# HISTORICAL REVIEW OF SYSTEMATIC BIOLOGY AND NOMENCLATURE

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## Contents



## Summary

The oldest roots of biological systematics are found in folk taxonomies, which are nearly universally developed by humankind to cope with the diversity of the living world. The logical background to the first modern attempts to rationalize the classifications was provided by Aristotle's logic, as embodied in Cesalpino's 16th century classification of plants. Major advances were provided in the following century by Ray, who paved the way for the work of Linnaeus, the author of standard treatises still regarded as the starting point of modern classification and nomenclature. Important conceptual progress was due to the French comparative anatomists of the early 19th century (Cuvier, Geoffroy Saint-Hilaire) and to the first work in comparative embryology of von Baer. Biological systematics, however, was still searching for a unifying principle that could provide the foundation for a natural, rather than conventional, classification. This principle was provided by evolutionary theory: its effects on classification are already present in Lamarck, but their full deployment only happened in the 20th century. The last few decades have witnessed a lively debate on the foundations and methods of biological systematics, with three main contenders, the phenetic, the cladistic and the evolutionary schools. In the meantime, evolutionary thinking and population genetics have shaken the traditional notions of biological species, with consequences on the species role as the basic units of classification. Progress in biological systematics has largely profited from the developments of natural history museums, as well as from the stabilization of nomenclature under international codes.

## 1. The origins

It has been said that taxonomy, the science of classifying animals and plants, is man's oldest profession. In some sense, it would be hard indeed to imagine a human being managing to survive without a working knowledge of many aspects of the surrounding living world. Such knowledge would include criteria for the identification of edible fruits and berries, of poisonous mushrooms and roots, of game birds and mammals, of poisonously biting snakes. Identification can be easily coupled to naming and, through this act, taxonomy smoothly entered the scene. Rather than inventing completely new names for every new kind of organism that was discovered and found worthy of naming, any new item to be added to the list of known species was more likely compared to those already known and named. Its name would often be quite similar to those already available in the growing thesaurus of animal or plant names, just modified through a suffix, or an adjective. The Europeans, indeed, manifested this attitude, when they first came in contact with the living world of other continents. Some large fruit-eating bats from the tropics, for instance, became known as flying foxes, while the Australian (Tasmanian) thylacine was dubbed the marsupial wolf, and the koala became the teddy bear. This way of naming presupposes a degree of kinship among all animals (or plants) sharing a part of the name and this is clearly a step towards a classification. Moreover, in addition to this widespread use of compound names, or names accompanied by adjectives, most languages developed some comprehensive, more inclusive terms, at one or two levels above the level of the basic kind, or 'genus'. We can expect to find, in very many languages, a few words corresponding to insect, bird, fish, or four-footed beast, as well as terms such as herb and tree, and animal and plant.

These are, in a sense, the pre-scientific roots of the modern biological systematics. During the last two or three centuries, the Western world has seen a widespread injection of technical concepts and terms, derived from the scientific classification, into the spoken languages. On the other hand, the average relationships of urbanized people with wildlife are increasingly different from those experienced by humans in ancient times, or by modern rural human populations. Accordingly, cultural anthropologists have recently turned their attention to the systems of classification and nomenclature developed by illiterate folks around the world. In some cases, their knowledge has turned out to be much more extensive than expected and, indeed, much larger than that of most literate people living in towns. For example, the Hanunoos of the Philippine Islands have one or more names for each of about 1 600 plant species. Still more astonishing are the taxonomic skills of some New Guinea tribesmen, who have 136 different names for the 137 species of birds identified by Western ornithologists in the forests in which they live: only in one case do they use the same name for two different bird species.

A practical (economical) basis is often apparent in folk taxonomies as well as in those of ancient writers who wrote about applied science, such as medicine or agriculture.

A strictly economical classification is found in the Persian *Avesta*, where animals are classified into domestic and useful, wild not amenable to domestication, and aquatic. Slightly more technical is the scheme adopted by the Chinese pharmacologist Li Che-Chen (1518-1593), who recognized the following five kinds of animals: insects, scaly animals, shelly animals, animals with feathers, and animals with fur.

## 2. From Classical Antiquity to the Renaissance Encyclopaedias

In classical antiquity, a precursor of modern systematics was, in some respect, Aristotle (384-322 BC.). His personal acquaintance with the animal world was very extensive and detailed. Some 500 species are mentioned in his writings. In particular, there is evidence for Aristotle having dissected no less than 12 different mammals, 9 birds, 4 reptiles, 2 amphibians, 10 fishes and a dozen invertebrates. His surviving books suggest that Aristotle developed something close to a formal classification but, if he indeed produced one, this has not been saved. At any rate, his seems to be the first distinction between vertebrate and invertebrate animals, two groups we find mentioned in his writings under the names of *Enema* (animals provided with blood) and *Anema* (bloodless animals) respectively. Impressive as his work as a naturalist may seem to be, however, Aristotle's contribution to the birth of modern systematics is mainly dependent on his work as philosopher.

Aristotle's binary logic was indeed followed by the Italian botanist Andrea Cesalpino (1519-1603) in his treatise *De Plantis* (On the plants), published in 1583. In this work, Cesalpino arranged the plant world according to a cascade of binary choices between opposing traits or sets of traits, beginning with a basic split between woody (i.e., trees and shrubs) and non-woody plants (i.e., herbs and grasses).

To a modern observer, the latter distinction seems to be a trifling one, as many natural groups of plants obviously include tall trees together with tiny herbaceous species: acacias and clovers, for example, are currently recognized as belonging to the same natural group, i.e., the legume family. A limited knowledge of the actual relationships between groups is also evident in the old zoological classifications. For example, browsing through the pages on the treatise *De animalibus* (On the animals) of the learned German bishop and scholar Albert the Great (1193-1280), we find the bats classified with birds, and the whales with fishes.

A scientific interest in the diversity of life on Earth was awakened in the Renaissance by the publication of encyclopedic works, such as those devoted to the animal world by the Swiss Konrad Gesner (1516-1565) and the Italian Ulisse Aldrovandi (1522-1605). Their bulky compilations (Aldrovandi's books sum up to some 7000 large-size pages), recorded everything that had been written on zoological matters up to that time. Their value, however, was severely limited by the authors' limited critical attitude, so that good behavioral or anatomical observations were presented on the same footing as folk legends or purely literary, fanciful accounts.

A classificatory effort is evident in Gesner's *Nomenclator aquatilium animantium*, where he distinguished 17 orders of aquatic animals. Eleven of these included different kinds of fishes, mostly distinguished on the basis of body shape, rather than their habitat (as was fashionable at the time) or skeletal peculiarities (as would become general practice a couple of centuries later). The other orders were those of cetaceans (including, however, seals and sea turtles), cephalopods, crustaceans, "testaceans" (molluscs with shell), "insects" (in fact, several kind of marine worms, plus isopod crustaceans and even the sea horse!) and zoophytes (corals and the like).

## 3. From the First Monographers to Linnaeus

Of more limited scope, but of much greater scientific value, were the monographs published by Pierre Belon (1517-1564) on the history of birds, and the books on fishes and other aquatic animals written by the French Guillaume Rondelet (1507-1556) and the Italian Ippolito Salviani (1514-1572).

The value of Belon's book on birds goes far beyond the purely descriptive level. A couple of drawings in this work - a human and a bird skeleton, printed on two facing pages, where the individual bones are labeled with the same letters in both figures - mark the origin of comparative anatomy, more than two centuries before the conventional beginning of this science.

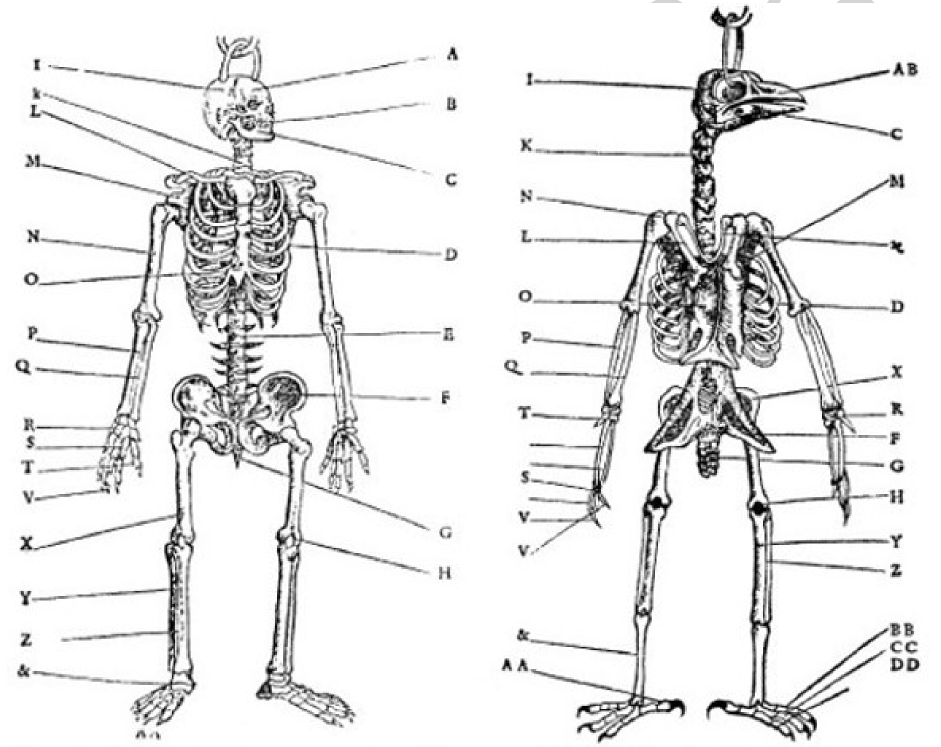

Figure 1. This bone-by-bone comparison of human and bird skeleton heralds the appearance of the comparative method in biology (from Pierre Belon's *Histoire de la Nature des Oyseaux*, 1555).

Progress in botany during the Renaissance was mainly at the descriptive level. The very speedy pace at which knowledge increased is marked by the rapid growth in the number of species filling the pages of the major monographs of the time, starting with the 500 species illustrated in his *De historia stirpium* (On the history of plants, 1542) by the German herbalist Leonhart Fuchs (1501-1556). The number had already grown to more than 6 000 in 1623, the year of publication of the *Pinax theatri botanici* (A picture of the botanical theatre) by the Swiss botanist Gaspard Bauhin (1560-1624). Sixty years later, the number had grown again to the remarkable figure of 18 655 species, those listed by the English naturalist and clergyman John Ray (1627-1705) in *Methodus plantarum nova* (A new method of botany, 1682).

Ray also had an exceptionally broad knowledge of plants and animals. Besides his thousands of accurate descriptions, however, Ray's contribution to the development of biological systematics includes several methodological advances. He remarked, in particular, that classification must proceed upwards, beginning with the description of species, to proceed then with the comparisons upon which the species may be grouped into genera, the genera into families, and so on. This was a basic, upside down revolution in respect to Cesalpino's method, in which Aristotle's logic was applied by dividing the whole of the plant kingdom into progressively smaller subgroups, down to the individual species.

Ray was also the first modern naturalist to address the question of the nature of the species. He observed that species breed indefinitely true, that is, the characters by which a species can be distinguished from all other species do not change from generation to generation. Simple varieties, to the contrary, are less stable, in that their distinguishing traits may progressively or even suddenly disappear in the course of generations.

While little serious efforts at classifying animal species can be found before the mid-eighteenth century, Ray's botanical works were soon superseded by the *Institutiones rei herbariae* (Institutions of botany, 1700), written by Joseph Pitton de Tournefort (1656-1708). This French botanist grouped the thousands of plant species already known in his days into 698 genera and arranged the latter in to the 122 sections of the 22 classes he recognized in the plant kingdom. His classification represented a remarkable progress over all previous schemes, but it was soon obscured by the works of the Swedish physician and naturalist, Carolus Linnaeus (1707-1778).

Linnaeus is universally known for his *Systema naturae* (The system of nature), a work that went through twelve editions during Linnaeus' lifetime, and was updated with a thirteenth much-enlarged edition in the years of the French revolution. The tenth edition, published in 1758, was eventually adopted by zoologists as the starting point of the scientific nomenclature of animals, much as another of Linnaeus's works - *Species plantarum* (Plant species, first edition, 1753) - got the same status in botanical nomenclature. Linnaeus was the last naturalist who managed to offer, as a single author, a comprehensive but also detailed survey of all plant and animal species described in his days. Within a clearly detailed and all-embracing hierarchical system, Linnaeus enumerated these species, accompanying each name with a short but pithy descriptive sentence, a comprehensive list of references and information about the species' homeland and, whenever possible, some remarks about its favorite habitat. The main reason for the lasting success of Linnaeus, however, was another. Starting with the works we have cited here, Linnaeus adopted a very simple, straightforward nomenclature. Each species became unequivocally identified by a pair of terms (the linnaean binomen: generic name and specific epithet) together forming the scientific species name. Examples of binomial nomenclature are found in some pre-Linnean works, but it was Linnaeus who first used this kind of name systematically, especially for animals.

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**Biographical Sketch**

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