary substances; for example, man of Peter, Paul, etc. The characteristic must not be merely in the individual; for example, being skilled in grammar. Grammatical skill leaves most of Peter out and therefore is not characteristic of him. Similarly man (all of mankind) is not in Peter; rather, he is in man.

Species is the secondary substance that is most proper to its individuals. The most characteristic thing that can be said of Peter is Peter is a man. An identity is being postulated: "man" is equal to all its individuals and only those individuals. Members of a species differ only in number but are totally the same type.

Genus is a secondary substance less characteristic of and more general than the species; for example, man is an animal. Not all animals are men. It is clear that a genus contains species. There is no limit to the number of Aristotelian genera that might be found to contain the species. Aristotle does not structure the genera into phylum, class, etc., as does Linnaean classification.

The secondary substance that distinguishes one species from another within a genus is the specific difference. Man can thus be comprehended as the sum of specific differences (the "differentiae" of biology) in less and less general categories. This sum is the definition; for example, man is an animate, sensate, rational substance. The most characteristic definition contains the species and the next most general genus: man is a rational animal. Definition is thus based on the unity problem: the species is one yet has many differentiae.

The very top genera are the categories. There are ten: one of substance and nine of "accidents", universals that must be "in" a substance. Substances exist by themselves; accidents are only in them: quantity, quality, etc. There is no higher category, "being", because of the following problem, which was only solved in the Middle Ages by Thomas Aquinas: a specific difference is not characteristic of its genus. If man is a rational animal, then rationality is not a property of animals. Substance therefore cannot be kind of being because it can have no specific difference, which would have to be non-being.

The problem of being occupied the attention of scholastics during the time of the Middle Ages. The solution of St. Thomas, termed the analogy of being, established the field of ontology, which received the better part of the publicity and also drew the line between philosophy and experimental science. The latter rose in the Renaissance from practical technique. The greatest scientific classifier, Linnaeus, a classical scholar, combined the two on the threshold of that great neo-classicist revival now called the Age of Enlightenment.

Renaissance through age of reason

An important advance was made by the Swiss professor, Conrad von Gesner (1516–1565). Gesner's work was a critical compilation of life known at the time.

The exploration of parts of the New World that produced large numbers of new plants and animals that needed descriptions and classification. The old systems made it difficult to study and locate all these new specimens within a collection and often the same plants or animals were given different names because the number of specimens were too large to memorize. A system was needed that could group these specimens together so they could be found, the binomial system was developed based on morphology with groups having similar appearances. In the latter part of the 16th century and the beginning of the 17th, careful study of animals commenced, which, directed first to familiar kinds, was gradually extended until it formed a sufficient body of knowledge to serve as an anatomical basis for classification. Advances in using this knowledge to classify living beings bear a debt to the research of medical anatomists, such as Fabricius (1537–1619), Petrus Severinus (1580–1656), William Harvey (1578–1657), and Edward Tyson (1649–1708). Advances in classification due to the work of entomologists and the first microscopists is due to the research of people like Marcello Malpighi (1628–1694), Jan Swammerdam (1637–1680), and Robert Hooke (1635–1702). Lord Monboddo (1714-1799) was one of the early abstract thinkers whose works illustrate knowledge of species relationships and who foreshadowed the theory of evolution. Successive developments in the history of insect classification may be followed on the website[2] by clicking on succeeding works in chronological order.

Early methodists

Since late in the 15th century, a number of authors had become concerned with what they called *methodus*, (method). By method authors mean an arrangement of minerals, plants, and animals according to the principles of logical division. The term *methodists* was coined by Carolus Linnaeus in his *Bibliotheca Botanica* to denote the authors who care about the principles of classification (in contrast to the mere *collectors* who are concerned primarily with the description of plants paying little or no attention to their arrangement into genera, etc). Important early methodists were an Italian philosopher, physician, and botanist Andrea Caesalpino, an English naturalist John Ray, a German physician and botanist Augustus Quirinus Rivinus, and a French physician, botanist, and traveller Joseph Pitton de Tournefort.

Andrea Caesalpino (1519–1603) in his *De plantis libri XVI* (1583) proposed the first methodical arrangement of plants. On the basis of the structure of trunk and fructification he divided plants into fifteen "higher genera".

John Ray (1627–1705) was an English naturalist who published important works on plants, animals, and natural theology. The approach he took to the classification of plants in his Historia Plantarum was an important step towards modern taxonomy. Ray rejected the system of dichotomous division by which species were classified according to a pre-conceived, either/or type system, and instead classified plants according to similarities and differences that emerged from observation.

Both Caesalpino and Ray used traditional plant names and thus, the name of a plant did not reflect its taxonomic position (e.g. even though the apple and the peach belonged to different "higher genera" of John Ray's *methodus*, both retained their traditional names *Malus* and *Malus Persica* respectively). A further step was taken by Rivinus and Pitton de Tournefort who made genus a distinct rank within taxonomic hierarchy and introduced the practice of naming the plants according to their genera.

Augustus Quirinus Rivinus (1652–1723), in his classification of plants based on the characters of the flower, introduced the category of order (corresponding to the "higher" genera of John Ray and Andrea Caesalpino). He was the first to abolish the ancient division of plants into herbs and trees and insisted that the true method of division should be based on the parts of the fructification alone. Rivinus extensively used dichotomous keys to define both orders and genera. His method of naming plant species resembled that of Joseph Pitton de Tournefort. The names of all plants belonging to the same genus should begin with the same word (generic name). In the genera containing more than one species the first species was named with generic name only, while the second, etc were named with a combination of the generic name and a modifier (*differentia specifica*).

Joseph Pitton de Tournefort (1656–1708) introduced an even more sophisticated hierarchy of class, section, genus, and species. He was the first to use consistently the uniformly composed species names which consisted of a generic name and a many-worded diagnostic phrase *differentia specifica.* Unlike Rivinus, he used *differentiae* with all species of polytypic genera.

Modern systems

Linnaean

Two years after John Ray's death, Carolus Linnaeus (1707–1778) was born. His great work, the *Systema Naturae*, ran through twelve editions during his lifetime (1st ed. 1735). In this work, nature was divided into three kingdoms: mineral, vegetable and animal. Linnaeus used five ranks: class, order, genus, species, and variety.

He abandoned long descriptive names of classes and orders and two-word generic names (e. g. *Bursa pastoris*) still used by his immediate predecessors (Rivinus and Pitton de Tournefort) and replaced them with single-word names, provided genera with detailed diagnoses (*characteres naturales*), and reduced numerous varieties to their species, thus saving botany from the chaos of new forms produced by horticulturalists.

Linnaeus is best known for his introduction of the method still used to formulate the scientific name of every species. Before Linnaeus, long many-worded names (composed of a generic name and a *differentia specifica*) had been used, but as these names gave a description of the species, they were not fixed. In his *Philosophia Botanica* (1751) Linnaeus took every effort to improve the composition and reduce the length of the many-worded names by abolishing unnecessary rhetorics, introducing new descriptive terms and defining their meaning with an unprecedented precision. In the late 1740s Linnaeus began to use a parallel system of naming species with *nomina trivialia. Nomen triviale*, a trivial name, was a single- or two-word epithet placed on the margin of the page next to the many-worded "scientific" name. The only rules Linnaeus applied to them was that the trivial names should be short, unique within a given genus, and that they should not be changed. Linnaeus consistently applied *nomina trivialia* to the species of plants in *Species Plantarum* (1st edn. 1753) and to the species of animals in the 10th edition of *Systema Naturae* (1758).

By consistently using these specific epithets, Linnaeus separated nomenclature from taxonomy. Even though the parallel use of *nomina trivialia* and many-worded descriptive names continued until late in the eighteenth century, it was gradually replaced by the practice of using shorter proper names combined of the generic name and the trivial name of the species. In the nineteenth century, this new practice was codified in the first Rules and Laws of Nomenclature, and the 1st edn. of *Species Plantarum* and the 10th edn. of *Systema Naturae* were chosen as starting points for the Botanical and Zoological Nomenclature respectively. This convention for naming species is referred to as binomial nomenclature.

Today, nomenclature is regulated by Nomenclature Codes, which allows names divided into ranks; see rank (botany) and rank (zoology).

Evolutionary

Whereas Linnaeus classified for ease of identification, it is now generally accepted that classification should reflect the Darwinian principle of common descent.

Since the 1960s a trend called cladistic taxonomy (or cladistics or cladism) has emerged, arranging taxa in an evolutionary tree. If a taxon includes all the descendants of some ancestral form, it is called monophyletic, as opposed to paraphyletic. Other groups are called polyphyletic.

A new formal code of nomenclature, the PhyloCode, to be renamed "International Code of Phylogenetic Nomenclature" (ICPN), is currently under development, intended to deal with clades, which do not have set ranks, unlike conventional Linnaean taxonomy. It is unclear, should this be implemented, how the different codes will coexist.

Domains are a relatively new grouping. The three-domain system was first invented in 1990, but not generally accepted until later. Now, the majority of biologists accept the domain system, but a large minority use the five-kingdom method. One main characteristic of the three-domain method is the separation of Archaea and Bacteria, previously grouped into the single kingdom Bacteria (a kingdom also sometimes called Monera). Consequently, the three domains of life are conceptualized as Archaea, Bacteria, and Eukaryota (comprising the nuclei-bearing eukaryotes). [3] A small minority of scientists add Archaea as a sixth kingdom, but do not accept the domain method.

Thomas Cavalier-Smith, who has published extensively on the classification of protists, has recently proposed that the Neomura, the clade which groups together the Archaea and Eukarya, would have evolved from Bacteria, more precisely from Actinobacteria.

Examples

The usual classifications of five species follow: the fruit fly so familiar in genetics laboratories (*Drosophila melanogaster*), humans (*Homo sapiens*), the peas used by Gregor Mendel in his discovery of genetics (*Pisum sativum*), the "fly agaric" mushroom *Amanita muscaria*, and the bacterium *Escherichia coli*. The eight major ranks are given in bold; a selection of minor ranks are given as well.

Rank	Fruit fly	Human	Pea	Fly Agaric	*E. coli*
Domain	Eukarya	Eukarya	Eukarya	Eukarya	Bacteria
Kingdom	Animalia	Animalia	Plantae	Fungi	
Phylum or **Division**	Arthropoda	Chordata	Magnoliophyta	Basidiomycota	Proteobacteria
Subphylum or	Hexapoda	Vertebrata	Magnoliophytina	Hymenomycotina	

subdivision					
Class	Insecta	Mammalia	Magnoliopsida	Homobasidiomycetae	Gammaproteobacteria
Subclass	Pterygota	Theria	Magnoliidae	Hymenomycetes	
Order	Diptera	Primates	Fabales	Agaricales	Enterobacteriales
Suborder	Brachycera	Haplorrhini	Fabineae	Agaricineae	
Family	Drosophilidae	Hominidae	Fabaceae	Amanitaceae	Enterobacteriaceae
Subfamily	Drosophilinae	Homininae	Faboideae	Amanitoideae	
Genus	*Drosophila*	*Homo*	*Pisum*	*Amanita*	*Escherichia*
Species	*D. melanogaster*	*H. sapiens*	*P. sativum*	*A. muscaria*	*E. coli*

Table Notes:

- The ranks of higher taxa, especially intermediate ranks, are prone to revision as new information about relationships is discovered. For example, the traditional classification of primates (class Mammalia — subclass Theria — infraclass Eutheria — order Primates) has been modified by new classifications such as McKenna and Bell (class Mammalia — subclass Theriformes — infraclass Holotheria) with Theria and Eutheria assigned lower ranks between infraclass and the order Primates. See mammal classification for a discussion. These differences arise because there are only a small number of ranks available and a large number of branching points in the fossil record.
- Within species further units may be recognised. Animals may be classified into subspecies (for example, *Homo sapiens sapiens*, modern humans) or morphs (for example *Corvus corax varius* morpha *leucophaeus*, the Pied Raven). Plants may be classified into subspecies (for example, *Pisum sativum* subsp. *sativum*, the garden pea) or varieties (for example, *Pisum sativum* var. *macrocarpon*, snow pea), with cultivated plants getting a cultivar name (for example, *Pisum sativum* var. *macrocarpon* 'Snowbird'). Bacteria may be classified by strains (for example *Escherichia coli* O157:H7, a strain that can cause food poisoning).
- A mnemonic for remembering the order of the taxa is: **D**o **K**oalas **P**refer **C**hocolate **O**r **F**ruit, **G**enerally **S**peaking? Other mnemonics are available at [4] and [5].

Terminations of names

Taxa above the genus level are often given names based on the type genus, with a standard termination. The terminations used in forming these names depend on the kingdom, and sometimes the phylum and class, as set out in the table below.

Rank	Plants	Algae	Fungi	Animals	Bacteria[6]
Division/Phylum	-phyta		-mycota		
Subdivision/Subphylum	-phytina		-mycotina		
Class	-opsida	-phyceae	-mycetes		-ia
Subclass	-idae	-phycidae	-mycetidae		-idae
Superorder	-anae				
Order	-ales				-ales
Suborder	-ineae				-ineae
Infraorder	-aria				
Superfamily	-acea			-oidea	
Epifamily				-oidae	
Family	-aceae			-idae	-aceae
Subfamily	-oideae			-inae	-oideae
Infrafamily				-odd	
Tribe	-eae			-ini	-eae
Subtribe	-inae			-ina	-inae
Infratribe				-ad	

Table notes:

- In botany and mycology names at the rank of family and below are based on the name of a genus, sometimes called the type genus of that taxon, with a standard ending. For example, the rose family Rosaceae is named after the genus *Rosa*, with the standard ending "-aceae" for a family. Names above the rank of family are formed from a family name, or are descriptive (like Gymnospermae or Fungi).
- For animals, there are standard suffixes for taxa only up to the rank of superfamily.[7]
- Forming a name based on a generic name may be not straightforward. For example, the Latin "*homo*" has the genitive "*hominis*", thus the genus "*Homo*" (human) is in the Hominidae, not "Homidae".
- The ranks of epifamily, infrafamily and infratribe (in animals) are used where the complexities of phyletic branching require finer-than-usual distinctions. Although they fall below the rank of superfamily, they are not regulated under the International Code of Zoological Nomenclature and hence do not have formal standard endings. The suffixes listed here are regular, but informal.[8]

Authorities (author citation)

The name of any taxon may be followed by the "authority" for the name, that is, the name of the author who first published a valid description of it. These names are frequently abbreviated: the abbreviation "L." is universally accepted for Linnaeus, and in botany there is a regulated list of standard abbreviations (see list of botanists by author abbreviation). The system for assigning authorities is slightly different in different branches of biology: see author citation (botany) and author citation (zoology). However, it is standard that if a name or placement has been changed since the original description, the first authority's name is placed in parentheses and the authority for the new name or placement may be placed after it (usually only in botany).

Notes

1. ^ *Categories* Section 5 and *Metaphysics* Book 6, but the terms are used in many places throughout the writings of Aristotle.
2. ^ NOMINA CIRCUMSCRIBENTIA INSECTORUM. Retrieved on 2006-09-09.
3. ^ See especially pp. 45, 78 and 555 of Joel Cracraft and Michael J. Donaghue, eds. (2004). *Assembling the Tree of Life*. Oxford, England: Oxford University Press.
4. ^ mnemonic-device.eu
5. ^ thefreedictionary.com.
6. ^ Bacteriologocal Code (1990 Revision)
7. ^ ICZN article 27.2
8. ^ As supplied by Eugene S. Gaffney & Peter A. Meylan (1988), "A phylogeny of turtles", in M.J. Benton (ed.), *The Phylogeny and Classification of the Tetrapods, Volume 1: Amphibians, Reptiles, Birds* 157-219 (Oxford: Clarendon Press).

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See also

- Binomial nomenclature
- Trinomial nomenclature
- Taxonomy
- International Code of Botanical Nomenclature
- International Code of Zoological Nomenclature
- List of chordate orders
- List of Latin and Greek words commonly used in systematic names
- Phylogenetic tree
- Virus classification
- Set
- Species problem
- All Species Foundation

External links

- The Tree of Life web project
- International Code of the Zoological Nomenclature (4th Edition) 2000
- International Code of the Botanical Nomenclature (St. Louis Code) 2000
- Phylocode
- Taxonomy Trainer at Omne Vivum News.
- Wikispecies: a directory of life
- For a cladistic approach to animal classification: Classification of living things

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