

# History of Taxonomy

The history of taxonomy dates back to the origin of human language. Western scientific taxonomy started in Greek some hundred years BC and are here divided into prelinnaean and postlinnaean. The most important works are cited and the progress of taxonomy (with the focus on botanical taxonomy) are described up to the era of the Swedish botanist Carl Linnaeus, who founded modern taxonomy. The development after Linnaeus is characterized by a taxonomy that increasingly have come to reflect the paradigm of evolution. The used characters have extended from morphological to molecular. Nomenclatural rules have developed strongly during the 19th and 20th century, and during the last decade traditional nomenclature has been challenged by advocates of the Phylocode.

Mariette Manktelow  
Dept of Systematic Biology  
Evolutionary Biology Centre  
Uppsala University  
Norbyv. 18D  
SE-752 36 Uppsala  
E-mail: [mariette.manktelow@ebc.uu.se](mailto:mariette.manktelow@ebc.uu.se)

## 1. Pre-Linnaean taxonomy

### 1.1. Earliest taxonomy

Taxonomy is as old as the language skill of mankind. It has always been essential to know the names of edible as well as poisonous plants in order to communicate acquired experiences to other members of the family and the tribe. Since my profession is that of a systematic botanist, I will focus my lecture on botanical taxonomy.

A taxonomist should be aware of that apart from scientific taxonomy there is and has always been folk taxonomy, which is of great importance in, for example, ethnobiological studies.

When we speak about ancient taxonomy we usually mean the history in the Western world, starting with Romans and Greek. However, the earliest traces are not from the West, but from the East. Eastern taxonomic works were not known to the Western world until the Middle Ages and could thus not influence the progress of Western sciences.

In the Eastern world, one of the earliest pharmacopoeias was written by Shen Nung, Emperor of China around 3000 BC (Fig. 1). He was a legendary emperor known as the Father of Chinese medicine and is believed to have introduced acupuncture. He wanted to educate his people in agriculture and medicine and is said to have tasted hundreds of herbs to test their medicinal value. The pharmacopoeia *Divine Husbandman's Materia Medica* included 365 medicines derived from minerals, plants, and animals.

Around 1500 BC medicinal plants were illustrated on wall paintings in Egypt. The paintings give us knowledge about medicinal plants in old Egypt and their names. In one of the oldest and largest papyrus rolls, Ebers Papyrus, plants are included as medicines for different diseases. They have local names such as "celery of the hill country" and "celery of the delta", species of Apiaceae that Egyptian doctors had to be able to distinguish in the field.

### 1.2. The Greeks and Romans

#### **Aristotle** (384–322 BC)

In Western scientific taxonomy the Greek philosopher Aristotle was the first to classify all living things, and some of his groups are still used today, like the vertebrates and invertebrates, which he called animals with blood and without blood. He further divided the animals with blood into live-bearing and egg-bearing, and formed groups within the animals without blood that we recognize today, such as insects, crustacea and testacea (molluscs).

**Theophrastus** (370–285 BC) was a student of Aristotle and Platon. He wrote a classification of all known plants, *De Historia Plantarum*, which contained 480 species. His classification was based on growth form, and we still recognise many of his plant genera, like *Narcissus*, *Crocus* and *Cornus*. This is because Carl Linnaeus accepted many of his generic names. *De Historia Plantarum* was used for taxonomic purposes until the Middle Ages in Europe.

**Dioscorides** (40–90 AD) was a greek physician, who travelled widely in the Roman and Greek world to gather knowledge about medicinal plants. Between 50-70 AD he wrote *De Materia Medica*, which contained around 600 species. *De Materia Medica* was used in medicine until the 16th century, and was copied several times. One famous copy from the 6th century is kept in Vienna (Fig. 2). The classification in his work is based on the medicinal properties of the species.

**Plinius** (23–79 AD) was involved in the Roman army and later in the Roman state. He wrote many books, but the only one that has survived is his *Naturalis Historia*, a work of 160 volumes, in which he described several plants and gave them Latin names. Many of these names we still recognize, like *Populus alba* and *Populus nigra*, and since latin was later kept for botanical science, we may call him the Father of Botanical Latin. Plinius died in Pompeii.

### 1.3 The Herbalists

With the art of book printing in Europe new books could be made in large numbers. This was the time of the different herbals written by herbalists like **Brunfels**, **Bock**, **Fuchs**, **Mattioli**, **Turner**, **L'Obel**, **Gerard**, **L'Ecluse**. We recognize some of these authors in beautiful plants later named by Linnaeus in honour of them: *Brunfelsia*, *Mattiolia*, *Turnera*, *Lobelia*, *Gerardia* and *Fuchsia*. There is usually not much of a classification in the herbals, and the earliest works were merely copying Theophrastos and Dioscorides. With time the herbals became more and more original with more elaborate woodcuts as illustrations.

## 1.4 Early taxonomists

It was not until the end of the 16th century that taxonomic works became original enough to replace the ancient Greek works. One of the reasons for this was the development of optic lenses, which made it possible to study details in the different species. Collection of specimens became part of the growing sciences, and the emphasis turned from medical aspects to taxonomic aspects.

One of the earliest authors was **Caesalpino** (1519–1603) in Italy, who is sometimes called "the first taxonomist". In 1583 he wrote *De Plantis*, a work that contained 1500 species. His classification was based on growth habit together with fruit and seed form, as was that of Theophrastos. Some groups that he recognized we still acknowledge, like the plant families Brassicaceae and Asteraceae.

Two Swiss brothers **Bauhin** (1541–1631; 1560–1624) wrote the work *Pinax Theatri Botanici* in 1623. The word *Pinax* means register, and the work is a listing of 6000 species. The Bauhin brothers included synonymes, which was a great necessity of the time. By this time, species were known with many different names in different books, and *Pinax Theatri Botanici* made a welcome order in the taxonomic world. The Bauhin brothers recognized genera and species as major taxonomic levels.

The English naturalist **John Ray** (1627–1705) wrote several important works through his life. His most important contribution was the establishment of species as the ultimate unit of taxonomy. In 1682 he published *Methodus Plantarum Nova*, which contained around 18 000 plant species, a result of a relatively narrow species concept. His complicated classification was based on many combined characters, as opposed to earlier taxonomists. Ray aimed at publishing a complete system of nature, which included works on mammals, reptiles, birds, fishes and insects, the latter including pioneering entomological taxonomic work.

In France **Joseph Pitton de Tournefort** (1656–1708) constructed a botanical classification that came to rule in botanical taxonomy until the time of Carl Linnaeus. In 1700 he published *Institutiones Rei Herbariae*, in which around 9000 species were listed in 698 genera. He put primary emphasis on the classification of genera, and many genera were accepted by Linnaeus and still in use today. Tournefort's plant classification was exclusively based on floral characters. Tournefort's system was the one used by Linnaeus as a young student, but whereas Tournefort denied the presence of sexuality in plants, Linnaeus on the contrary based his system on that argument.

## 2. Linnaean era

### 2.1. Starting point of modern taxonomy

For nomenclatural reasons two works of **Carl Linnaeus** (1707–1778, Fig. 4) are regarded as the starting points of modern botanical and zoological taxonomy: the global flora *Species Plantarum*, published in 1753 and the tenth edition of *Systema Naturae* in 1758 including global fauna. The reason for this is that Linnaeus introduced in these books a binary form of species names called "trivial names" for both plants and animals. For each species he created an epithet that could be used together with the genus name. The trivial names were intended for fieldwork and education, and not to replace the earlier phrase names. The phrase names included a description of the species that distinguished it from other known species in the genus. With an expanded knowledge of the global fauna and flora through 17th and 18th century scientific expeditions, a large number of new species were found and named, and more terms had to be added to each phrase name. By the time of Linnaeus the situation was really bad. Linnaeus counted 8530 species of flowering plants in 1753.

The simplicity of Linnaeus' trivial names revolutionized nomenclature, and soon binary nomenclature

came to replace the phrase names. Today, every plant or animal name published before 1753 or 1758, respectively, is called "prelinnaean" and is thus not valid. Also early names published by Linnaeus himself are "prelinnaean"!

## 2.2 Transforming botany and zoology into a science

Carl Linnaeus started his career by publishing a system of all living things and minerals in 1735 called *Systema Naturae*. In this he introduced the sexual system of plants, an artificial classification based on the sexual parts of the flower: the stamens and pistils. In a time when people debated whether plants had sexuality or not, this suggestion from an unknown person not belonging to any classical European school of natural sciences more or less shocked the scientific world. However, the practical use of the system and Linnaeus careful observations persuaded the critics and Linnaeus sexual system of plants became the highest fashion also outside the scientific community.

In an attempt to make order in the world of taxonomy and explain his way of thinking, Linnaeus published several books that would transform botany and zoology into sciences of their own. Until then, these two disciplines had merely been a fringe of practical medicine built on scattered observation of different species, a *Historia Naturalis*. With the works of Linnaeus, botany and zoology transformed into a *Scientia*, a science surrounded by philosophy, order and systems, just like the disciplines of theology, philosophy and law.

In 1735 he published *Critica botanica*, with rules for the formulation of generic names. In the same year came *Genera Plantarum* with a list of all known genera. In subsequent books like *Fundamenta botanica* in 1736 and *Philosophia botanica* in 1751 he created rules for species descriptions, terminology, and even instructions on how to build a proper herbarium cupboard. Linnaeus established many of the rules taxonomists use today. Terms like *corolla*, *stamen*, *filament* and *anther* were created by him, as well as well-known taxon names like *Mammalia*.

After a long life with a massive publication in the philosophy and practicality of systematics, Linnaeus had laid out the foundation for botany and zoology, and it was now time for subsequent taxonomists to improve this newborn science.

## 3. Post-Linnaean taxonomy

### 3.1. Natural system emerging in France

One of the few countries in which the Linnaean systematics did not make success was France. The French stuck to Tournefort and continued to work on a development of the natural system. Four French scientists emerged that made an impact on future biological sciences.

**Georges-Luise Leclerc de Buffon** (1707–1788) was a strong critic to Linnaeus work, and he found it wrong to impose an artificial order on the disorderly natural world. His approach was to describe the world rather than to classify it. His theories touched upon development of species, infraspecific variety and acquired inherited characters in species, which opened up a pathway for an evolutionary theory.

**Michel Adanson** (1727–1806) wrote *Familles des Plantes* already in 1763. He launched the idea that in classification one should not put greater emphasis on some characters than on others, but use a great range of characters. He criticized Linnaeus' works, and considered Tournefort's classification far superior.

**Antoine Laurent de Jussieu** (1748–1836) changed the system of plants with his *Genera Plantarum* in 1789, in which he launched a natural system based on many characters that came to be a foundation of modern classification. He divided the plants into acotyledons, monocotyledons and dicotyledons and established the family rank in between the ranks "genus" and "class".

**Jean-Baptiste de Lamarck** (1744–1829) launched an evolutionary theory including inheritance of acquired characters, named the "Lamarckism". This was foreboding the theory of evolution presented by Charles Darwin and Alfred Russel Wallace in 1858 in London.

The French scientific work, the development of anatomy and physiology and improved optical

instruments made way for a new era of taxonomy, which was trying to cope with an increasing number of species in a rapidly expanding flora and fauna of the world.

### 3.2. Rules for nomenclature

One of the first attempts to create rules in botanical taxonomy was made by **Augustin Pyramus de Candolle** (1778–1841) in *Théory élémentaire de la botanique* in 1813. There he stated that published names should have priority according to the date of publication, starting with Linnaeus (without mentioning a particular year). The English did not follow that rule. On a congress in Paris, 100 botanists adopted the rules in a book by the son **Alphons de Candolle** (1806–1873), *Lois de nomenclature adoptée* from 1867. The rules were thereafter discussed and different starting points for botanical taxonomy were suggested. During the years 1891 to 1898 the German botanist **Otto Kuntze** (1843–1907) published the controversial work *Revisio generum Plantarum*, in which he applied Candolle's laws from 1867 rigidly. He changed 1000 generic names and 30 000 species names.

Kuntze's strict application of insufficient nomenclature laws and the nomenclatural mess he made triggered botanists to create a code of botanical nomenclature. In Europe this was decided on a botanical congress in Vienna in 1905. During this meeting the starting point for priority of botanical names was set to 1753, the year of Linnaeus' *Species Plantarum*. To stabilize nomenclature after Kuntze's rigid work, a list was made of well-established names, *nomina conservanda*, that should be conserved although they did not have priority, *i.e.* were not the first names published. In 1907 American botanists created a code of their own where they introduced type specimens and allowed tautonyms (identical names in a species name, now only allowed in zoology, *e.g.* *Grus grus*). Not until 1935 did the European and American codes merge into one international code of botanical nomenclature (ICBN).

The initiation of a zoological code started somewhat later. In 1842 a British ornithologist **Hugh Edwin Strickland** (1811–1853) elaborated the first nomenclatural laws for zoology, the "Strickland Code". He was assisted by a committee where Charles Darwin was a member, among others The Strickland Code was accepted among British and American zoologists within three years. However, in 1881 a geological international congress in Bologna modified the code to make it applicable also to fossils. During the next five years a number of different codes were suggested by French zoologists, American ornithologists, German zoologists and English entomologists, creating an impractical condition of taxonomic anarchy. The need of an international code of zoological nomenclature was obvious, and the first was accepted on an international congress in Moscow in 1892. In 1905, a further modified international code was published in French, English and German languages.

There are continuous modifications of the codes of botanical nomenclature and zoological nomenclature. Changes in the botanical nomenclature is decided by discussions and votes on open meetings at every International Botanical Congress, held every sixth year. The latest botanical code decided upon in Vienna 2005 opens up for extended possibilities to reject or conserve plant names to promote nomenclatural stability. Changes in the zoological code are decided upon by the International Commission on Zoological Nomenclature, elected by the international society of zoologists. The zoological code differs in many ways from the botanical. Among other things, species do not need to be described in Latin. Since 1953 there is also an international code of nomenclature for cultivated plants, and since 1980 there is a code for bacteria (prokaryotes), excluding the cyanobacteria, which are still included in the botanical code.

### 3.3 From phenetics to phylogenies

**Charles Darwin** (1809–1882) och **Alfred Russel Wallace** (1823–1913) launched the evolutionary theory in 1858. However, this did not affect systematics in the beginning. **Ernst Haeckel** (1834–1919) and **August Wilhelm Eichler** (1839–1887) were two German biologists who started the construction of evolutionary trees. Haeckel established the term "phylogeny". However, the main part of the 20th century was dominated by extended phenetics, *i.e.* looking for similarities and differences to create systematics. Not only gross morphology was used to find characters, but anatomy, chromosomes, pollen, biochemistry and eventually proteins. The systems of plants and animals were now huge, in flowering plants approaching a quarter of a million species. Masters in plant systematics were **Eugen Warming** (1841–1924), **John Hutchinson** (1884–1972), **Armen Leonovich Takhtajan** (1910–), **Arthur J. Cronquist** (1919–1992), **Robert F. Thorne** (1920–) and **Rolf Dahlgren** (1932–1987), each arguing for different systems built up on many characters, uncertain parts of the system relying on

personal, professional experience. It was difficult to test a systematist's theory of a suggested system.

The German biologist **Willi Hennig** (1913–1976) founded the cladistic era in 1966, by stating that only similarities grouping species (synapomorphies) should be used in classification, and that taxa should include all descendants from one single ancestor (the rule of monophyly). Hypothesis on systematics could now be tested through cladistic methods.

The new method, called cladistics, was controversial, and it took around 20 years before it started to become established. As earlier during the century, the reformation of systematics happened earlier among zoologists than botanists. The 1980's were a decade of great debates and discussions where scientists claimed themselves to be for or against cladistics. There was an urgent search for characters in the species analyzed in order to get phylogenies with high resolutions, a fact that limited the use of the method. With the invention of the polymerase chain reaction (PCR), which made it economically possible to amplify DNA-sequences for use in systematics, and the strong development of computer programs that could handle large data sets, cladistics became more or less the rule for systematic work.

### **3.4. PhyloCode**

With the breakthrough of cladistic analysis and constructions of phylogenetic hypotheses, the taxonomy built on the Linnaean hierarchic system became a matter of intense discussion and criticism. Two zoologists from USA, Kevin de Queiroz and Jacques Gauthier, started the discussions in the 1990's and laid the theoretical foundation to a new nomenclatural code for all organisms, the PhyloCode. A meeting in Harvard in 1998 drew out the lines for a PhyloCode, and a first draft was published on the web in 2000.

The PhyloCode reflects a philosophical shift from naming species and subsequently classifying them (i.e., into higher taxa) to naming both species and clades. The main idea with the PhyloCode is that only species and clades should have names, and that all ranks above species are excluded from nomenclature. The aim is to change current names as little as possible and to build the stability on clades rather than on ranks.

The PhyloCode is still only a draft, it is controversial, and has led to a worldwide and very interesting debate. Its success will depend on the number of taxonomists that will use it for their taxonomic work.

#### **Some websites associated with this lecture**

Emperors of China

<http://www.nlm.nih.gov/hmd/chinese/emperors.html>

Picture of Ebers papyrus

[http://www.ub.uni-leipzig.de/site.php?page=die\\_ubl/sosa/rundgang/ebers&lang=de&stil=fc](http://www.ub.uni-leipzig.de/site.php?page=die_ubl/sosa/rundgang/ebers&lang=de&stil=fc)

Materia Medica of Dioscorides at

<http://www.bnnonline.it/biblvir/dioscoride/dioscoride.htm>

Linné online

<http://www.linnaeus.uu.se/online/index-en.html>

International Code of Botanical Nomenclature

<http://ibot.sav.sk/icbn/main.htm>

International Code of Zoological Nomenclature

<http://www.iczn.org/>

PhyloCode

<http://www.ohiou.edu/phylocode/>

Figures



Fig. 1. Shen Nung, Emperor of China and Father of Chinese Medicine. (Portrait from Ch'en Hsueh-lou, *Chung-kuo li tai ming i t'u chua* (Biographies and Portraits of Chinese Famous Doctors in Past Dynasties), Nan-ching, 1987.)

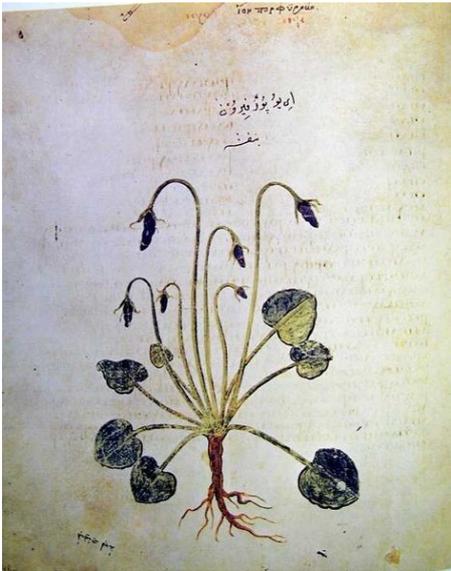


Fig.2. Picture of Violet in *De Materia Medica* by Dioscorides from a copy in Vienna. Source: <http://en.wikipedia.org/wiki/Image:ViennaDioscoridesFolio148vViolet.jpg>



Figure 3. Binomial nomenclature facilitated taxonomy greatly. The old phrase name of *Plantago media* was *Plantago foliis ovato-lanceolatis pubescentibus, spica cylindrica, scapo tereti*.  
Picture by C. A. M. Lindman. From Bilder ur Nordens Flora. <http://runeberg.org/nordflor/inneh.html>



Figure 4. The Swedish botanist Carl Linnaeus (1707–1778) founded modern taxonomy.  
Painting by Johan Henrik Sheffel in 1739. Uppsala University Art Collections.