Carolus Linnaeus (1707–1778): an overview of his life, science and legacy

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INTRODUCTION

The renowned Swedish naturalist Carl (Carolus) Linnaeus was awarded many honours during his lifetime and many tributes during the 300 years since his birth. Without doubt he was one of the most influential scientists in history, crucial to present day understanding of how all living species on this planet relate to one another. As a genius ahead of his times, Carl Linnaeus was unusual in that he achieved worldwide recognition during his lifetime for his application of *scientific method* to his work. It is remarkable that the essence of his contributions to natural history were completed while he was virtually still a student, and published in *Systema Naturae* in 1735. There were many revised editions of his works published throughout his lifetime.

Linnaeus had many thousands of specimens in his collections of living species, fossils and minerals. In order for each specimen to have an adequate distinction, it was necessary for him to reform the classification and nomenclature used by both early and contemporary natural historians. He drew up new rules, to apply in bringing order and consistency to his own collections, and to support his reforms. He was a born cataloguer. His many publications illustrated these reforms and because of their consistency, many natural scientists applied his scientific method. During his lifetime, with the adoption and application of Linnaean conventions, natural history took its place alongside other sciences, such as physics, which had dominated during the previous century. Shortly after his death in 1778, International Conventions formally accepted the Linnaean biodiversity classifications and the binomial nomenclature. This was a personal triumph and recognition of his extraordinary natural abilities.

Isaac Newton's publication of *Principia* in 1687 marked the moment that science came of age. This reflects just how far behind the biological sciences were in their development, and what a giant leap Linnaeus had made, to have the biological sciences accepted as an equal, mature and intellectual discipline. Over time there seems to have been some overlap in the terms natural history, naturalist etc. Perhaps Linnaeus in this century should be referred to as a systematic biologist and taxonomist but he was also an author of travel books, a physician and a noted explorer.

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Throughout history natural scientists have classified and named living species and minerals to distinguish those that would be useful as food, medicine, recreation, ceremony and for industry. These efforts were often inconsistent, inadequate, and could not be shared among natural historians internationally. One of the great achievements of science in the 18th Century was the development by Carl Linnaeus of a reliable and coherent system for distinguishing, and classifying living species, fossils and minerals. Linnaeus then applied a binomial specific nomenclature to living species, using Latin so that the names of species could have international acceptance and application.

After his publications of *Species Plantarum* (1753) together with *Genera Plantarum* (5th ed., 1754) there was international agreement among botanists that the Linnaean binomial nomenclature was the accepted method for botanic nomenclature. The awkward and wordy names given to plants prior to 1753 were no longer applicable. This even included some allocated by Linnaeus to species, before 1753. Similarly, on publication of Linnaeus's *Systema Naturae* Vol. I (10th ed., 1758), zoologists worldwide accepted his method of scientifically naming animals. The acceptance of Linnaean classification together with his consistent adoption of binomial nomenclature and the tremendous contribution he personally made to natural history have been the main focus of the recent international celebration of the tercentenary of his birth.

Linnaeus's religious devotion from childhood led him to the belief in the constancy of each living species and that the study of nature could enable scientists to construct a natural classification. Many of his contemporaries and earlier natural historians shared this view and strove to reflect in their classifications, the divine constancy of nature. During his lifetime his central scientific purpose was an attempt to list, name and order all living species and minerals, as well as study their relationship and comparison with each other.

A SHORT BIOGRAPHY

There is a lot to be said about the life and career of Linnaeus, who wrote four autobiographies detailing his own work and experiences. In those days this was quite accepted. It was rather like writing up your own curriculum vitae. Linnaeus was the son of a clergyman who was also an amateur botanist and a keen gardener. Carl spent his childhood in the south east of Sweden where seasonal changes could be observed in the plants he nurtured in his own gardens from the age of five years. The Great Northern War (1708–1721) resulted in a resounding defeat for Sweden, which lost its supremacy over neighbouring Baltic States. Poland, Denmark, and Russia were united against Sweden. The population of Sweden was reduced to about 1,250,000.

There was little or no family money to support Carl's education. At school he had an obsessive interest in natural science and was recommended by his

teacher to study medicine rather than follow his father, as expected of the eldest son. Permission to study medicine and not ecclesiastics came reluctantly. With little financial help from his family, throughout his university studies he was mainly dependent upon influential friends for accommodation and support. As time moved on, he was able to do some tutorial work and teaching.

He started medical studies at a new redbrick university in Lund, in 1727, but was recommended by a teacher to move to the university in Uppsala the next year. The University of Uppsala, founded in 1477, about 60 km north of Stockholm, was prestigious in Scandinavia and well respected throughout Europe. He was able to continue his medical studies, remaining at Uppsala University during the period 1728–1733. Linnaeus was particularly interested in botany and went far beyond the curriculum requirement for medical students. It was during this period, while studying Sebastian Valliant (1669–1722), that he developed the idea that plants could be classified simply.

His talents were soon recognised at Uppsala University by Olaf Celsius and he was appointed lecturer in botany in 1730. He was an extremely popular tutor with students flocking to his demonstrations at the University Botanical Gardens, and field trips to the surrounds of Uppsala. Always noting, describing and cataloguing the holdings, which later he put in manuscript form. These he added to his collection in his student's den of natural exhibits, books, and manuscripts that he had written himself. Linnaeus thought of himself as a second Adam and liked to say *Deus creavit, Linnaeus disposuit* which is Latin for *God created, Linnaeus organized*. This self-perception was illustrated on the cover of his *Systema Naturae*, which depicts a man giving Linnaean names to new creatures as they are created in the Garden of Eden.

His studies at Uppsala University were interrupted in 1732 when the Uppsala Society of Science supported him on a major expedition to Lapland. Its purpose was to replenish the collections lost in a fire. Linnaeus travelled alone covering thousands of kilometres, which took him well into the Artic Circle. His bounty of plants and minerals and also his perilous excursions were well documented. He gained great personal recognition because of his description of his extensive collection, previously unknown to naturalists in Europe.

At Christmas 1733 during a private visit to the copper/silver mining town of Falun, Linnaeus was invited to organise an expedition to the northern district of Darlana to look for mineral deposits—all expenses paid. During the summer recess in 1734 he took seven students with him on an 830 km disappointing excursion. Back in Falun his reward was to meet Sara Elizabeth Moraea, who some years later he married. Having qualified in medicine in Sweden he had to travel abroad to obtain a doctorate. In the 18th Century it was customary for Swedish medical students to take their doctorate in Holland. In 1735 Linnaeus travelled via Germany to the medical school in Harderwijk, where he quickly obtained his doctorate with a thesis focussed on malaria. But there

were other good reasons for Linnaeus to spend time in this wealthy trading nation. In Leiden he had the opportunity to meet the prominent medical scientist Professor Herman Boerhaave.

The senator of Leiden—Johan Frederick Gronovius—who was a botanist, provided Linnaeus with the financial support to publish six of the manuscripts he had brought with him from Sweden. Leiden being a European centre for book trading and publishing these treatises were widely distributed and brought Linnaeus immediate recognition outside his own country, exceeding his highest expectations.

Now well known in Holland he moved to Amsterdam, and was employed by a prominent shareholder of the Dutch East India Trading Company—George Clifford—an Englishman who had developed his own private and extensive botanical gardens. Working in Clifford's botanical garden in Amsterdam, travelling throughout Holland to add to the collections, culminated finally in the publication of *Hortus Cliffortianus,* illustrated by George D. Ehret, one of the foremost botanical illustrators of that century. This renowned publication set a new standard for communicating botanical theory and facts. At Clifford's expense he travelled to England, meeting Professor Dillenius in Oxford and Sir Hans Sloane in London, collecting and cataloguing more specimens for himself and the Clifford garden. Back in Holland he continued his research work in private libraries, herbaria and gardens, publishing a number of these studies. Leaving Clifford he travelled to Paris to meet Professor Anton de Jussieu and his two brothers who showed him the rich botanical gardens and herbaria in Paris during his month-long stay. In June 1738 Linnaeus returned to Sweden, never to leave again.

He settled in Stockholm establishing a successful practice as a physician—attending the Royal family on occasion. In 1739 he married Sara Moraea and two years later Linnaeus was appointed by the King of Sweden to a chair in practical medicine at the University of Uppsala. There was a second chair of medicine and by arrangement in 1742, he exchanged his original appointment and now would teach general medicine, materia medica, botany and other subjects, and also became the Director of the University Botanical Garden. This exchange delighted Linnaeus, who held this academic appointment until his death in 1778. In 1761 he was granted a patent of nobility (backdated to 1757) and became Carl von Linne. He used his titled name in many later publications, but it is the name Linnaeus that he gave to posterity.

Linnaeus remained a popular teacher. He encouraged and selected many of his graduate students (his *apostles* as they were called) to join worldwide expeditions and voyages of discovery that were taking place in that century. Daniel Solander was employed by Joseph Banks and joined James Cook's first voyage to the Pacific on board the *Endeavour*. Solander Island, off the South Island of New Zealand was named after him. Anders Sparrman (of the famed

Cook's scurvy grass—*Lepidium oleraceum* Sparrm. ex G.Forst.) was recruited by the naturalists Johann and Georg Forster to assist with research (Dawson 1998) and joined James Cook's second circumnavigation (1772–1775). Others ventured to China, Japan, Asia, the Middle East and the American and African continents. Some died tragically during their expeditions but many sent back to Linnaeus samples and descriptions.

Because of illness, in August 1775 the young King came to pay his respects in person to Linnaeus in Uppsala. In his final three years his cardio-vascular condition deteriorated, so he retired to his beloved countryside house some miles from Uppsala where he had a small detached work area, museum and herbarium. He died in January 1778 and his funeral was held in Uppsala Cathedral, where he is now buried.

THE LINNAEAN CLASSIFICATION

Linnaeus's essential contribution to natural history was the development and application of a system, which enabled scientists internationally, whether professional or amateur, to distinguish living species and minerals. His principles of distinction could be readily understood and permitted information storage, sharing and retrieval. Linnaeus began by dividing each natural kingdom (flora, fauna and mineral) into classes, and then divided classes into orders, then orders into genera and genera into species. This hierarchical system is still followed today with modification and additions.

The classification of the kingdom of animals

Linnaeus's first publication of *Systema Naturae* was a fourteen-page booklet, published while in Amsterdam in 1735. In this he demonstrated his classification principle—*divisio et denominatio* which was his method of simply naming each item and then progressively ranking them from the larger to smaller units. In this publication in 1735 individual species were often given long names but in his tenth edition of *Systema Naturae* published in 1758, these were refined and provided with binomial names.

He began by dividing animals into six classes—mammals, birds, amphibia, fish, insects and worms. His grouping of mammals was defined according to their teeth and teats, and included whales—no longer classed as fish. Worms were a variety of invertebrates, which were completely re-organised by others in later years. His most controversial hierarchical grouping was to place man (*Homo sapiens*) in the same genus as orangutan (*Homo troglodytes*). This caused uproar among his colleagues and within the community. Subsequently science, evolutionary theory and DNA analysis has proved the great Linnaeus to have been right all along.

The classification of the kingdom of plants

As a physician the importance of medicinal plants was an impetus to Linnaeus to develop a simple system that students, and those with a little knowledge of plants, could easily learn and apply. Botany was a part of every medical student's preparation, since most medicaments were derived from plants.

Well before Linnaeus, natural historians had been trying to systematically classify plants by recognising characters of plants that would enable association with some and comparison with others. The famous English naturalist, John Ray (1627–1705) was of the opinion that all characters of a plant should be considered in determining its structural similarity with others, rather than one or a few characters. In 1724, while at school, Linneaus's senior master had taught him the system developed by the French scientist Joseph Pitton de Tournefort (1656–1708) that focussed on petals and flowers. Linnaeus was dissatisfied with Tournefort's method and devised his own plan for classification, developing it from this method, and what he had been taught at school about the functions of stamen and pistils (Sebastian Valliant's essay). In 1753, Linnaeus published *Species Plantarum w*hich described the basic arrangement that he had adopted for all his botanical classifications.

He divided all his collections of plants into 24 classes dependent upon the number of stamens. Those with one stamen he named Monandria, those with two stamens Diandria, and so on. These classes were then divided into orders based on the number of pistils (Monogynia, Digynia). The system was simply arithmetical. To place a plant into its class and order all that was needed was to count stamens and pistils. By studying the characters of the genera within the group it could then be slotted into its genus. This practical system had far reaching applications. Students, naturalists, botanists amateur and professional who were travelling to the great continents beyond Europe, could now collect, preserve and return with an increasing variety of classified plants. Furthermore, these travellers could teach the Linnaean system to colonists worldwide. Linnaeus admitted that later workers would improve his botanical system, and this was so. But it was so successful its facile application was difficult to replace with a natural system. His practical classification system was widely applied until about 1810 and modified, referring back to the earlier works of the French botanist Antoine de Jussieu, and the English naturalist John Ray. Then the system of classification focussed on the morphological evidence from all parts of the organism in different stages of development. Linnaeus's most valuable and lasting contribution to botanical classification was his careful descriptions and publication of approximately 7,700 plant species arranged in genera, and his rules for the nomenclature of plants.

Linnaeus's method of classification

Since Aristotle, natural historians had applied the word genus to describe a group of organisms possessing similarly developed and observable characters. But opinion varied as to how genera should be grouped. Linnaeus's innovation was to group genera with higher taxa, which were also based on shared physical similarities. A genus was a rank below classes, classes below orders and orders below kingdoms. His objective was to classify as many living species, fossils and minerals as it was possible for him to collect. It is estimated that he distinguished 7,700 plants and over 4,000 animals. There is uncertainty about the quantity and quality of his mineral collection as this was not as well documented as others.

Linnaeus believed that both genus and species were formed by nature and were units formed by natural characters that could be identified. On the other hand higher taxa—classes and orders—were categorised by recognising selected features, which could include both natural and key artificial attributes (such as colour). The possession of natural characters was important to Linnaeus, because they were considered to be stable. His distinction of genus was based on the sum of their shared natural characters, and had features that could be compared with others.

Having allocated the genus of a plant or animal, his next task was to allocate it as a species. Species had one definable unique character possessed by no other organism. Species were natural and unchangeable, permitting inclusion into the higher category—genus. In his later years he noticed how some species might create a form, which had the appearance of new species, but tended to think that this was deterioration rather than a new species. Below the rank of species he sometimes recognised taxa of a lower (un-named) rank now referred to as sub-species or variety.

The giving of names

For naturalists, it is always crucial for every species to have a name which is the same in all languages and which designates that species and no other. It has been said, time and time again, that one of the enduring contributions to the study of biodiversity that can be attributed to Linnaeus was the clarity and consistency of his binomial nomenclature that became universally accepted. Linnaeus's success with the binomial system stems from his clear understanding of species and genera, which allowed him to apply names. The binary system of applying the first name to a group and the second to a single member, using many words for each, had its origin almost 200 years earlier—the work of Gaspard and Johann Bauhin. But it was Linnaeus who intentionally and constantly applied binomial nomenclature, applying two words. With the large number of plants and animals being brought back from Europe, Asia, Africa, and America there was some urgency to have a workable naming system.

In 1737 Linnaeus published in Leiden *Critica botanica*, reforming the binary

expressions and describing the fundamental rules he applied, naming species using two parts to the name (still applying the binary system). Previously, many words in each of the two expressions led to confusion, particularly when they were altered at will. His rules naming each species stated that the name of living species should consist of two expressions, the genus and a description of the species, which included its specific entity (*differentia specifica)* which should be as brief and concise as possible. His other rules were simple and self evident to us today.

Whenever possible he preserved names given by earlier workers—so when he placed the lion, tiger, leopard, cat in the same genus *Felis,* the epithets given were*: leo*, *tigris*, *leopardus* and *catus*. Linnaeus was the first to consistently write nomenclature expressions in Latin using two sets of names concurrently.

With his reforms published in 1753 and in subsequent publications, he consolidated his use of the binomial nomenclature for species. Some years later he added an abbreviated designation alongside the proper specific name. This label or designation, was referred to as the *nomen triviale* or the specific epithet of the binomial nomenclature, and could be attached to an individual species but never to a new species later discovered. He recognised the true significance of the *nomen triviale*, and warned against its alteration.

He was so busy that he often provided specific epithets with whatever came into his mind. They might be a geographic epithet such as *lapponica.* His epithets for mammals and insects often referred to their host plants. Sometimes the epithet commemorated a student such as *solandri.* Sometimes they were descriptive, e.g., *bicolor*, *caeruleus* (blue), *melanocephalus* (black head). Finally, he used ecological terms, e.g., *littoralis* (shore-line), *fluvius* (river), and *mons* (mountain).

THE LEGACY OF LINNAEUS

Some years after his death, Linnaeus's widow sold most of his collections, manuscripts, and some of his 180 publications to a wealthy botanist in London, James Edward Smith. When he opened the boxes that had arrived from Sweden, he found he had acquired a parcel more valuable than the Elgin Marbles. The bounty list was incredible. They included:

- 1,900 pressed sheets of plants
- 180 manuscripts (mostly his own writing but some from worldwide scientists)
- 300 books
- All of Linnaeus's correspondence to and from, local and worldwide scientists
- 3,200 insects, 1,500 shells, about 750 pieces of coral and 2,500 mineral specimens (which have since disappeared from the collection).

James Edward Smith later became knighted. He also became president of

EXAMPLES OF ANIMAL AND PLANT CLASSIFICATION

Linnaeus placed animals into six classes—mammals, birds, amphibia, fish, insects and worms. Plants were placed into 24 classes. When he finally ranked these into a hierarchical system they were given only five ranks: kingdom*, class*, order*, genus* and species*. The examples below give an idea of the present ranks, which are still being added to.

Classification of 'man'		**Classification of cultivated lettuce**	
KINGDOM*	Animalia	**KINGDOM***	Plantae
PHYLUM	Chordata	**DIVISION**	Tracheophyta
SUBPHYLUM	Vertebrata		
CLASS*	Mammalia	**CLASS***	Angiosperm
		SUBCLASS	Dicotyledonae
ORDER*	Primates	**ORDER***	Asteridae
SUBORDER	Anthropoidea		
FAMILY	Hominidae	**FAMILY**	Asteraceae
		SUBFAMILY	Lactuceae
GENUS*	Homo	**GENUS***	*Lactuca*
SPECIES*	sapiens	**SPECIES***	*sativa*
		VARIETY:	*Lactuca sativa* var. *longifolium*
		This is cultivated lettuce with long leaves	

NOTES ON ABOVE

Linnaeus applied Phylum to animals; Division was traditionally used for plants. Since Linnaeus, additional ranks have been included above and below his original five.

Two amusing and simple mnemonics to remember the taxonomic levels are:

Kay **P**uts **C**andy **O**ut **F**or **G**ood **S**tudents.

King **P**hillip's **C**lass **O**rders the **F**amily **G**enius to **S**peak

the Linnean Society of London. When he died the Society purchased the Linnaean collection and it still remains their property. Today this Society is widely acknowledged as an international centre for the study of natural history in all its branches. The Linnaean collection can be viewed in the Society's rooms, in Burlington House, London, where it is kept in a designed, climate controlled strongroom.

The work of Linnaeus provokes greater concerns for the preservation of our biodiversity and the need to mount greater support for the work of our systematic biologists, taxonomists, and conservationists, as is being done overseas.

WHAT OF THE FUTURE?

General consesus seems to be that DNA bar coding can supplement but not replace the science of classification based on observed characters promoted by Linneaus during the 18th century. Should the Linnean system be overthrown it will be by the scientific community through their international conventions which they have held over 300 years.

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