

The Rise of Systematic Biology

An International Initiative in the Time of Linnaeus



A suggested serial cultural landscape nomination tentatively including sites in Sweden, Australia, France, Japan, The Netherlands, South Africa, United Kingdom and United States of America, proposed by Sweden.

Front illustration by Jonas Lundin.

The symbol for “The Rise of Systematic Biology” shows extant species once described and studied by Linnaeus and his students on five continents: Central on top Linnaeus’ natural cabinet in Hammarby, Uppsala, Sweden, with the extant species Hammarby houseleek *Jovibarba globifera* described by Linnaeus. Other species in clockwise direction are: Sazanka *Camellia sasanqua* in Japan described by Thunberg, Old Man Banksia *Banksia serrata* in Australia collected by Solander and Banks and described by Linnaeus the younger, African buffalo *Syncerus caffer* in South Africa described by Sparrman, Coco de mono *Lecythis ollaria* in Venezuela described by Loeffling, Raccoon *Procyon lotor* in Delaware, USA described by Linnaeus and further observed by Kalm.

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State, Province or Region:

See Table 1 below.

Latitude and Longitude, or UTM coordinates:

See Table 1 below.

Name of property

The Rise of Systematic Biology

An International Initiative in the Time of Linnaeus

Thirteen sites in eight countries (see Table 1) with historic traces of the foundation of systematic biology as laid out by Carl Linnaeus and scientists in his network.

Summary of description below

”The Rise of Systematic Biology” is a tentative serial nomination of thirteen sites in eight countries (see Table 1), suggested by Sweden, representing the foundation of the science of systematic biology. The sites together form the arena where the science developed strongly due to the Swedish scientist Carl Linnaeus (1707–1778) and his international scientific network. The Swedish sites are described in short, and an overview is given for each of the other sites. The authenticity in the sites is to a large extent present in remnant organism populations once used to develop the science.

Table 1. Sites tentatively included in the serial nomination “The Rise of Systematic Biology”.

| Site number | Site Name | State Party | Province or Region, Municipality | Coordinates of Centre Point | Area (km²) |
|--------------------|--|--------------------------|---|------------------------------------|------------------------------|
| I | Linnés Råshult | Sweden | County of Kronoberg, Älmhult | 56° 36' 57" N 14° 12' 00" E | 0.464 |
| II | Linnéträdgården and Linnémuseet | Sweden | County of Uppsala, Uppsala | 59° 51' 44" N 17° 38' 02" E | 0.012 |
| IIIA | Herbationes Upsalienses, Hågadalen–Nåsten Nature Reserve | Sweden | County of Uppsala, Uppsala | 59° 49' 7" N 17° 34' 25" E | 17 |
| IIIB | Herbationes Upsalienses, Fäbodmossen Nature Reserve | Sweden | County of Uppsala, Uppsala | 59° 56' 35" N 17° 19' 18" E | 1.525 |
| IV | Linnés Hammarby | Sweden | County of Uppsala, Uppsala | 59° 49' 02" N 17° 46' 36" E | 2.70 |
| V | Chelsea Physic Garden | United Kingdom | London, Kensington and Chelsea | 51° 29' 6" N 0° 9' 46" W | 0.014 |
| VI | Hortus botanicus Leiden | The Netherlands | Zuid-Holland, Leiden | 52° 9' 22" N 4° 29' 3" E | 2.5 |
| VII | Jardin des Plantes | France | Île-de-France, Paris | 48° 50' 38" N 2° 21' 35" E | 0.28 |
| VIII | Bartram's Garden | United States of America | Pennsylvania, Philadelphia | 39° 55' 50" N 75° 12' 45" W | 1.84 |
| IX | Table Mountain National Park, part of World Heritage Site Cape Floral Region | South Africa | Western Cape Province, Cape Town | 33° 57' 26" S 18° 24' 11" E | 221 |
| X | Dejima | Japan | Nagasaki prefecture, Nagasaki | 32° 44' 37" N 129° 52' 22" E | 0.013 |
| XI | Hakone National Park | Japan | Kanto Region, Kanagawa, Hakone | 35° 11' 33" N 139° 1' 34" E | 103.56 |
| XII | Botany Bay National Park | Australia | New South Wales, Sydney | 34° 01' 14" S 151° 13' 29" E | 4.90 |

Description - introduction and background

The science of systematic biology

Systematic biology is the study of biological diversity and its origin. The discipline includes collection, naming, classification and describing of organisms as well as a reconstruction of their evolutionary history. Systematic biology has developed strongly during the last decades, partly due to improved molecular techniques and more powerful computers. This has increased our knowledge of how life on earth has developed and how organisms are related to one another. The tree of life¹ is continuously updated by systematic biologists all over the world.

Many scientific disciplines depend on the results from systematic biology. Analyses of evolutionary processes rely on well-founded hypotheses of evolutionary relationships. A reliable identification of species is a prerequisite for scientific work involving organisms of any kind, especially in applied science, for example agriculture, horticulture and pharmacognosy.

Species are currently going extinct all over the world at an accelerating rate. Many of these species are yet unknown to us. Although hitherto more than 1.8 million species have been described, estimates of the number of undescribed species range from 5 million to over 50 million.² Systematic biology is more needed than ever before. This has been recognised by the international community, which has recently led to global initiatives to facilitate systematic research³.

The rise of systematic biology

Systematic biology stands out among biological sciences in being dependent on research on historical collections and publications. The starting points in this research are two works by Linnaeus, *Species plantarum* published in 1753 for systematic botany⁴ and *Systema naturae* 10th ed. published in 1758 for systematic zoology⁵. Names and descriptions of species before these publications are not considered by contemporary scientists. The reason for this is Linnaeus' consistent use in these publications of short names for species, names that later developed into the currently used binary or binomial nomenclature.

Scientists and historians generally consider the works of Carl Linnaeus as cornerstones in the main foundation of systematic biology. The reasons for this are manifold, not only those governed by nomenclature as mentioned above. Although Linnaeus' scientific deeds (which are described more in detail in next chapter) were based on works by earlier scientists - that he greatly acknowledged - he managed to create a development of the science strong enough to transform systematic biology from a marginal part of medicine into a discipline of its own, a

¹ See for example www.tolweb.org.

² Chapman, A. D. 2005. Numbers of living species in Australia and the world. Report for the Department of the Environment and Heritage, Canberra, Australia.

³ www.cbd.int/gti/ (Global Taxonomy Initiative).

⁴ Linnaeus, C. 1753. *Caroli Linnæi Species plantarum : exhibentes plantas rite cognitatas ... secundum systema sexuale digestas*. Holmiæ. Vol I and II.

⁵ Linnaeus, C. 1758. *Caroli Linnæi ... Systema naturæ per regna tria naturæ, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*. Editio decima, reformata. Holmiæ. Vol. I. Animalia. Holmiæ.

discipline that later developed into the several branches of biological sciences that we see today.

Before Linnaeus, systematic biology was a *historia naturalis* that dealt mainly with observations of different objects in nature to help classify and identify important species used for medicinal purposes. Linnaeus transformed systematic biology into a state of *scientia*, a science with a philosophy, system and book of rules, equivalent to disciplines like law, theology and philosophy⁶.

This transformation created by Linnaeus could only be carried out through observations of a large number of organisms from different regions of the world. The observed organisms were gathered by Linnaeus himself, by scientists in his large network, and by his students during expeditions to different parts of the world. Although the driving force in this development was Linnaeus himself, it resulted in a collaborative work involving himself, his students, and his fellow scientists.

The metaphoric name “The Rise of Systematic Biology” has been chosen for the series of sites in this tentative serial cultural landscape nomination to reflect the strong development of the science during the time of Carl Linnaeus.

How Linnaeus developed systematic biology

Linnaeus’ development of systematic biology started with pre-academic observations in the fields of southern Sweden during the 1710’s and 1720’s, where he made his first studies that eventually led to a classification of plants by the number of stamens and pistils. He began academic studies, initially at Lund University and then at Uppsala University, both in Sweden. A lack of lecturers at the universities made him at this stage in many ways an autodidactic scholar, although he studied and greatly acknowledged former scientists like Caspar Bauhin (1560–1624), John Ray (1627–1705) and Joseph Pitton de Tournefort (1656–1708).

In Uppsala he developed his classification scheme further together with his fellow student Peter Artedi. Together they divided the organisms between them. Linnaeus was in charge of plant classification and Artedi of fish classification, and they entered into a pact to publish each other’s works if one of them should die. During this time Linnaeus developed the classification of plants based on numbers of stamens and pistils. He also argued strongly that these were the sexual organs of plants.

During an academic journey to Holland 1735-1738 Linnaeus defended a doctoral thesis in Medicine on malaria. He also managed to get funding for publication of one of the manuscripts that he had brought from Sweden, *Systema naturae*⁷, a classification of the three kingdoms of plants, animals and minerals. The classifications were partly completely new to science, especially the plant classification. The publication caused great protests within the academic society, since the plant classification - later referred to as the sexual system of

⁶ Ekedahl N. 2005. Collecting Flowers. Linnaean Method and the Humanist Art of Reading, in Hedberg, I. (ed.), *Species Plantarum 250 ys*, proceeding of the *Species Plantarum Symposium* held in Uppsala August 22-24 2003. *Acta Universitatis Upsaliensis, Symbolae Botanicae Upsalienses* 33:3, pp. 47-59.

⁷ Linnaeus, C. 1735. *Systema naturae, sive regna tria naturæ systematice proposita per classes, ordines, genera & species*. Lugduni Batavorum.

plants - did not only differ from all known plant classifications, but emphasized a theory of plant sexuality originally suggested by Sébastien Vaillant (1699–1722) and not accepted by many. However, as the sexual system was an artificial system very handy to use, it became more or less a success with time.



Figure 1. The sexual system of plants based on stamens and pistils. Drawing from 1736 by Georg Dionysos Ehret. Copyright Uppsala University.

During his stay in Holland, Linnaeus published a number of fundamentally important books, such as *Bibliotheca botanica*⁸ in 1736 listing all literature in botany, *Fundamenta botanica*⁹ in 1736 with principles and rules to be followed in the classification and naming of plants,

⁸ Linnaeus, C. 1736. Caroli Linnæi Bibliotheca botanica recensens libros plus mille de plantis huc usque editos, secundum systema auctorum naturale in classes, ordines, genera & species dispositos, additis editiones loco, tempore, forma, lingua & c. cum explicatione Fundamentorum botanicorum pars 1:ma. Amstelodami.

⁹ Linnaeus, C. 1737. Caroli Linnæi ... Critica botanica in qua nomina plantarum generica, specifica, & variantia examini subjiciuntur, selectiora confirmantur, indigna rejiciuntur; simulque doctrina circa denominationem plantarum traditur seu Fundamentorum botanicorum pars IV. Accedit Johannis Browallii de necessitate historiæ naturalis discursus. Lugduni Batavorum.

*Genera plantarum*¹⁰ in 1737 with all plant genera and rules for delimiting them, and *Critica botanica*¹¹ in 1737 with nomenclatural rules for plants. His friend and scientific colleague Peter Artedi died in Amsterdam 1735, and Linnaeus was left to publish Artedi's grand work on fish systematics.

During his three years abroad, Linnaeus interacted with some of the most important botanists and zoologists at the time, such as Herman Boerhaave, Gronovius (1668-1738), Hans Sloane (1660-1753), Johann Jakob Dillenius (1687-1747) and Bernhard de Jussieu (1699-1777). This network of scientists became important to Linnaeus' own development and to his impact on the European scientific community, something that has become reflected in his great, international correspondence¹². The scientific network was as important in the 18th century as it is today for the development of science.

In 1741 Linnaeus became professor of medicine at Uppsala University in Sweden. This platform made it possible for him to further develop his scientific methods and try out different ideas. He extended the botanical garden *Hortus Upsaliensis* and filled it with plant species that he received as gifts from scientists in his network and also with different animal species. The garden was constructed as to facilitate the teaching and understanding of his sexual classification system. As he was a charismatic and skilled teacher with splendid rhetoric and great enthusiasm, he managed to create a network of talented students who could test his hypotheses and extend his collections. No less than 186 doctoral theses were written and defended under his presidium. He developed an excursion system around Uppsala, *Herbationes Upsalienses*, influenced by *i.a.* Bernhard de Jussieu's excursions around Paris. During the excursions he used teaching methods that were to inspire his students to explore the unknown flora and fauna within Sweden and abroad. His scientific network expanded internationally in the same rate that his name became known all over the western world.

Linnaeus was one of the persons who founded the Royal Swedish Academy of Sciences in 1739, and through his contacts there he managed to help funding the expeditions that his students made to remote areas. The students were well trained in methods for collecting, observing and describing. To collect, name and classify species was not only of importance to scientists, but was a part of a global economy developing in the 18th century focusing on investigating the utility of nature. Because of this, the development of systematic biology created effects that influenced the essentials of the life of humanity.

During Linnaeus' time in Uppsala some important corner stones in systematic biology were published. In 1751 he published *Philosophia botanica*¹³, a concise book describing the philosophy, rules and methods of systematic botany, part of which is valid still. In 1753 his most important work in botany, *Species plantarum*, was published. This was a flora of all

¹⁰ Linnaeus, C. 1737. Caroli Linnæi ... corollarium generum plantarum, exhibens genera plantarum sexaginta, addenda prioribus characteribus, expositis in generibus plantarum. Accedit methodus sexualis. Lugduni Batavorum.

¹¹ Linnaeus, C. 1737. Caroli Linnæi ... Critica botanica in qua nomina plantarum generica, specifica, & variantia examini subjiciuntur, selectiora confirmantur, indigna rejiciuntur; simulque doctrina circa denominationem plantarum traditur seu Fundamentorum botanicorum pars IV. Accedit Johannis Browallii de necessitate historiae naturalis discursus. Lugduni Batavorum.

¹² Linnaeus correspondence is currently being published on www.linnaeus.c18.net.

¹³ Linnaeus, C. 1751. Philosophia botanica in qua explicantur fundamenta botanica cum definitionibus partium, exemplis terminorum, observationibus rariorum, adjectis figuris æneis. Stockholmia.

known plant species in the world. Most of the around 8000 species in this book had been observed by Linnaeus himself, his students or trusted scientists in his network.

The main ambition of Linnaeus' scientific reformation was intelligibility in communication. This resulted in several books of rules. His work aimed at totality, expressed in the global *Species plantarum*, but it also nourished local knowledge through works like *Flora svecica*¹⁴ and *Fauna svecica*¹⁵. He inspired his students to undertake expeditions to foreign countries, sowing the seeds of curiosity in the meadows around Uppsala. He aimed at order and simplicity and structured his flowerbeds in strict quarters, but was amazed by the rich diversity of life, a diversity that never seemed to cease, but with time made the systematic work overwhelming and almost going over the brink. An international legion of scientists would soon stand prepared to continue the development of systematic biology from the base worked out by Linnaeus.

Table 2. Some publications by Linnaeus important to the development of systematic biology, focusing on classification, nomenclature and method, as defined by William Stearn in an addendum to the Swedish edition of Blunt, W. 1971. The complete naturalist. A Life of Linnaeus. (Carl von Linné. Trevi. Stockholm)

| Important publications | Impact | Scientific field |
|--|--|-------------------|
| Systema Naturae 1735 | Practical artificial system made systematic botany and sexuality of plants widely known. | Botanical system |
| Systema Naturae 1735 | Insect systematics and mammals, important revisions. | Zoological system |
| Genera Plantarum 1737 | Consistent definitions of genera, rules for generic names. | Genera |
| Critica botanica 1737 | Thorough definition of species, rules for naming species. | Species |
| Fundamenta botanica 1736 Philosophia botanica 1751 Termini botanici 1762 | Botanical terms and species description structure. | Botanical Latin |
| Species plantarum 1735 Systema naturae 10 th ed 1758 | Introduced trivial names that rapidly transformed into binary nomenclature | Nomenclature |

Development of systematic biology after Linnaeus

The simplified and artificial systems constructed by Linnaeus were not able to last for long, and the first developments were made by himself. He admitted already in 1735 in the first edition of *Systema naturae* that the sexual system of plants was artificial and must later be replaced by a natural system. He tried to develop a natural system, starting already in 1738 in *Classes plantarum*¹⁶ by describing 65 natural orders of plants. He never managed to construct a fully developed natural classification. Apart from the problems connected with an artificial science, Linnaeus was also aware of the problems that the biblical rules of natural sciences caused when confronted with the complex variation among and in organisms. In 1744 he wrote a thesis stating that there was a possibility that speciation through hybridization may

¹⁴ Linnaeus, C. 1745. *Flora Svecica exhibens plantas per regnum Sveciæ crescentes, systematice cum differentiis specierum synonymis autorum nominibus incolarum solo locorum usu pharmacopæorum*. Lugduni Batavorum.

¹⁵ Linnaeus, C. 1747. *Fauna svecica sistens animalia Sveciæ regni: quadrupedia, aves, amphibia, pisces, insecta, vermes, distributa per classes & ordines, genera & species. Cum differentiis specierum, synonymis autorum, nominibus incolarum*. Stockholmiae.

¹⁶ Linnaeus, C. 1738. *Classes plantarum seu systemata plantarum omnia a fructificatione desumta, quorum XVI universalis & XIII partialia, compendiose proposita secundum classes, ordines et nomina generica cum clave cujusvis methodi et synonymis genericis*. Fundamentorum botanicorum pars II. Lugduni Batavorum.

occur within the plant kingdom¹⁷. However, it was too early for such theories to develop in the society, and he and his scholars had to leave many questions unanswered.

The development of systematic biology after Linnaeus went rapidly towards a natural system where species with overall similarity would be classified together, as opposed to Linnaeus' artificial sexual system where the number of stamens and anthers were emphasized. The natural system arose first in France, where Linnaeus had one of his greatest scientific opponents Georges-Louis Leclerc de Buffon (1707–1788) who disagreed on imposing an artificial order on the disorderly natural world. Buffon's theories, together with earlier works in France by Michel Adanson (1727–1806) and the pre-Linnaean scientist Joseph Pitton de Tournefort (1656–1708) made way for the natural system presented in 1789 in *Genera plantarum*¹⁸, published by Antoine Laurent de Jussieu (1748–1836), a scientist in Jardin des Plantes in Paris.

Linnaeus' great collections had been sold to London by the family, and in 1788 the Linnean Society of London was founded to take care of the collections and create a meeting place for the cultivation of the science of natural history. The United Kingdom was to play an important part in the development of systematic biology during the 19th century. A development of the natural system was worked out by the botanist Robert Brown (1773–1858), partly due to his immense collections from Australia. Earlier investigations of the continent had been carried out during the voyages by Captain James Cook when the Linnaean scholar Daniel Solander and Sir Joseph Banks visited the now famous Botany Bay south of Sydney. The high number of species they collected pointed towards the need for a natural system that could cope with earth's biodiversity.

The shift of paradigm caused by the theory of evolution would become the most important theory change affecting systematic biology. However, it took more than 100 years until the theory could be fully applied within this science. Early versions of evolutionary theories had been suggested during the 19th century, the most important one by the Jean-Baptiste de Lamarck (1744–1829) in France, but it was not until Charles Darwin (1809–1882) and Alfred Russel Wallace (1823–1913) presented their hypothesis at the Linnean Society of London in 1858 that a theory of evolution made a great impact. Systematic biology eventually aimed at basing their classifications on the new theory, but for decades theories on evolutionary trees were based on personal analyses of similarities and differences between organisms that could not be tested. Concurrently, the systems of plants and animals were growing huge with an increasing number of species new to science.

In 1950, the German biologist Willi Hennig (1913–1976) presented revolutionary new ideas that became the foundation of the cladistic era of systematic biology. He proposed that only shared-derived features (“synapomorphies”) could be used to infer relationships, and that classifications should be based on such phylogenetic relationships rather than on overall similarity. Moreover, the taxonomic units (species, genera etc.) should include all descendants of a single ancestor (the “rule of monophyly”). The molecule carrying the genetic information of life forms, DNA, had already been detected in 1953 by James D. Watson (1928–) and Francis Crick (1916–2004), and a few decades later the development of the polymerase chain reaction (PCR) facilitated DNA sequencing immensely. Together with the concurrent

¹⁷ Linnaeus, C. 1744. *Dissertatio botanico de Peloria*. *Amoenitates Academica*. Uppsala.

¹⁸ Jussieu, A. L. 1789. *Genera Plantarum Secundum Ordines Naturales Disposita, Juxta Methodum in Horto Regio Parisiensi*. Paris.

development of more powerful computers and analytical programs, this enabled a widespread use of DNA sequence data to infer relationships among organisms.

The science of systematic biology is currently in a phase of strong development. New species are continually being discovered, and the importance of systematic work is now widely acknowledged. National and global documentation of organisms are as much on the agenda today as it was in the 18th century. For example, Sweden has recently launched “The Swedish Taxonomy Initiative”, which aims at identifying and describing all Swedish multicellular organisms¹⁹.

Our understanding of how different organisms have diversified through the process of evolution is rapidly increasing. Refined methods for phylogenetic analyses, species identification by molecular markers, and the rapid extinction of species on earth are issues in focus for the modern scientist. Seemingly trivial issues, like the naming of species, are of central importance. Although systematic biology of today may seem far away from that founded by Carl Linnaeus in the 18th century, the tools serving scientists describing new species may indeed be traced back to his works. Furthermore, a main concern is still that we, *Homo sapiens*, are dependent on the cobweb of species on earth, and that in order to study or use other life forms we need to know their names and understand their history as well as their context. There is no other possible alternative for the future.

¹⁹ http://www.artdata.slu.se/svenskaartprojektet/svenskaartprojektet_eng.asp. This project was launched in 2002.

Description - “The Rise of Systematic Biology”

The foundation of systematic biology laid out by Linnaeus and his scientific network was totally dependent on the possibility to observe a large enough number of organisms. These were observed by scientists in their natural habitat, then generally collected and further analysed dead or alive. Large collections of preserved organisms are kept in museums all over the world. Living organisms are kept in gardens, zoological parks and in bacterial and fungal cultures. For each species described, a certain individual is assigned as a type specimen and preserved. There is a connection between the type specimen and its original population in nature.

Since systematic biology is a science based on observations of organisms, a World Heritage Site reflecting the foundation of the science must be defined in areas where descendants still exist of organisms once studied and preserved by scientists. This could be a field collection area or a historical garden. Such extant populations are not only of cultural value, they are also of great scientific value; if type specimens would be destroyed in the museums - like when the Berlin herbarium was bombed during the second world war - interchangeable collections can be made in extant populations. A recent example is when in 2002 a neotype (a type specimen selected as a substitute for a missing or insufficient original type) was needed for the species common cotoneaster *Cotoneaster integerrimus*, described by Linnaeus. The neotype was collected in an extant population along one of the excursion trails in *Herbationes Upsalienses*.²⁰

In the tentative serial cultural landscape nomination of a World Heritage Site named “The Rise of Systematic Biology”, properties will be included with extant populations consisting of descendants to the once collected individuals that contributed to the foundation of systematic biology by Carl Linnaeus and scientists within his network. The properties below all carry such populations, in many cases preserved due to the fame of the unique scientific achievements connected to them. Some of these sites also include preserved buildings and structures from the 18th century. The extant populations have a strongly probable continuous local history since the 18th century.

The different properties complete each other, and together they represent “The Rise of Systematic Biology. The properties in Sweden were central for the development of the science as carried out by Carl Linnaeus: his initial study site (Råshult), his garden, research facilities and excursion sites in Uppsala. The garden sites in Europe and USA are examples of gardens important for the exchange of plants and animals within science and with a connection to Linnaeus’ development of the science. Additionally, three collection areas are included on three continents. In these areas collections were made that became important to the central development of science directly or to local development of systematic biology.

Apart from the sites described below, it must here be mentioned that the collected individuals, i.e. the museum specimens, once collected from these populations are of uttermost value to science, especially Linnaeus’ personal natural collection kept in London by the Linnean Society of London. Those will, however, not be included in the possible nomination.

²⁰ Thulin, M. & Ryman, S. 2003. Proposal to conserve the name *Mespilus cotoneaster* (Rosaceae) with a conserved type. *Taxon* 52(2), pp. 371-372.

I. Sweden – Linnés Råshult, Älmhult

Every great scientific achievement has its roots in initial observations. The scientific revolution that Linnaeus made in systematic biology started when he in his childhood and youth performed his first studies of the local flora and fauna in the parish Stenbrohult in southern Sweden. During this naïve stage of his scientific development, Linnaeus botanised in the vegetation typical of the 18th century, where he studied stamens and pistils in flowering plants, observations that later developed in the sexual system.

Linnaeus was born in Råshult in the parish Stenbrohult. The homestead, an agricultural vicarage, held a species-rich garden created by his father, a garden that according to Linnaeus himself sparked off his great interest in plants. At the age of two years, Linnaeus and his family moved to a vicarage not far from Råshult, close to the parish church. However, the family retained the farm in Råshult as a compensation for an extended household now including Linnaeus grandmother, who had become a widow. The family could easily walk between the two homesteads on the church road connecting the two places.

Linnaeus grew up in an intellectual home. His father and uncle were both knowledgeable in medicinal plants, reading was encouraged in the vicarage, as was knowledge about plants. Linnaeus received classical, medicinal books from his father, like “*Historia plantarum*” by Theophrastus, and further knowledge was given to him later by his tutor in secondary school, Johan Rothman. The intellectual environment nurtured Linnaeus’ perceptual mind. So did a strong relationship to the Swedish countryside in a time of history when meadows and forests had a colourful biodiversity of flowering plants.



Figure 2. The meadows of Råshult have a high biodiversity due to 18th century agricultural methods. Photograph by Mariette Manktelow.

As a teenager, Linnaeus explored the meadows and forests within the parish. Using the classification by the French scientist Tournefort, he was puzzled to find unidentifiable plants not included in that work. To find the answers to his growing number of questions he turned to both books and nature. Already as a teenager he felt the need to complete his library with a

book of his own, *Örtaboken* (The Book of Herbs), written by hand between 1725 and 1727²¹. The young Linnaeus naturally must have spent much of his time in the meadows and fields belonging to the vicarage in Stenbrohult parish, and Råshult was an obvious base for his nature studies.

Today the meadows of Råshult are a cultural reserve where the agricultural landscape since many years is managed by 18th century methods. The other meadows, once studied by Linnaeus in the parish, are since long overgrown and their vegetation changed, but in Råshult the vegetation has been preserved by the local society treasuring Linnaeus' memory. Especially the latest years' management in Råshult has resulted in an almost explosive expansion of authentic populations common in Linnaeus' Stenbrohult in the 18th century. Plants that earlier were rare are now common in the meadows: viper's grass *Scorzonera humilis*, arnica *Arnica montana*, quaking grass *Briza media*, bitter vetch *Lathyrus linifolius*, lesser butterfly orchid *Platanthera bifolia*, heath spotted orchid *Dactylorhiza maculata*, lousewort *Pedicularis sylvatica*, marsh gentian *Gentiana pneumonanthe*. This historical vegetation type in Råshult is the only one present not only in the parish Stenbrohult, but in the whole of Kronoberg county.

The father's vicarage garden was described by Linnaeus in *Adonis Stenbrohultensis* 1732. The father started planting the garden at Råshult, and moved parts of it at to the vicarage at Stenbrohult church. A dozen species from the garden in Råshult have survived there, for example elderflower *Sambucus nigra*, lilac *Syringa vulgaris*, orange daylily *Hemerocallis fulva*, red currants *Ribes rubrum*, and small grape hyacinth *Muscari botryoides*.

The buildings in Råshult are positioned in the same place as in the time when Linnaeus family lived there. One of the buildings was reconstructed and made a museum in 1930, furnished as a typical vicarage of early 18th century. A reconstruction of Linnaeus' father's special garden structure is made on the same area as the original garden was laid out, with flowerbeds shaped as a dining table with chairs for guests.

Linnés Råshult is a cultural reserve since 2002, managed by the Kronoberg County Administrative Board, the buildings are protected by Swedish law as notable buildings since 1977.

II. Sweden – The Linnaeus Garden (Linnéträdgården) and the Linnaeus Museum (Linnémuseet), Uppsala

The garden of Uppsala University, *Hortus Upsaliensis*, was central to Linnaeus' scientific work, which makes it a living complement to his writing and his natural collection to anyone who wishes to understand the Linnaean era of systematic biology. The garden was the living source to the fundamental global flora *Species plantarum*.

After 1741, when Linnaeus became a professor at Uppsala University, the botanical garden soon became a central place for Linnaeus scientific reformation and foundation of systematic biology. The garden had been strongly deteriorated after a fire, but with help from scientists in his network, Linnaeus managed to increase the number of species from 300 to more than 3000. Having visited grand gardens in Europe, like those of Leiden, London and Paris, he wanted his new creation to outdo them all. The Court Architect and Director of the Public

²¹ Örtaboken is published on <http://www.vaxjo.se/ortaboken>.

Works Carl Hårleman drew a garden plan of a straight symmetric "jardin à la française" with trimmed hedges and parallel parterres, the university gave more land and funding for a new greenhouse, and the new garden was built during 1743-1745.

The new garden became an important research facility to Linnaeus where he performed many of his studies. Apart from systematic research some studies concerned night behaviour of plants, cultivation of the Chinese rhubarb root, and how to tell the time from the opening and closing of flowering plants by the *horologium florum*. However, the main purpose of the garden was that of a lecturing room. Linnaeus could here demonstrate not only medicinal plants to the students, but also ongoing research. The species were ordered according to the sexual systems. The students could learn the habitats of different plant species needed through three different wet habitat areas, partly created from a well in the garden. These were the first ecological plantations made in a botanical garden. Spring and autumn quarters as well as annual and perennial quarters helped the students to understand the phenology of plants. The economic and geographic aspects of plants could be studied in hedges of different quality and species as well as in a collection of Swedish tree species. Foreign medicinal plants were imported and tried out in the garden to make cultivation of them in Sweden possible. Linnaeus' international contacts and the travels by his students were reflected in the species composition of the garden. Scientists from Europe came to Uppsala to visit the garden, as it had become the largest in the world in number of species. There was also a collection of living animal species, for example different species of monkeys, kept in special pole houses, peacocks and a raccoon.

Uppsala botanical garden was moved to a new location when King Gustaf III in 1794 donated the Castle Garden in Uppsala to Uppsala University to honour the memory of Linnaeus. The property of the old botanical garden was used by the students. The main greenhouse was converted into housing, but the warmhouses on the side still carry traces from flowerbeds inside.

The Swedish Linnaeus Society was founded in 1917 in order to preserve as much as possible of the Linnaeus heritage. In 1923 the Society reconstructed Linnaeus' botanical garden. Flowerbeds and hedges were recreated in their exact positions, as found out from preserved detailed building plans from the 1740's. The middle axis path has remained in the garden over the years, authentic material from rubbish heaps and parterres are continuously found in the earth layer and the pressure from the artesian well fills the central dam, one of the three ecological plantation areas restored. Around 1500 plants of the same species as Linnaeus grew here were returned from the new botanical garden. Some of these were authentic specimens, and other authentic species were later planted in the garden. Examples are liverwort *Hepatica nobilis* and winter blooming bergenia *Bergenia crassifolia* and other species from Hammarby, as well as royal fern *Osmunda regalis* and aspen *Populus tremula* from Linnaeus' observation sites in Sweden. A few species have always remained in the garden, like gageas *Gagea* spp., yellow wood anemone *Anemone ranunculoides*, noble fumitory *Corydalis nobilis* and wild tulip *Tulipa sylvestris*. The garden is still used for demonstrations of plants for schools and visitors.



Linnaeus' teaching is continued in the Linnaeus Garden.

The Linnaeus Museum is seen in the background.
Photograph by Kalbar/Uppsala Tourism.

In the forecourt of the garden we find the old professor's home, now the Linnaeus museum. This is where Linnaeus lived a short time as a student in Prof. Olof Rudbeck the younger's home and where he later moved in himself as a professor in 1743 and stayed until his death in 1778. The house was, like the garden, in a deteriorated state, and Linnaeus had it partly rebuilt. The ceiling was elevated so that rooms could be built in the attic, and when finished the house had 12 rooms in total. Special rooms were furnished as library, natural cabinet and lecture room. The greater part of his scientific work was written in this house. Linnaeus held both university lectures and private lectures in the home, as it was easier to demonstrate living plants so close to the garden. From the library he could keep a watching eye on the garden and the gardeners.

After Linnaeus' death in 1778, the house was inhabited by a succession of professors in medicine as well as in music until 1935. The Swedish Linnaean Society, founded in 1917, had taken initiative to an antiquarian investigation, which led to a reconstruction of Linnaeus' home. With help from relatives to Linnaeus the house could be furnished with authentic objects and the museum could open in 1935.

A visit to the Linnaeus museum in the Linnaeus garden elucidates Linnaeus' scientific work as well as his family life. In Linnaeus' study there are scientific instruments, such as his microscope, compass and botanical knife. His herbarium cupboard and other museum cupboards are standing here, and one room displays conserved species from the 18th century collections of Uppsala University. His study is furnished with original furniture. The world

famous portrait, picturing Linnaeus in Samish costume while in Holland, emphasizing his scientific work, hangs in the lecture room.

The Linnaeus Garden with the Linnaeus Museum is national property and protected by Swedish law as notable buildings since 1935 and 1993, respectively.

III. Sweden – Herbatationes Upsalienses (Linnéstigarna), Uppsala

Teaching was an important part of Linnaeus scientific activities. He used what we would call modern methods to inspire the students. By teaching them his new efficient methods, his philosophy and practical science he made them part of his network. The students thus became important in the development of systematic biology, either by contributing to Linnaeus knowledge of organisms by sending him collections from their expeditions, or making a career of their own and extend the scientific scope.

Excursions became a central part of Linnaeus' teachings, inspired from similar excursions in Paris, London, Göttingen and Halle, driven by his philosophy "During excursions one may see every plant in its natural habitat, from which a mindful observer may not only get a great pleasure, but also a more thorough knowledge about the plants."²² A number of excursions ended the spring lectures under the name *Herbatationes Upsalienses*.

The rules for the excursions were strict and described in *Philosophia botanica*.²³ There were eight excursion trails, along which most plants and animal species around Uppsala had been seen. The clothing should be purposeful and loose fitting. The students should bring proper reference works and collection devices into the field. One student was assigned by Linnaeus to keep order of the group. Another student would shoot the birds to be studied. A third student became a secretary, annotating every word uttered by the teacher during the excursion. These protocols are preserved and give us information on which species the students saw. The students divided into groups to collect plants, animals and minerals, and Linnaeus regularly demonstrated their findings, a teaching method very inspiring to the students.

Linnaeus could use the excursions to select talented students capable of performing good research in systematic biology. *Herbatationes Upsalienses* were a first expedition into nature, in a safe, controlled manner.²⁴ They became an important breeding ground for new scientists and a scientific network around Linnaeus was created in the field. Since the species along the trails were studied repeatedly by Linnaeus with new students every year, they became the base for the fundamental works *Species plantarum* in 1753 and *Systema naturae* in 1758. The excursions also worked as an arena for experimenting with scientific methods. Linnaeus tested his short trivial names (later developing into binary nomenclature) in his group of students before final publication in *Species plantarum*.²⁵ *Herbatationes Upsalienses* were to

²² Linnaeus, C. 1753. Herbatationes upsalienses, quas, consent. experient. Facult. Medica in Regia Academia Upsaliensi, sub praesidio ... Dn. Doct. Caroli Linnæi, ... publico examini submittit alumnus regius, Andreas N. Fornander, Smolandus. In auditorio Carol. Majori Die XIII Octobr., anno MDCCLIII.

²³ Linnaeus, *Philosophia botanica*, 1751, p. 293.

²⁴ Hodacs H. & Nyberg, K. 2007. *Naturalhistoria på resande fot : om att forska, undervisa och göra karriär i 1700-talets Sverige*. Nordic Academic Press. Stockholm. p. 57.

²⁵ Nyberg, K. and Manktelow, M. 2005. 'Linnés apostlar och tillkomsten av *Species plantarum*', In Hedberg, I. (ed.), *Species Plantarum 250 ys, proceeding of the Species Plantarum Symposium held in Uppsala August 22-24 2003*. Acta Universitatis Upsaliensis, *Symbolae Botanicae Upsalienses* 33:3, pp. 21-24.

Linnaeus and his students what a scientific laboratory is to a contemporary scientist and his lab group.

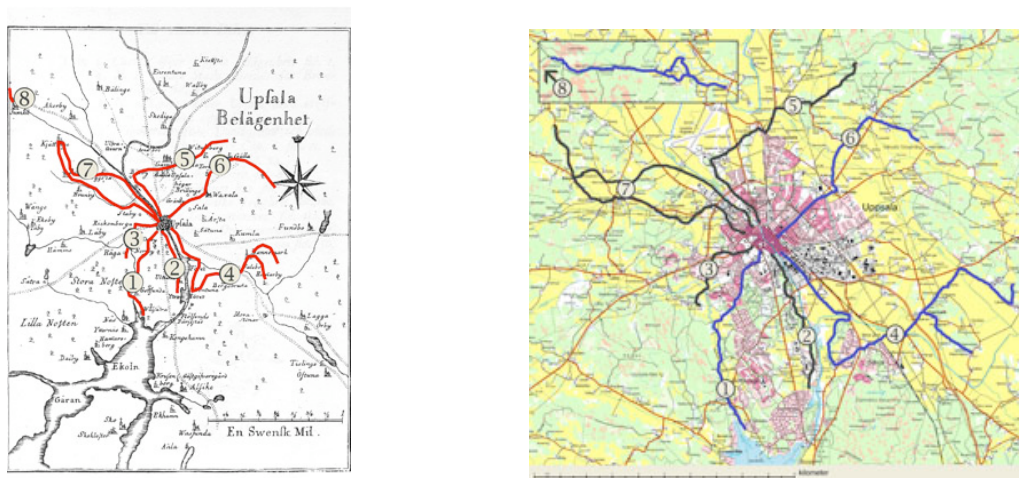


Figure 3. *Herbationes Upsalienses* on a map of Uppsala from 1772 (left, trail no 8 not fully included) and from 2005 (right, blue trails have been reconstructed). Legend: 1. *Herbatio Gottsundensis*. 2. *Herbatio Ultunensis*. 3. *Herbatio Hogensis*. 4. *Herbatio Danensis*. 5. *Herbatio Upsaliae-antiquae*. 6. *Herbatio Waxalensis*. 7. *Herbatio Husbyensis*. 8. *Herbatio Jumkilensis*. From Busser, J. B. 1772. Utkast till beskrivning om Uppsala. Uppsala. and www.linnaeanlandscapes.org.

The *Herbationes Upsalienses* are today partly reconstructed. Three excursions (1, 6 and 8, see Fig. 3) were constructed by Uppsala municipality in collaboration with Swedish Linnaean Society in 1978. In the preparations of the Linnaeus tercentenary in 2007 those were redrawn in collaboration with the project Linnaean Landscapes and a fourth excursion (no 4) added. The last four excursions (2, 3, 5 and 7) are currently under reconstruction.

Around 1000 plant species and 500 animal species are known from the protocols. Many of these do still thrive along the excursion trails. Three areas with a protected biodiversity along the *Herbationes Upsalienses* trails are currently under protection by Swedish law as nature reserves. Two of these are known to contain a high number of species populations once studied by Linnaeus and his students, Hågadalen-Nåsten Nature Reserve and Fäbodmossen Nature Reserve. The *Herbationes Upsalienses* excursion paths will be surveyed during 2009 to identify other possible areas with high degree of authenticity.

IIIA. Sweden – Hågadalen–Nåsten Nature Reserve, Uppsala

The Hågadalen-Nåsten Nature Reserve includes two trails of *Herbationes Upsalienses*, *Herbatio Gottsundensis* in the Eastern part and *Herbatio Hogensis* in the Northern part. These excursions are relatively well-documented by student protocols from Linnaeus' excursion, especially *Herbatio Gottsundensis*. A high number of species once studied by Linnaeus and his students still thrive in this nature reserve, some plant examples are oak *Quercus robur*, common buckthorn *Rhamnus cathartica*, fly honeysuckle *Lonicera xylosteum*, spurge laurel *Daphne mezereum* and common toothwort *Lathraea squamaria*. Elements like Norby well and the Håga river are still positioned in the same localities as in the 18th century.

IIIB. Sweden – Fäbodmossen Nature Reserve, Uppsala

The Fäbodmossen Nature Reserve is positioned West of the ending point of the present reconstruction of *Herbatio Jumkilensis*. Linnaeus and his students went by horse and carriage all the way to Jumkil Parish to stay overnight and next day wander through the vast forests of Jumkil. The western part of this excursions went through extensive bogs, sometimes including

Fäbodmossen, which is a preserved bog area where vegetation has not been destroyed by draining and ditching. Classical populations from this excursion are still present in Fäbodmossen Nature Reserve, like moor-king *Pedicularis sceptrum-carolinum*, bog rosemary *Andromeda polifolia*, marsh ledum *Ledum palustre* and common hair moss *Polytrichum commune*. Since the 18th century, Fäbodmossen has never been drained or ditched.



Linnaeus went to Fäbodmossen with his students to study moor-king *Pedicularis sceptrum-carolinum*.
Photograph by Sophia Bryntse.

IV. Linnaeus' Hammarby (Linnés Hammarby), Uppsala

In 1758 Linnaeus bought the farmstead Hammarby 10 km SE of Uppsala with some adjacent village houses. This became his first private property. He soon developed the area into a private research station and held his private lectures for international students there during the summers. He built a manor for his family, his scientific activities and some of his collections. Later on he built a specially designed museum for his natural collections, which he also moved out from Uppsala. He laid out botanical gardens, flowerbeds and planted trees and hedges. Initially he transferred plants from *Hortus Upsaliensis*, and later he planted seeds that he received as gifts. He stayed in Hammarby all summer, but visited the *Hortus Upsaliensis* regularly. He received scientists and celebrities from Sweden and abroad as visitors in Hammarby, for example Lord Baltimore III from England and crown prince Gustaf of Sweden, both attracted by his fame as a scientist.

Linnés Hammarby is a property with unique remnants from the foundation of systematic biology. Linnaeus' study (Fig. 4) in the main building was never used after his death, and many details in the room bears direct trace from his hand. A wallpaper consisting of plates of American plants drawn by Plumier in the work *Plantarum americanarum*. These plates were once glued to the wall by Linnaeus and are still present in the same position as he put them. In the adjacent bedroom the walls are covered with hand-coloured plates drawn by Ehret and published in the work *Plantae selectae*. Some of the plates carry his handwriting. Along the ceiling in the study there are several details that remain from Linnaeus' scientific activities, such as paper images of different bird species glued on the ceiling spline, an oil-painting of

his Coat of Arm placed above the entrance door, a personal proverb written above the bedroom door and oil-paintings of monkeys and a raccoon, animals that he kept alive for his studies. His writing chair remains in the room at a desk by the window, a place where he wrote many of his manuscripts. The whole atmosphere in this unique study gives a strong sense of presence of a scientist who managed to create an important development of systematic biology.



Figure 4. Linnaeus' study at Hammarby. Photograph Staffan Claesson.

The large natural collection of Uppsala University, mainly gathered by Linnaeus and his scientific network, was threatened by a fire in 1766. He then built a special museum at Hammarby that would accommodate his own collections. After having moved his natural collections to Hammarby he had to go there also in the winter when he needed to study his natural collections. The building is beautifully preserved in an original state on the top of a hill on the property. The actual collections were sold to England in 1784 and are today managed by the Linnean Society of London as the world's most treasured organism collection in systematic biology. However, the little empty museum in Hammarby and the collections are forever connected with one another. Left in the museum in Sweden is Linnaeus' lecture chair and the student benches used in his private lectures. Outside the museum there is a flattened surface on the moraine hill, once made to create an outside lecture room. The museum is a unique scientific landmark from a time when systematic biology was founded and spread from this place to many countries in the world.

Hammarby is also the site where the strongest biological cultural heritage from the Linnaean era of systematic biology is to be found. The structures of botanical plantations, such as the Siberian garden, shrub quarters and single trees planted by Linnaeus remain relatively undisturbed. Two parterres in the main yard are reconstructed, and some perennials in the main garden remain where once planted. Almost 50 plant species have survived where once planted or naturalized within and around the property, some of the most striking are

belladonna scopolia *Scopolia carniolica*, Russian peashrub *Caragana frutex*, St Lucie cherry *Prunus mahaleb*, dog's mercury *Mercurialis perennis*, barrenwort *Epimedium alpinum*, turk's head lily *Lilium martagon* and Hammarby houseleek *Jovibarba globifera*. Some animals studied and described by Linnaeus and his students are still to be found on the property, such as the stild bees, for example Fabricius nomad bee *Nomada fabriciana* and a the Burgundy snail *Helix pomatia*. The surrounding area has recently become a cultural reserve, where 18th century agricultural methods will help expanding the once common, but now diminishing populations from the 18th century agricultural landscape. Examples of species that were common in the Hammarby landscape, but now rare are maiden pink *Dianthus deltoids*, wild thyme *Thymus serpyllifolium* and carline thistle *Carlina vulgaris*, species that Linnaeus used in his lectures in the fields.

Linnaeus had the possibility to try out planting experiments in his garden and in the surrounding farmland. The Hammarby estate was not as formalized as the *Hortus Upsaliensis*, and thus easier to use for dynamic planting. He focused on plants that would contribute to the economy of the country and help the single farmer to increase his outcome. He planted purple willow *Salix purpurea* in the fields as he wanted to use it to bind his oats. He built a *Hortus Sibiricus* to investigate whether plants from Russia could survive in Sweden and be of use in the poor northern part of the country. He also planted Siberian crab apple *Malus baccata* here to try out grafting and search for the original apple species. The apple and willow are still growing in their original places.

The remote position of this property in the countryside in one of the least populated countries in the Western world, once the centre of systematic biology, thereafter left without larger reconstructions, presently with a high number of cultural entities remaining, puts Hammarby in a class of its own as a preserved cultural site and landmark of one single scientific field, the systematic biology.

The central part of Linnaeus' property of Hammarby has been a museum since 1879 and is currently protected under Swedish law as a notable building (1935 and 1993). It is owned by the National Property Board, which manages it together with Uppsala University. The surrounding area is a cultural reserve since 2007 owned by Uppsala Akademiförvaltning and managed by the County Administrative Board of Uppsala.

V. The United Kingdom – Chelsea Physic Garden, London

Linnaeus visited Chelsea Physic Garden in the 1730's, a visit that influenced him and gave him contacts. The scientific connection to England became important to his own development of science as well as the later development of systematic biology in England. The increased knowledge of North American species was channelled via England, as well as the grand discoveries of flora and fauna in other parts of the world. Linnaeus' student Daniel Solander, well trained in Linnaeus' methods, had an influence on the development of systematic biology through his collections together with Banks in Australia and other places. Chelsea Physic Garden is a well preserved garden from that time, with several species still in cultivation that have their origin in the 18th century. Discussions on a participation in a world heritage serial nomination have been initiated with the curator of Chelsea Physic Garden. The Chelsea Physic Garden Board will discuss a participation in the world heritage nomination in July 2009.

VI. The Netherlands – Hortus Botanicus Leiden

The botanical garden of Leiden was an important place for Linnaeus' development as a scientist, and he worked in this garden during his stay in Holland. The garden bears traces of great botanists such as Clusius, Boerhaave and Van Royen. The garden still harbours a number of plants studied by Linnaeus and planted by the scientists that influenced him. Among these are plants from Clusius' time and numerous plants introduced into the garden by his mentors Boerhaave and Van Royen and by botanists he greatly admired such as Paul Hermann. The original Clusius Garden dating from 1592–94 has recently been reconstructed on its original site, and the garden is annex to the old Academy Building still serving as the ceremonial centre of Leiden University where Linnaeus attended lectures by Boerhaave and other Leiden scholars. Discussions on a participation in a world heritage serial nomination have been initiated with the management of Hortus Botanicus Leidens.

VII. France – Jardin des Plantes, Paris

Jardin des plantes in Paris is where Linnaeus got most of his plants from when he restored the Hortus Upsaliensis. Prof. Bernhard de Jussieu in Paris was an important contact to Linnaeus. Paris inspired Linnaeus to create the *Herbationes Upsalienses*. The French scientist Buffon opposed greatly to his theories, and the lack of idolization of Linnaeus in France created a vacant space that made it possible to develop the science further by creating a natural system. This work was made by Antoine de Jussieu, who was active in Jardin des Plantes in Paris. The garden contains several trees and plants still surviving from the 18th century. There are also other remnant structures, such as greenhouses and flowerbeds. Discussions on a participation in a world heritage serial nomination have been initiated with the management of Muséum National d'Histoire Naturelle, of which Jardin des Plantes is a part.

VIII. South Africa – Table Mountain, Cape Region

Several students of Linnaeus collected plants and animals around the Cape, but few made such extensive collections as Carl Peter Thunberg and Anders Sparrman who made expeditions in and around Table Mountain, among other places in the Cape region. Sparrman described some well-known animals like the African Buffalo and the now extinct Quagga. Thunberg made extensive collections and wrote the first Flora of South Africa, investigations that became important to the development of systematic biology in southern Africa. Ever since the exploration of the southern tip of Africa was initiated, Table Mountain has been treated as a living laboratory. Given its immense visual impact, it has attracted the attention of scores of biodiversity and natural history scholars. Table Mountain National Park is located on the Cape Peninsula, the south-western extremity of Africa. It stretches from Signal Hill in the north (33° 54' S, 18° 24' E) to Cape Point in the south (34° 21' S, 18° 29' E) and includes Table Mountain. Due to the extraordinary biodiversity and scenic landscapes, the Table Mountain National Park was declared a Natural World Heritage Site in 2003. Within an area of 471km², 2285 indigenous plant species occur making the Cape Peninsula flora one of the richest for any similar-sized area, both in the Cape Floral Kingdom and elsewhere in the world. Discussions on a participation in a world heritage serial nomination have been initiated with South Africa National Parks. Support for Table Mountain to be included in "The Rise of Systematic Biology" has also been expressed by the South Africa National Biodiversity Institute (national Department of Environmental Affairs and Tourism).

IX-X. Japan – Dejima Island, Nagasaki, and Hakone National Park, Kanagawa

In a time when Japan was isolated from the rest of the world, Linnaeus' student Carl Peter Thunberg arrived to the country disguised as a Dutchman to collect plants. Together with other foreigners, he was isolated on the island Dejima outside Nagasaki. From there he managed to make collections that became the foundation of the Flora of Japan. He traded his knowledge in medicine against plants, and extracted flowering plants from the fodder brought to the animals on Dejima. He was allowed to make one journey to Edo (Tokyo), where he managed to collect several plant species, many of them in the Hakone Mountains area. The island Dejima is today reconstructed with some original elements still preserved. Hakone National Park still carries an authentic part of the Tokaido road on which Thunberg travelled, and around Hakone populations remain of the flora that Thunberg once collected. Discussions on a participation in a world heritage serial nomination have been initiated with the managements of Hakone National Park and Dejima museum.

XI. United States of America – Bartram's garden, Philadelphia

John Bartram (1699-1777) founded a botanic garden on his farm in Philadelphia in 1728, and traveled widely throughout the colonies of British North America. He had a wide correspondence with European and American scientists and amateurs, including Linnaeus, and together with his friend Benjamin Franklin, Bartram helped found the American Philosophical Society in Philadelphia in 1743. About 1733 John Bartram began a correspondence with the London merchant Peter Collinson (1694–1768), who soon became middleman for a scientific trade in seeds, plants, and natural history specimens. Bartram's plants were exchanged with Miller, Catesby, and Sloane in London, Dillenius at Oxford, and Gronovius at Leiden.

When the first edition of Linnaeus's *Systema naturae* was published in Leiden in 1735, Peter Collinson forwarded a copy to James Logan in Philadelphia. Logan also served as an encourager for Bartram, and together in the summer of 1736 the two studied Linnaeus' system. Bartram was soon applying Linnaeus' method and examining stamens and styles, often under magnification. Distance forced Bartram and Linnaeus to carry on a desultory correspondence, but information and plant specimens from Bartram passed to Linnaeus through Collinson in London and Gronovius at Leiden. Linnaeus dubbed Bartram "the greatest natural botanist in the world."

Linnaeus's student, Pehr Kalm visited Bartram during his stay in North America, 1748-51. Kalm was taken with Bartram's "peculiar genius" for natural philosophy and natural science, and Bartram shared much of his knowledge and many of his plants with Kalm. Kalm was based on the Delaware, opposite Philadelphia, during his stay in North America and most of his collections were made in the area. Collections from this area, which included the former colony of New Sweden, also reached Linnaeus in other ways. Among other species Linnaeus studied a raccoon that he kept as a pet in Uppsala, observed and finally dissected and described. When Kalm returned to Sweden he provided a wealth of new material for Linnaeus. Kalm's collections increased Linnaeus' knowledge greatly and they served as a direct inspiration for him to initiate the important work *Species plantarum* published in 1753.

Bartram's garden and part of his farm are today preserved as Bartram's Garden, the oldest botanic garden in the USA. The area is a vivid place for learning and inspiration, and still carries many traces from the 18th century. The garden site is intact and Bartram's house, largely built with his own hands, survives as well as his 1760 greenhouse. Many of the plants

Bartram sent to Europe have been identified through thorough research by Prof. Mark Laird and Bartram Curator, Joel T. Fry. Around a dozen of species are hitherto identified as authentic from Bartram's garden, and some of them have possibly spread in the area as invasive species. Discussions on a participation in a world heritage serial nomination have been initiated with the management of Bartram's Garden. Support for the issue has been given by the Swedish Colonial Society in Philadelphia

XII. Australia – Botany Bay National Park, New South Wales

Daniel Solander was one of Linnaeus' most skilled students, selected by Linnaeus to become his successor. However, after having moved to London to promote the new systematic biology he eventually lost contact with Linnaeus. Together with Sir Joseph Banks he collected new species all over the world on one of James Cook's voyages. In Australia they made important collections that contributed to the development of a natural system by the English scientist Robert Brown. The area where many important collections were made is today known as Botany Bay, where many of the populations once collected by Banks and Solander remain. One of the species, an icon for the area, is *Banksia serrata*, named in honour of Banks. The area of 4.9 km² is a national park protected under Australian government law managed by New South Wales National Parks and Wildlife Service. Discussions on a participation in a world heritage serial nomination have been initiated with the management of Botany Bay National Park.

Justification of Outstanding Universal Value

The areas of the proposed world heritage nomination named “The Rise of Systematic Biology” together represent a cultural and biological heritage that is unique in reflecting one of the scientific fields of basic need to humanity: systematic biology. To be able to pass on information on organisms important for our survival we are dependent on knowing the names of the organisms around us.

The transformation of the science of systematic biology was mainly due to the work of a single person, Carl Linnaeus. Because of this, the sites connected with this development are tightly linked with one another and reflect also the scientific network at the time. There are reasons to as why the biodiversity of these sites are well documented. Linnaeus taught and practised careful documentation as part of the observational methods that he linked to the science. Plant and animals specimens were carefully collected and preserved and are still available in the museums. Moreover, the extensive correspondence within Linnaeus’ network has been preserved to a large part, and is a great source of information²⁶.

The biodiversity of the selected places and historic man-made remnants, such as buildings, flowerbeds and greenhouses are mainly preserved because of their great scientific and cultural importance. Many of them have been protected by law for a century or more.

Every site has its own importance, but together they are of outstanding universal value. Included are the central sites of the scientific environment of Carl Linnaeus in Sweden. Some of the world’s most important collection sites at the time, in Asia, Australia and Africa, are included as are important representatives of the scientific network of botanical gardens. Some of these sites, like Jardin des Plantes in France and Botany Bay National Park in Australia, were important to the scientific development that continued after the Linnaean era, a development that became a prerequisite for the science of today and the radiation into several disciplines within biology.

The four sites in Sweden are unique in many ways by being the actual places where the scientific ideas were born by Linnaeus and the inner circle of his network. The preserved flora and fauna together form an outstanding trace of the scientific activities performed in the areas. The garden structures from the 18th century help the visitors to understand the historical context of the places. The two preserved homes, positioned in the traces of their 18th century gardens, show to a high degree Linnaeus’ scientific work and deed.

²⁶ See for example Linnaeus correspondence linnaeus.c18.net.

Criteria met according to § 77 of the Operational Guidelines

Criterion vi

The site is directly or tangibly associated with events or living traditions, with ideas, or with beliefs, or with artistic and literary works of outstanding universal significance.

An expert workshop in London 21–23 January 2008²⁷ brought together international experts from the areas of science and the UNESCO Convention. The aim was to discuss how to facilitate the definition of a scientific framework for the identification of sites of the heritage of science and technology of outstanding universal value to recognise them on the World Heritage List. The outcome of the meeting were suggestion of guidelines for the identification of sites, a preliminary framework for the evaluation of properties of interest for the heritage of science and technology and their potential inscription on the World Heritage List. The cultural heritage connected to Linnaeus' important work was presented as a case study for the biological sciences at the meeting.

In a context paper written by the United Kingdom for the meeting²⁸, interpretations of the world heritage site criteria were made for the heritage of science and technology. Criterion (vi) was interpreted as such:

”Criterion (vi) - be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance - should cover places associated with the development of scientific ideas of great importance provided that physical evidence related to this survives.”

The sites included in “The Rise of Systematic Biology” agree with this criterion as interpreted on the workshop in London. The foundation of the science systematic biology was initially one man's work, as seen in Linnaeus' revolutionary publication of *Systema naturae* in 1735. It soon became a grand cooperative work of scientists within his network and beyond. The science developed further already within the same century into a shape that we recognize still today with a natural system and ideas of species development. With time, the science of systematic biology branched into all the disciplines of biology that we see today. One of the branches has maintained the initial task of describing and naming, classifying and understanding the world's biodiversity.

The very foundation of systematic biology, the rise of a broad and genial idea in the 18th century, is still tangible and concrete in the remaining populations of the organisms studied in the wild and in cultivation, in structures found in historic gardens and in the scientific working places, homestead and excursion fields of Carl Linnaeus and his scientific colleagues.

The nomination work might show a need for additional criteria.

²⁷ Meeting presented at http://www.unesco.org.uk/Workshop_Papers.htm

²⁸ To be found on http://www.unesco.org.uk/Workshop_Papers.htm.

Statements of authenticity and/or integrity

Much of the authenticity in the sites of “The Rise of Systematic Biology” is found in extant populations of once studied plants and animals at the different sites. The discussion on authenticity of living organisms has been a vivid part of the science systematic biology due to the type concept. The compulsory assignment of a type specimen was introduced well after Linnaeus’ death. A type specimen is a collected individual that connects a name to a living organism, and thus connects the name to the population where the specimen once was collected and to its taxonomic unit. Accordingly, there has been a period from Linnaeus’ time and onwards when valid names were published, but no type specimen assigned. A demanding task for systematic biologists has therefore been to define which population the scientist referred to when a certain species was described and named. In the absence of specimens, extant populations known to have been studied by the author(s) of a name can then be collected and used.

Extant populations related to a certain specimens may be genetically related to the original organism in different ways. An organism in an extant population may be identical to the once studied individual if it is asexually propagated, i.e. cloned. More often, it is the result of a sequence of sexual propagations with several genetic recombinations involved. The extant population should have a non-broken continuity in the area since the time when the first specimen was collected.

The sites in “The Rise of Systematic Biology” all have authentic populations with organisms related to those studied by the scientists who contributed to the initial development of systematic biology. Apart from the living material, authentic elements found on the sites are different garden structures, houses, roads and landscapes.

At the four Swedish sites the degree of integrity varies among the sites.

In Råshult, the vegetation today is the same as that studied by the young Linnaeus. The flora has not been introduced to the area, but retrieved from the same populations that Linnaeus studied. The topology and geography is the same as in the 18th century and 18th century cultivation methods promote the historical flora and fauna. A few garden plants as kept by Linnaeus’ father still thrive. Elements in the farm yard and the main building are authentic.

The Linnaeus garden with the Linnaeus museum is authentic in its main structures, the plant material and elements in the house structures. The Linnaeus museum is filled with authentic furniture and objects and historic findings hidden in the double flooring have been made. The resurrected garden with its intricate teaching system gives a visitor the same experience as it gave a visitor in the 18th century. The soil frequently reveals authentic objects from rubbish heaps continuously found in the area.

The *Herbationes Upsalienses* holds the largest amount of authentic populations identified by the protocols from the many excursions held there by Linnaeus and his students. Landscapes and structures of fields and meadows remain in some areas the same as in the 18th century. Due to the high degree of field studies in Uppsala since Linnaeus’ time, the continuity of the populations is possible to establish. Recently, as described above, material along the *Herbationes* trails have been selected as a neotype for a Linnaean name.

Linnés Hammarby is remarkably intact in many ways. Here we find Linnaeus’ study still as he left it during his lifetime, never inhabited since. The museum, once hosting the most

important natural collection in the world, still stands intact on the property, surrounded by extant populations of species that Linnaeus included in the collections. The surrounding area is currently transformed into an 18th century agricultural landscape with a biodiversity of that time, enhancing rare species that were common when Linnaeus lived there.

Comparison with other similar properties:

There is no other property on the World Heritage List that embodies the science systematic biology. “The Rise of Systematic Biology” is fully unique. The authentic populations and material structures present in the sites included are together a full representation of the foundation of systematic biology not able to find anywhere else.

Taken one by one, each area has its comparable site. Historic gardens like Kew Garden in the United Kingdoms and Orto Botanico in Padua, Italy, have a similar history part of the scientific history. However, none of these were directly involved in the initiation of systematic biology made by Linnaeus, and their unique values are based on other criteria.

There are some World Heritage Sites strongly connected to biological sciences, like the World Heritage Site Galapagos Islands in Ecuador, which were crucial for Charles Darwin’s formulation of the evolutionary theory. However, the science heritage of extant populations is not described in detail in the documentation nor used as authenticity. The islands have their unique values in the endemic species, not only species studied specifically by Darwin. Also the Table Mountain (part of the World Heritage Site Cape Floral Region), partner in “The Rise of Systematic Biology” is on the World Heritage List. However, it is the unique flora and fauna belonging to the Cape Floral Region that stands out as the main values of this site in the documentation. In combination with the other sites in “The Rise of Systematic Biology” the scientific value of the site is emphasized.

In no site on the World Heritage List has extant populations been regarded as part of the authenticity of the property. This unique form of authenticity would be possible only for a scientific world heritage of a science focusing on a pan-global study of all organism groups, systematic biology.

Appendix

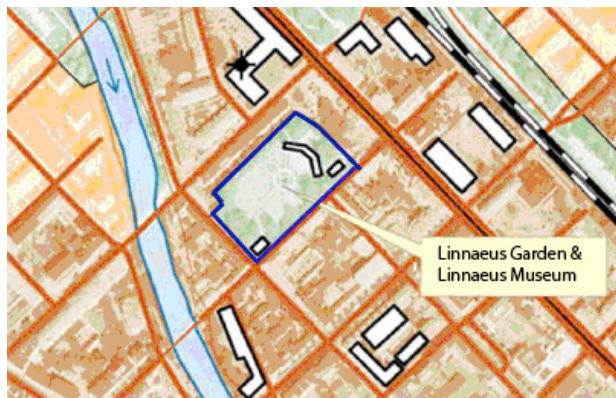
Maps of the Swedish sites

I. Råshult, Stenbrohult, Älmhult

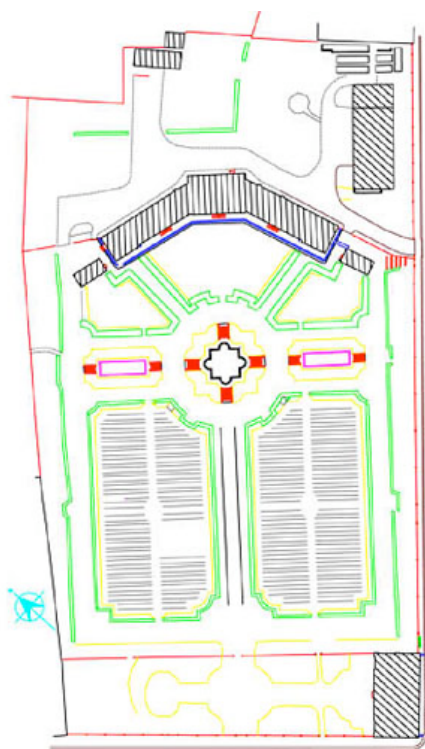


Original map from Lantmäteriet.

II. The Linnaeus Garden (Linnéträdgården) and the Linnaeus Museum (Linnémuseet), Uppsala

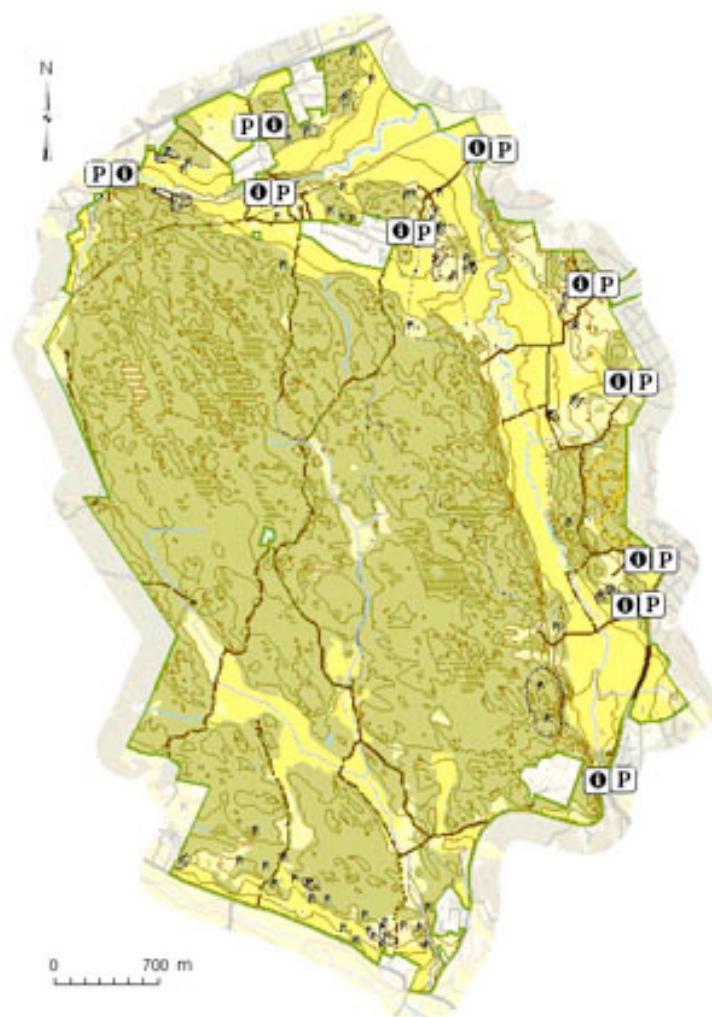


Original map Fastighetskartan, Lantmäteriet.



Detailed map of the garden, museum in lower right corner. From Uppsala University.

IIIa. Hågadalen-Nåsten Nature Reserve, Herbatationes Upsalienses (Linnéstigarna), Uppsala



Map from Uppsala County Administrative Board

IIIb. Fäbodmossen Nature Reserve, Herbatationes Upsalienses (Linnéstigarna), Uppsala



Map from Uppsala County Administrative Board

IV. Linnaeus' Hammarby (Linnés Hammarby), Uppsala



Map from Uppsala County Administrative Board