The Background of Linnaeus's Contributions to the Nomenclature and Methods of Systematic Biology

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THE background of the contributions by Carl Linnaeus (1707-78) to the nomenclature and methods of systematic biology is, of course, an 18th century one, seemingly remote from the modern problems with which a symposium honoring him and at the same time marking the tenth anniversary of the Society of Systematic Zoology is primarily concerned. Many of these problems, however, either had their origin then or were problems which Linnaeus and his contemporaries had to tackle. Nomenclaturists in particular are forced to go back to the works of that period and some knowledge of 18th century methods and viewpoints is essential for determining the correct application of the generic and specific names transmitted through such works to modern biology. The agreement of names tends indeed to obscure the very different circumstances of their origin. As regards Linnaeus and his work, they must certainly be studied, to quote Bremekamp (1953b), "against a background filled by men who were used to debate on theological questions and who even when the debate concerned questions of a different nature clothed their arguments in a theological form and we should be careful not to place him in the circle of the physicists and physically orientated philosophers of that time: that was a world with which he had no contact." In keeping with his personal ecclesiastical background and that of his period Linnaeus chose carefully his numerous Biblical quotations. As text for this occasion organized by the Society of Systematic Zoology he would doubtlessly have approved St. Paul's injunction to Timothy: "Let no man despise thy youth but be thou an example" (*Timothy* I.4.12). It is with some youthful aspects of Linnaeus's work, more particularly with the origin and first use of binomial nomenclature and its dependence on Linnaean taxonomy as expressed in polynomial nomenclature, that the following paper mostly deals. The relations between these are simple but often ignored, a fact which will, I hope, excuse some prolixity of treatment and repetition for emphasis here.

By a coincidence quite unplanned the Society's tenth anniversary has come in the same year as the 200th anniversary of the publication in 1758 of the first volume of the tenth edition of Linnaeus's *Systema Naturae,* which is the internationally accepted starting-point of modern scientific zoological nomenclature. In that volume, published when Linnaeus was fifty-one, he first gave binomial names to all the species of animals known to him, nearly 4,400, including man. Since for nomenclatorial purposes the specimen most carefully studied and recorded by the author is to be accepted as the type, clearly Linnaeus himself, who was much addicted to autobiography, must stand as the type of his *Homo sapiens!* This conclusion he would have regarded as satisfactory and just. As he himself said, *"Homo nosce Te ipsum."*

Linnaeus's Use of Binomial Nomenclature before 1753

The year 1758 is, however, simply an official zoological starting-point. Already in 1752 Linnaeus had given such names as *Phalaena annularia, Ph. antiquata, Ph. ocellata, Ph. caeruleocephala* and *Ph. nigromaculata* to insects considered in the dissertation *Hospita Insectorum Flora subjicit J. G. Forsskåhl;* moreover his works *Museum Tessinianum* (1753) and *Museum S:ae R:ae Adolphii Friderici* (1754) likewise apply a binomial Latin nomenclature to animals. Even earlier, however, he had used binomials for plants, such as *Nymphaea lutea, N. alba, Papaver Rhoeas, Chelidonium majus,* etc., in the index of a travel-book *Öländska och Gothländska Resa* (1745) and in several dissertations, e.g., *Gemmae Arborum* (1749), *Pan Suecicus* (1749), *Splachnum* (1750), and *Plantae esculentae Patriae* (1752). He first applied such names to the plant kingdom as a whole in his *Species Plantarum* (1753) which deals with some 5900 species and is the accepted starting-point of modern botanical nomenclature. Earlier still he had used a binomial system of citation for books in his *Flora Lapponica* (1737) and *Hortus Cliffortianus* (1738) and had advocated it as a suitable method in his *Critica Botanica,* no. 322 (1737): "In every citation the author's name should be given in an abbreviated form, corresponding to the generic name of a plant, and his works, corresponding to the scientific name, since a particular author often owes his fame to more than one work—in the form *Dillen. elth., Dill. gissens., Dill. gener.*—the name of a book should be abbreviated into a single word." Here *Dillen.* and *Dill.* refer to J. J. Dillenius, *elth.* to his *Hortus Elthamensis* (1732), *gissens* to his *Catalogus Plantarum sponte circa Gissam nascentium* (1719), and *gener.* to the appendix *Nova Plantarum Genera* (1719). Thus it is as foolish to be bewitched by the dates 1753 and 1758 in systematic biology as by 1066 and 1776 in history.

Characteristics of Binomial Nomenclature

In botany and zoology the term *binomial nomenclature* refers to that system of naming associated with Linnaeus whereby a species of plant or animal is designated by a two-word name (binomen, binomial), e.g., *Homo sapiens,* consisting of a generic name, e.g., *Homo,* followed by a one-word specific epithet (trivial, trivial name), e.g., *sapiens.* The same generic name covers all species, living and extinct, put in the same genus. The two-word specific name applies to only one species but covers all the individuals classified in that species. A specific epithet has precision only when associated with a generic name; standing by itself it may be without meaning. Generic names and specific names have to be linked to descriptions of genera and species. In other words, the binomial system of biologists derives from a very old and widely used system of naming in general and is based on the assumption that the organisms to be named can be classified into genera and into species, i.e., into entities of different rank (or taxa as they are now called). Even the terms *genus* and *species* are by no means the exclusive property of biologists. They belong also to logic, for example, and the system of treating the individuals of the living world as representatives of the categories *genus* and *species* and named accordingly has been taken into biology from logic, in which they are purely relative terms. The botanical family *Liliaceae* can be logically described as a genus and the botanical genera *Lilium, Hyacinthus, Scilla,* etc., as species of it. In the hands of Linnaeus's 17th century predecessors, notably John Ray (1628-1705) and Tournefort (1656-1708), these two terms acquired the specialized biological applications which Linnaeus adopted.

Linnaeus had reasonably clear-cut ideas on matters of hierarchic arrangement and their expression in nomenclature, although he sometimes found difficulty in applying them, just as have later systematists; for some parts of the animate world genus and species are not concepts which give a good picture of what is going on; they express discontinuity, which does not always exist. As has been indicated already, these concepts did not originate with Linnaeus. His achievement was to take systems of procedure which his predecessors had used incidentally or piecemeal or on a very small scale, to analyse and evaluate them from the standpoint of their practical usefulness, and then to apply them consistently, methodically, and on a large scale to the whole living world as then known.

The nature of this achievement has been misunderstood, e.g., by Raven (1942), and its importance has been underrated through reaction against undue emphasis on Linnaeus's originality. Linnaeus did not invent binomial nomenclature: he did not abandon polynomial nomenclature, i.e., the use of several word names such as *Amyris foliis pinnatis, foliolis sessilibus,* for diagnostic purposes; he introduced a dual system of nomenclature which led to the replacement of diagnostic polynomials by merely designatory binomials. Thus many binomial names which Linnaeus adopted are to be found in the works of his predecessors, notably Konrad Gesner (1516-1565), Clusius (1525-1609), Caspar Bauhin (1560-1624), Willughby (1635-1673), and Ray (1628-1705), e.g., *Crocus sativus* C. Bauh., *Triticum aestivum* C. Bauh., *Panicum americanum* Clus., *Turdus iliacus* Ray, etc. The nomenclature of Gesner and Ray (cf. Greene, 1888) is in some of their works predominantly binomial. Furthermore Pierre Richer Belleval (1562-1632) introduced a deliberate binomial system of nomenclature about 1605. In this a generic name in Latin was followed by a specific epithet in Greek characters expressing several features of the plant, e.g., *Fritillaria* πλατυφυλλαγθομηλινος, *Anemone* αλπιχολευχανθος (cf. Planchon, 1869). Some of Linnaeus's binomials, e.g., *Allium ursinum* and *Lilium candidum,* had even been vernacular plant names among the Romans some two thousand years ago. Names of this kind must have come into existence long before the invention of writing because they arise from a common human need and a common human limitation. This need is that of simultaneously indicating both resemblance and difference. The limitation is that of ordinary human memory; it is easier to keep two words associated than three or four, even though the long phrase may be more informative. The system of naming which Linnaeus built up is based, as Cain (1958) has emphasized, on the conviction that naturalists should be able to ascertain the names of organisms by means of a conspectus and descriptions and to commit these names to memory. The binomial method, derived from the usages of prehistoric hunters and peasants, is simply to have a collective name, such as *owl,* for objects with common attributes and then to distinguish each kind within the group by adding a single word easy to remember, as *barn, burrowing, hawk, little, tawny, snowy,* etc. In English this added word (epithet) normally comes first, although we talk of both *fern royal* and *royal fern;* in Latin, as in many other languages, it commonly follows the generic word. Since these epithets, e.g., *burrowing, little, tawny,* need not be mutually exclusive, the organisms concerned cannot necessarily be recognized simply by means of their names. Thus a person who has seen an owl can recognize other birds of prey with large flattened faces as being of the same nature and call them "owls" likewise, but their specific names, *burrowing owl, little owl,* and *tawny owl,* for example, not being always mutually exclusive, do not enable him, without prior knowledge, to distinguish the species concerned. They are effective means of communication only between people who associate these names with the same concepts; they fail when the same name is associated with different concepts, when for example, the name *screech owl* is applied to both *Tyto alba* (as in England) and *Otus asio* (as in U.S.A.). These associations are learned and memorized among primitive peoples only by direct teaching and experience. Among more advanced peoples they can be recorded in books with pictures and descriptions, which are a form of memory outside the man, and thereby made stable in form and application both from people to people and from generation to generation. These pictures and descriptions must, however, themselves be adequate to establish such a tradition of unambiguous use. They can only do this if they form part of organized knowledge. Linnaeus's big achievement was thus not the invention of binomial nomenclature, which he owed to his predecessors, or even the coining of binomials for some 6,000 species of plants and 4,000 of animals, which he did on the whole with good taste and aptness, but the linking of these names with some 10,000 descriptions and carefully drafted definitions; at the same time he set in order the previous literature, so that other people could thereafter associate the same binomial with the same concept. This was an encyclopedic task in keeping with the general encyclopedic and systematizing effort of the 18th century (cf. Stearn, 1957: 11-12).

Because, however, the *Species Plantarum* of 1753 and the *Systema Naturae* of 1758 are the only Linnaean works now at all widely known, because they are consulted primarily for the binomial names adopted in them, and because it is for these names that Linnaeus is remembered and honored today, the giving of such names might well appear to have been Linnaeus's major activity and the main object of the work concerned. This supposition, though endorsed by textbooks, is erroneous.

In the *Species Plantarum* and the *Systema Naturae* Linnaeus used two sorts of specific names simultaneously for the same organism: binomials or two-word names, such as *Potamogeton natans*, which remain in currency, and polynomials or several-word descriptive and diagnostic names (phrase-names), such as *Potamogeton foliis oblongo-ovatis petiolatis natantibus*, which became obsolete almost in his own lifetime. A true specific name (*nomen specificum legitimum*) was for him the second sort of name, the polynomial or phrase-name, which distinguished the species by its characters from its congeners, rather than simply designated it. These polynomials were thus concise definitions; they functioned as summaries within a system of knowledge, whereas binomials were merely convenient but not essential references to them and by themselves were useless. Linnaeus's binomial nomenclature was in truth a by-product, almost an accident, of his task of providing definitions and means of identifying genera and species. His success in this won acceptance of the binomial names along with his polynomials.

Out of these considerations come various questions relevant to an understanding of the names and methods inherited by modern biology from Linnaeus. His own answers to such questions are mostly to be found in his *Critica botanica* (1737). This work was published when he was 30 years old and expands his *Fundamenta botanica* (1736) which had evidently been drafted earlier. Thus the *Systema Naturae* of 1758 and the *Species Plantarum* of 1753 lead back to the crucial period of his career, his student years from 1727 to 1734. In the *Fundamenta botanica* and *Critica botanica* Linnaeus set forth the basic methods used in his later botanical and zoological works.

Function and Formation of Names

The most important of these questions is: what is the function of a name in biology? On this matter Linnaeus stated (*Crit. bot.* no. 210): "a rustic knows plants and so maybe does a brute beast, but neither can make anyone else the wiser. The botanist is distinguished from the layman in that he can give a name which fits one particular plant and not another, and which can be understood by anyone all the world over." In other words, a name should be a means of communication both precise and suitable for international use.

He then laid down a series of propositions concerning generic names:

"213. All those plants which belong to one genus must be designated by the same generic name."

"214. All those plants which belong to different genera must be designated by different generic names."

"217. If one and the same generic name has been adopted to designate two different genera, it will have to be banished from one of the positions which it occupies."

"228. Generic names with a similar sound give a handle to confusion."

Linnaeus considered that generic names should be apt in meaning, pleasant to hear, easy to say and to remember, and not more than 12 letters long. This led him to shorten *Anapodophyllum*, for example, to *Podophyllum* and *Hydroceratophyllum* to *Ceratophyllum* and to replace *Hypophyllocarpodendron* by *Protea*. "The names bestowed by the ancient Greeks and Romans I commend, but I shudder at the sight of most of those given by modern authorities," he wrote in 1737. In works of 1957 we find such names as *Baccharidastrum notobellidastrum*, *Pteropentacoilanthus hypertrophicus*, and *Echinofossulocactus zacatecasensis*. Rowley (1956) has justly termed them caconyms. Linnaeus would have agreed with him.

Coming to specific names Linnaeus wrote:

"225. A plant is completely named when it is furnished with a generic and specific name."

"256. The specific name should distinguish the plant from all others of the same genus."

"258. The specific name will identify the plant which bears it at the first glance, since it expresses the differentia which is imprinted on the plant itself."

These propositions emphasize the functions of names as means of identification. The kind of names Linnaeus had in mind are, of course, the diagnostic polynomials mentioned above, such as *Salix foliis serratis glabris orbiculatis*, and *Salix foliis utrinque lanatis subrotundis acutis*. These were the names to which he attached most importance, these the names on which he spent most of his creative life; paradoxically we honor him now for getting rid of them! What is the explanation of this seeming contradiction?

The truth is that for most of his life Linnaeus did not realize that he was trying to make a name do more than a name can possibly do. Until 1753 the international scientific name for a species had two rather conflicting functions: (1) to provide a designation which could be held in the memory; and (2) at the same time to state the character or characters distinguishing the species from other species of the same genus. Unfortunately the more species there are in a genus the more difficult it is to state their distinguishing features in a few words. The longer and more efficient the name becomes for diagnosis, the more inefficient and awkward it becomes as a designation. This difficulty, ultimately solved by Linnaean binomial nomenclature, was not so evident in Linnaeus's youth, the period when his ideas took shape, because his knowledge was bounded by the Swedish flora and the then poorly stocked botanic gardens of Sweden. He had no idea of the number of species waiting to be named.

Even in 1753 Linnaeus believed that the number of species of plants in the whole world would hardly reach 10,000; in his whole career he named about 7,700 species of flowering plants. Now life is not so simple. Modern estimates put the number of known species of flowering plants as between 250,000 and 380,000, many times more than he thought possible for the whole vegetable kingdom, and genera such as *Senecio* and *Solanum* each contain over 1,000 species; between 1900 and 1955 botanists described some 198,000 species of flowering plants as new, undoubtedly with undue optimism! The number of living species of Insecta is estimated at about 754,000—850,000 and of animals as a whole 930,000—1,120,000. It is indeed fortunate for biology that Linnaeus passed his life in blissful ignorance of such frightening statistics. Thus, believing that no genus would contain more than 100 species, he calculated (wrongly, as it happens) that the character of a species could always be expressed in 12 words or less.

Memorizing of Genera but not Species

Another reason why Linnaeus did not face this problem during his crucial years was that he was at first pre-occupied with the genus as the unit of classification (cf. Cain, 1956). Before defining the species he had to define the genera and to group these into classes and orders. He took the view that naturalists should be able to memorize the genera, both their characters and their names. In 1737 appeared his *Genera Plantarum.* Explaining the nomenclature employed he stated, that the names of genera should consist of only one word, not used as a technical term, easy to pronounce and not too long, "because generic names have to be committed to the memory, while few need remember specific names."

This last remark is very revealing. Apparently not even Linnaeus expected people to remember long diagnostic specific names. Hence limitations of the memory did not curb their length. By making them ever more precise, loaded with words and pregnant with meaning, Linnaeus inevitably restricted them more and more to learned use. Even in teaching students, they must have been very inconvenient and it may well be that Linnaeus's awareness of his students' difficulties made him favorably receptive to a simpler alternative naming system for everyday use and thus led to the restoration of binomial nomenclature. It is unlikely that he clearly recognized the problem and introduced binomials as a solution.

Influence of Vernacular Nomenclature

A scientific name such as *Primula foliis dentatis rugosis* might be difficult to remember, but what could Linnaeus's students have used instead? A vernacular name? This would create another difficulty. Whose vernacular name? A man from Gotland might know this plant as 'Giökblomma,' one from Småland as 'Käringtänder,' one from Vestergötland as 'Jungfru Mariae Nycklar,' from elsewhere as 'Oxlägg,' and so on. Yet in vernacular nomenclature lay the germ of the answer to this unstated problem. Vernacular names, the names used by unlearned peasants, woodsmen, hunters and farmers, have everywhere the same characteristics: they are mostly short and easy to remember. Even such exceptions as "Welcome home husband though never so drunk"[1] and "Kiss me by the garden gate"[2] have associations that hold them in mind!

This vernacular nomenclature often has a binomial character, sometimes disguised, however, by fusion of its two elements. The blue anemone[3] which Linnaeus in 1745 was calling *Hepatica,* Swedish countrymen then knew and still do as "Blåsippa." The white anemone which he then called *Anemone seminibus acutis foliolis incisis, caule unifloro* they knew as "Hwitsippa" (i.e., 'Vitsippa').[4] Linnaeus did not despise these vernacular names of the Swedish peasantry. On the contrary he was so keenly interested in them that he may have invented a few himself! He recorded them region by region along with scientific names in his *Flora Suecica* (1745). Thus the scientific names adopted in that work under *Bromus,* for example, are polynomials such as 84 *Bromus panicula patente, spiculis ovatis, aristis rectis,* but the Swedish vernacular names are all binomials, as 84 "Råg-losta," 85 "Ren-

[1] *Sedum acre* L.

[2] *Viola tricolor* L., *Viola* x *wittrockiana* Gams.

[3] *Anemone hepatica* L. (*Hepatica nobilis* Miller)

[4] *Anemone nemorosa* L.

losta," 86 "Tak-losta," 87 "Rak-losta," 88 "Lang-losta," 89 "Spärr-losta." In other words, the vernacular binomial system for these grasses preceded the scientific binomial system; indeed it gave rise to this. Thus when Linnaeus dealt with these species in his *Species Plantarum* (1753), he provided them with Latin binomials which are simply translations or near equivalents of their already existing Swedish vernacular names, e.g.

1. *Bromus secalinus,* Råg-losta (i.e., rye-brome)
6. *Bromus arvensis,* Ren-losta (i.e., fieldside-brome)
7. *Bromus tectorum,* Tak-losta (i.e., roof-brome)
8. *Bromus hordeaceus,* Rak-losta (i.e., straight-brome)
9. *Bromus giganteus,* Lang-losta (i.e., tall-brome)
10. *Bromus pinnatus,* Spärr-losta (i.e., ratchet-brome)

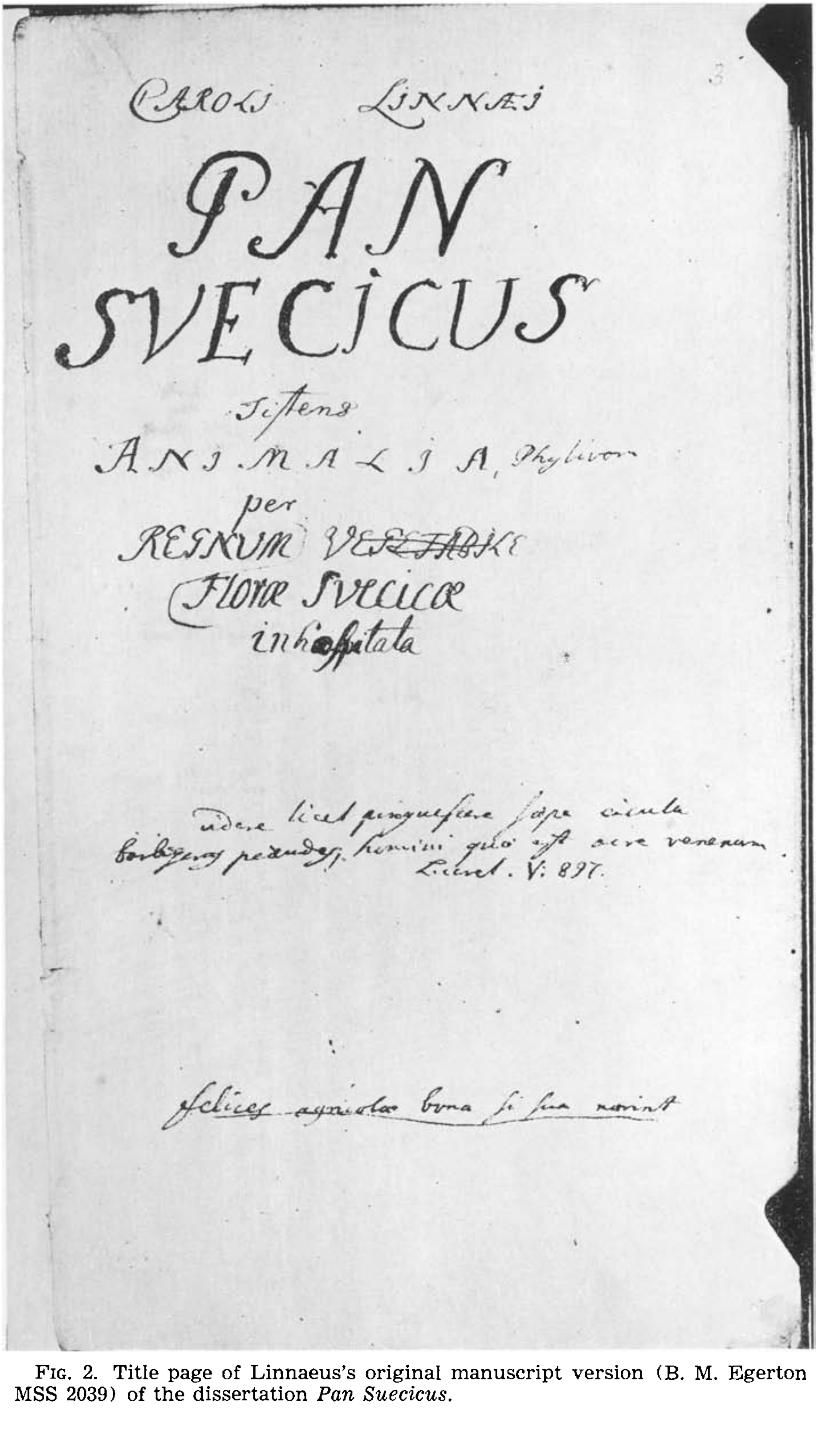
By the introduction of his binomial system of nomenclature Linnaeus gave plants and animals an essentially Latin nomenclature like vernacular nomenclature in style but linked to published, and hence relatively stable and verifiable, scientific concepts and thus suitable for international use. This was his most important contribution to biology.

Origin of Linnaean Binomial Nomenclature

How did this come about? One can surmise only, since Linnaeus left no statement, that it began humbly as a device for the use of students concerned with the Swedish flora, providing them with names easy to index and to remember, thereby saving paper, time, and mental effort, and that it was not intended at the start to be a general system of biological naming. Indeed, however useful it had proved for teaching purposes, it could not have been applied to the whole living world in 1745, when Linnaeus introduced it, because there did not then exist a systematic framework of well-organized diagnostic phrases and descriptions of species upon which such arbitrary binomials could be imposed. Only a few specific epithets occur in the 1746-1748 draft of the *Species Plantarum* and Linnaeus may not have decided to apply them to the whole vegetable kingdom until 1751 when he began to write the final draft published in 1753. Contact with students may, as already indicated, have been the decisive factor.

On his 1741 expedition to the Baltic islands of Oeland and Gotland, Linnaeus was accompanied by "six young, handsome and intelligent youths." It is in the index to the report of this journey, *Öländska och Gothländska Resa* (1749), that he first used consistently and extensively a binomial nomenclature for species. In the dissertation *Pan Suecicus—submittit N. L. Hesselgren* (1749), such a nomenclature was applied to 856 Swedish species (Fig. 1). The authorship of this dissertation has been incorrectly attributed to the student Nicolaus Hesselgren. Linnaeus's letter of 13 April, 1743, to Sauvages (cf. Cassan, 1860: 47) mentions as being in preparation a work *"Pan Suecianus ubi quadrupedes, aves, amphibia, pisces, insecta, vermes omnes Sueciae mihi notae distribuentur—cum loco natali et planta in quibus vivunt insecta."* This evidently became the *Fauna Suecica* (1746). Meanwhile Linnaeus enlisted the help of four students, later increased to more than eight, Hesselgren not being originally one of them, in an enquiry into the plants eaten by livestock, and it is their results which are published in the dissertation *Pan Suecicus* (1749). The original manuscript of this (British Museum, Egerton MSS 2039)[5] is entitled *"Caroli Linnaei Pan*

[5] Since this address was prepared, Ramsbottom (1959, May) has published photographs of three pages of this long-overlooked Linnaean manuscript. They can be compared with the corresponding pages reproduced in facsimile by Heller and Stearn (1959, February; pp. 89–91), as can Ramsbottom (1959) pp. 151–152, 166 with Stearn (1957) pp. 51–55, 67.



CAROLI LINNAEI

PAN
SVECICUS

sistens
ANIMALIA,
per
REGNUM VEGETABILE
FLORAE SVECICAE
inhospitata

videre licet pinguescere saepe cicuta
barbigeras pecudes, homini quae est acre venenum.
Lucret. V: 897.

felices agricolae bona si sua norint

FIG. 2. Title page of Linnaeus's original manuscript version (B. M. Egerton MSS 2039) of the dissertation *Pan Suecicus*.

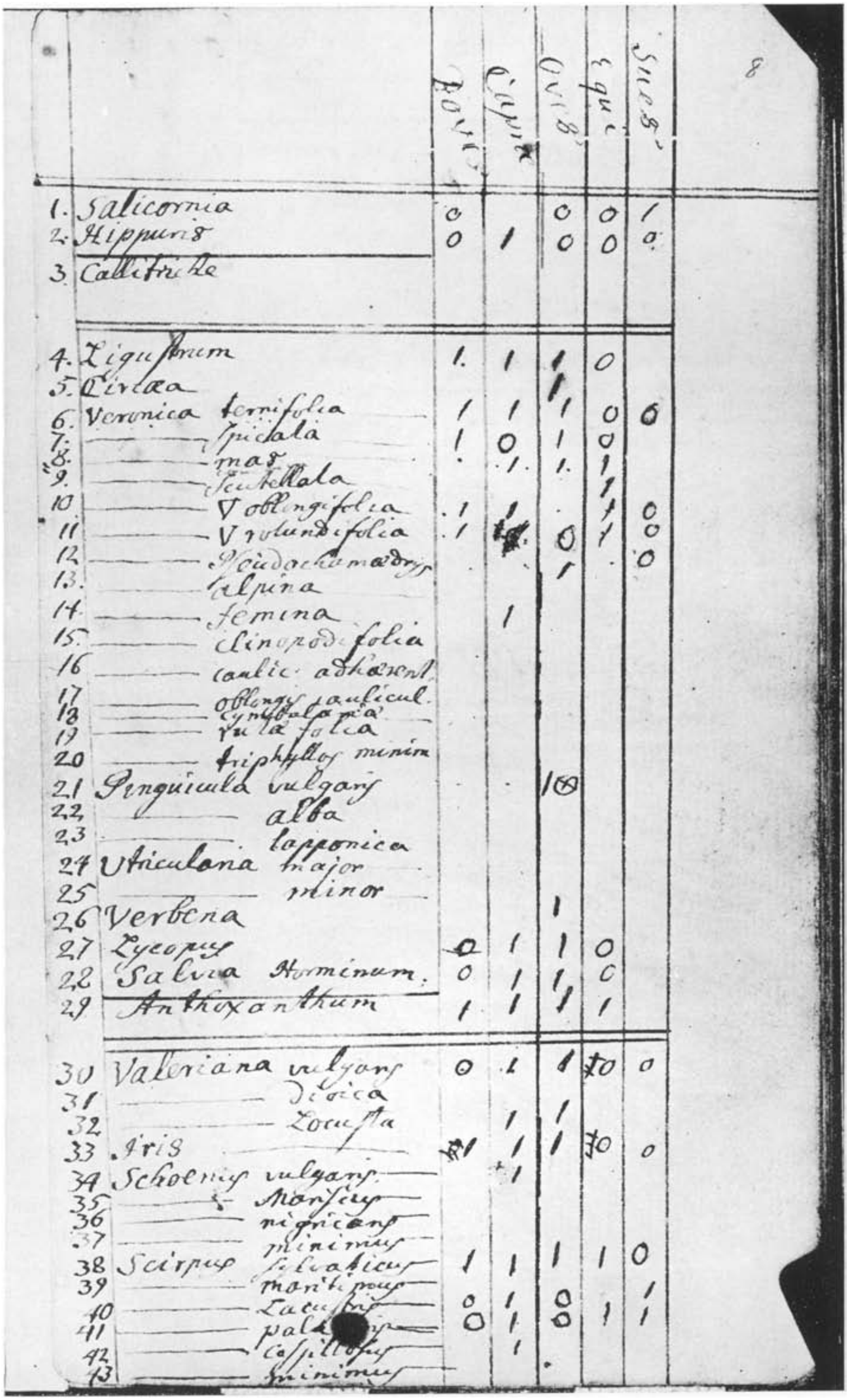


FIG. 3. Specimen page of Linnaeus's manuscript (B. M. Egerton MSS 2039), listing under *Flora Suecica* numbers the Swedish plants eaten or rejected by domestic animals. This is the basis of the dissertation *Pan Suecicus* (1749) and is the earliest surviving manuscript of Linnaeus using deliberate binomials.

E Bibl. Linn. propria. 1784. J E Smith.

D. D.

PAN SVECICUS,

QUEM.

CONSENSU AMPLISS. FACULT. MED.
IN REG. ACAD. UPSALIENSI,

PRÆSIDE

VIRO CELEBERRIMO ET EXPERIENTISSIMO,

DN. DOCT. CAROLO LINNÆO,

S:Æ R:Æ M:TIS ARCHIATRO,
MED. ET BOTAN. PROFESS. REG. ET ORD.
ACADD. IMPERIBL. N.C. MONSPEL. STOCKHOLM.
UPSAL. ET BEROLINENS. SOCIO,

PUBLICO EXAMINI MODESTE SUBMITTIT

NICOLAUS L. HESSELGREN,

WERMELANDUS.

IN AUDIT. CAROL. MAJOR. AD DIEM IX DECEMB.
ANNI MDCCXLIX.

H. A. M. C.

UPSALIÆ

FIG. 1. Title page of the Linnaean dissertation *Pan Suecicus* as published in 1749.

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FLORA SVECICA

	Boves	Capræ	Oves	Equi	Sues
I. MONANDRIA					
1 Salicornia maritima	o	-	o	o	1
2 Hippuris aquatica	o	1	o	o	o
3 Callitriche paluſtris	-	-	-	-	-
II. DIANDRIA					
4 Liguſtrum vulgare	1	1	1	o	-
5 Circæa utraque	-	-	1	-	-
6 Veronica ternifolia	1	1	1	o	o
7 - - ſpicata	1	o	1	o	-
8 - - mås	-	1	1	1	-
9 - - ſcutellata	1	1	1	1	-
10 - - Beccab. oblong.	1	1	-	1	o
11 - - - - rotund.	1	1	o	o	o
12 - - Pſeudo Chamædrys	1	1	1	-	o
13 - - alpina	-	-	-	-	-
14 - - femina	-	1	-	-	-
15 - - clinopodifolia	-	-	-	-	-
16 - - caulic. adhærent.	1	1	1	-	-
17 - - oblongis caulic.	1	1	1	-	-
18 - - cymbalarifolia	1	1	1	-	-
19 - - rutæfolia	-	-	-	-	-
20 - - minima	-	-	-	-	-
21 Pinguicula vulgaris	-	o	o	-	-
22 - - alba	-	o	o	-	-
23 - - minima	-	o	o	-	-
24 Utricularia major	-	-	-	-	-
25 - minor	-	-	-	-	-
26 Verbena vulgaris	o	o	1	o	-
27 Lycopus paluſtris	o	1	1	o	-
28 Salvia Hominum	o	1	1	o	-
29 Anthoxanthum vulgare	1	1	1	1	-

III. TRI-

FIG. 4. Specimen page of the Linnaean dissertation *Pan Suecicus* (1749), listing Swedish plants eaten or rejected by domestic animals.

Suecicus sistens Animalia phytivora per Regnum Florae Suecicae inhospita." In the introduction of this manuscript (cf. Uggla, 1957; Ramsbottom, 1959), presumably written in or after 1746, the year of publication of the *Fauna Suecica,* neither binomials nor polynomials appear; species are designated simply by a generic name and a number which refers to an entry in the *Flora Suecica* (1745), e.g., *Euphorbia* 436 or Stormhatten (i.e., *Aconitum*) 422, or in the *Fauna Suecica* (1746), e.g., *Phalaena* 825. This was evidently the general procedure of the period. In other Linnaean works of a concise or general nature, e.g., the dissertations *Flora oeconomica—submittit E. Aspelin* (1748), *De Oeconomia Naturae—submittit I. J. Biberg* (1749), and *Cui bono?—offert C. Gedner* (1732), species are likewise designated only by the *Flora Suecica* or *Fauna Suecica* number and their generic name, e.g., 404 *Filipendula* and 405 *Filipendula, Sturnus* Fn. 183, *Fringilla* Fn. 99. To correlate the observations later published in the *Pan Suecicus,* Linnaeus listed by their *Flora Suecica* numbers and generic names all the species enumerated in the *Flora Suecica* and ruled five columns into which a note could be made stating whether the plant was eaten or rejected by cattle, goats, sheep, horses, or swine (Figs. 3, 4). When the species belonged to a monotypic genus, he simply entered the generic name without epithet, e.g., 1. *Salicornia,* 2. *Hippuris,* 3. *Callitriche,* 4. *Ligustrum,* 5. *Circaea,* but when there were several species of the same genus he added an epithet to the generic name, e.g., 21. *Pinguicula vulgaris,* 22. *Pinguicula alba,* 23. *Pinguicula lapponica,* 24. *Utricularia major,* 25.

Utricularia minor. This is the same system as he adopted at about the same time in the index of the *Öländska och Gothländska Resa* (1745) where, however, the *Flora Suecica* number comes between the generic name and the epithet, e.g., *Pinguicula* 21 *vulgaris, Utricularia* 24 *major*. It was a convenient tabulating and indexing device with potentialities which he may not have fully appreciated then but which he exploited later.

It seems likely, however, that the long diagnostic specific names never were in conversational or general use. Essentially book-names coined in the study, they imposed too great a burden upon the memory for much use anywhere else, e.g., in the garden and on botanical excursions. The "herbationes Upsalienses" of Linnaeus were very popular, sometimes attended by 200 to 300 persons, and in the course of them he discussed the medicinal properties and uses of the plants found. His students took notes and presumably, like students everywhere, they had to jot down the professor's information quickly. It is hard to believe that even Linnaeus would have said something like "this roadside weed is *Achillea foliis duplicato-pinnatis glabris, laciniis linearibus acute laciniatis;* over there in that damp hollow is *Galium foliis quaternis obverse ovatis inaequalibus;* in this dry place we have *Dianthus floribus solitariis, squamis calycinis lanceolatis, corollis crenatis;* look sharp and list them!" Fortunately a few original notes (protocols) of these Linnaean excursions around Uppsala still exist (cf. Hjelmquist, 1951; Berg and Uggla, 1951). They reveal that, even before the introduction of consistent binomial nomenclature for species of plants in 1753, Linnaeus did not use such long-winded names in the field. Thus on an excursion of 1748, the three species just mentioned were simply designated as *Achillea* 705, *Galium* 119, *Dianthus* 342, the numerals referring to species-entries in Linnaeus's *Flora Suecica* (1745) where their diagnoses (*nomina specifica legitima*) are to be found. This is really a binomial system, with a number serving as a specific epithet. The disadvantage of the number was that it had meaning only when associated with a given entry in a given edition of a certain book, and possessed nothing distinctive to link it with a particular species. Linnaeus himself said in his *Critica botanica*, no. 258 (1737), when outlawing as absurd such names as *Tinus prior, Tinus alter, Tinus tertius,* that "the numerical order which the old botanists stamped on their own brains they assuredly failed to stamp on plants, in such a way that anyone can perceive a trace of it." In the index to the *Öländska och Gothländska Resa* (1745; reproduced in Stearn, 1957) already mentioned, Linnaeus followed the number by a catchword or epithet, as *Galium* 116 *luteum, Galium* 118 *album, Galium* 119 *cruciata, Filipendula* 404 *vulgaris, Filipendula* 405 *Ulmaria, Achillea* 705 *Millefolium.* After the publication of the *Species Plantarum* in 1753, *Achillea* 705 could be designated as *Achillea millefolium, Galium* 119 as *Galium palustre,* and *Dianthus* 342 as *Dianthus deltoides;* the epithets (*nomina trivialia*) were now linked with diagnostic names (*nomina specifica legitima*) in the *Species Plantarum* just as definitely as the *Flora Suecica* numbers had been linked to diagnostic names. The numerals thus acted as a means of transition from the polynomial to the binomial system when the need for the latter was becoming evident to Linnaeus. This transitional stage is well exemplified in the lists of species on pp. 265-275 of Linnaeus's *Philosophia botanica,* written in 1750, when Linnaeus needed concise designations but apparently had not yet definitely made up his mind about their formation; here designations such as *Campanula* h. cliff. 4, *Melampyrum* Fl. su. 510, *Lactuca* 1 *sativa, Calendula africana* Hort. ups. 274 n. 2., *Reseda vulgaris* concisely replace polynomials but have not been reduced to a uniform style.

Advantages of Binomial Nomenclature

As a means of communication the binomial system had two advantages over the polynomial one: firstly, a concise albeit arbitrary name such as *Veronica spicata* was easier to remember than the alternative diagnostic one *Veronica floribus spicatis, foliis oppositis, caule erecto;* secondly, it could remain constant as long as the plant remained in the same genus, whereas a diagnostic name in order to remain diagnostic had to be revised whenever related new species came to hand. Thus Linnaeus's 1738 polynomial for this species was *Veronica foliis oppositis, caule spica terminato,* i.e., 6 words; his 1745 polynomial *Veronica floribus spicatis, foliis oppositis, caule erecto,* i.e., 7 words; his 1753 polynomial *Veronica spica terminali, foliis oppositis crenatis obtusis, caule adscendente simplicissimo,* i.e., 11 words. The alternative two-word name *Veronica spicata,* introduced by Linnaeus in 1745 and retained by him in 1753, has remained unchanged to the present day. These two advantages were in fact noted by Linnaeus in his *Philosophia botanica* no. 257 (1751).

The binomial was intended for general everyday use, as the term *nomen triviale* introduced in *Philosophia botanica* (1751) for the epithet of a binomial and the adverb *Vulgo* (for all the world, generally) placed before the new binomials *Splachnum rubrum* and *Splachnum luteum* in the dissertation *Splachnum—subjicit L. Montin* (1750) make evident, but it was not intended to supersede the polynomial, such as *Splachnum umbraculo convexo* or *Splachnum umbraculo plano,* for diagnostic purposes.

By no means all known species had been designated by polynomials before they received binomials. About 300 of the genera recognized by Linnaeus in 1753 were then monotypic, and for the designation of their one and only species the generic name alone would have sufficed. The binomial system actually lengthened the names of such species. Thus E. L. Greene pointed out, "in 1751 he [Linnaeus] founded the genus *Sarothra.* There was but one species and *Sarothra* was all the name it needed. Two years later, coming to the fulfilment of his purpose of a universal binomial nomenclature, he gave it its merely decorative or balancing appendage of a specific name and called it *Sarothra gentianoides.*" Linnaeus's deliberate and systematic expansion of monomials into binomials was just as significant a departure from accepted usage as the contraction of polynomials into binomials; under the old system it would have been highly illogical. He began this in 1745 by attaching the "merely decorative or balancing appendage" *unicus* to the generic names *Anthoxanthum, Aphanes, Asperugo, Hottonia, Glaux, Scheuchzeria, Trientalis, Adoxa, Butomus, Agrostema, Hepatica, Caltha, Linnaea,* and *Taxus,* thereby indicating the then monotypic state of the genera concerned; it was not simple pride that led him to name the twinflower *Linnaea unica!*

Concurrent Binomials and Polynomials

Thus Linnaeus separated the two functions, designatory and diagnostic, of names for species. As mentioned above, this involved the concurrent use of two sets of names: 1) the binomial, such as *Phlomis fruticosa,* which designated the species, 2) the polynomial, such as *Phlomis foliis subrotundis tomentosis crenatis, involucris lanceolatis,* which stated the characters distinguishing it from other species. Linnaeus did not discard the old many-word specific names (*nomina specifica legitima*) when he introduced the new single-word epithets (*nomina trivialia*) often taken from earlier authors, e.g., Gesner, Clusius, C. Bauhin (see above), to maintain continuity; he often used the two kinds of name side by side and kept on coining both concurrently for the rest of his life. The polynomial because of its key function within Linnaeus's vast system of biological recording gave meaning and stability to the more easily memorized binomial. Hence its importance, too often overlooked or ignored, in the typification of Linnaean species which is essentially determination of the specimen or illustration providing the characters expressed in the polynomial, applied to a species in a genus not monotypic.

Linnaeus's Character

The introduction of this binomial system of nomenclature has proved Linnaeus's most lasting contribution to systematic biology but it arose out of his other achievements, which in turn can only be understood by reference to his career and character, his own aims and the general knowledge of his time. On these there is abundant information elsewhere (cf. Boerman, 1953; Gourlie, 1953; Hagberg, 1952; Stearn, 1957). His father, the first man to bear the name Linnaeus, was a Lutheran clergyman of limited means, interested in natural history—he possessed, for example, Aristotle's *Historia Animalium* (cf. Fredbärj, 1956)—and in gardening. His influence probably helped Linnaeus towards the belief that it was his mission to reveal the three realms of Nature in an orderly manner, to produce his *Systema Naturae.*

The character of Linnaeus was too complex to find expression as a whole in any one technical work, but the *Systema Naturae* in its history, its aim, its format, its arrangement and its contents, somehow epitomizes what are for us the most important aspects of it. To unravel, however, all that lies behind that book in its tenth edition would be a task comparable in magnitude to, and needing the same wide scholarship as, analysing Goethe's *Faust* or following the intricate intellectual meanderings and digressions of Samuel Taylor Coleridge along *The Road to Xanadu* traced by J. L. Lowes. Linnaeus's *Systema Naturae* of 1758-59 looks a rather dull and formal reference book, to be taken off the shelf merely to check the spelling of a name and its typification. It is a little hard to see it in its full significance as a work wherein a single mind sought to grasp and to record succinctly the distinguishing features of all the genera and all the species of animals and plants upon the face of the earth and in its waters. The mere thought of doing this today, when an army of systematists cannot accomplish it, is staggering. I am reminded of what J. M. Keynes has said about Newton in one of the shortest and most illuminating essays ever written about that strange man, "the last of the magicians," because although the intellects of Newton and Linnaeus were of very different quality their attitudes were alike conditioned by theological interests alien to the modern scientific world. Newton, as Keynes has convincingly argued, "regarded the universe as a cryptograph set by the Almighty—by pure thought, by concentration of mind, the riddle he believed would be revealed to the initiate." Linnaeus never attempted Newton's probing of the esoteric, but he believed the universe to have a divine plan. Concerning this Hofsten (1958) has indicated the influence of Seneca's *Quaestiones* in reinforcing impressions gained from the Bible: "Linnaeus's general concept of Nature as a wonderful harmony manifesting a divine purpose is on the whole very often a reflection of ideas in Stoic philosophy." Backed by such views on the orderliness and coherence of Nature, Linnaeus set out to reveal the Creator's work to his fellow men and in so far as this concerned distinguishing of genera and species he succeeded remarkably. His achievement, as J. H. Plumb has written of Dryden's, raises "the fascinating question of success, of the relationship between certain varieties of human temperament and the societies which valued them and allowed them to cultivate their gifts. Probably genius is not uncommon but needs great luck—luck of time, luck of circumstance. Neither Newton, nor Wren, nor Pope would have stood much chance if they had been humbly born in the slums of St. Giles-in-the-Fields or in tenth-century

Stornoway." It was Linnaeus's good fortune that his gifts were those which supremely met the needs of the time in biology and that at crucial periods of his life he came into contact with men who were able to keep him on the way to the full exercise of those gifts. His enthusiasm, his ability and his genial disposition—even though jealousy often lay behind it—convinced wealthy backers at the right time. Their perspicacity, as it happens, has embalmed their names in biology: the genera *Celsia, Rudbeckia, Gronovia, Lawsonia,* and *Cliffortia* commemorate Linnaeus's patrons.

The Systema Naturae

When in 1735, at the age of 27, Linnaeus left Sweden for Holland, he had planned and partly written all of his later major works. He took with him, among other manuscripts, the draft of the first edition of his *Systema Naturae.* This ingenious work was just what naturalists of the time needed. The Dutch had holdings in South America, the West Indies, South Africa, and the East Indies, with an outpost in Japan, while the British held part of Eastern North America, the West Indies, and India (cf. Stearn, 1958b). From these countries an immense number of natural history specimens and plants for gardens were being introduced, via Holland and England, into Europe. The owners of collections needed a system of arranging and naming their material (cf. Stearn, 1959). Linnaeus's *Systema Naturae* provided a concise, methodical, and ingenious synopsis whereby a mineral, a plant or an animal could be referred to a definite place within a system and associated with a name. Gronovius and Lawson were so impressed that they sent the young Swede's work to be printed at their own expense. It consists of only 12 folio pages, now so rare that a copy was sold in London in 1930 for £350, another in 1954 for £1100, and a third in 1959 for £2900.

In 1740 Linnaeus brought out a second edition, octavo this time, in 1748 another (sixth edition); neither of these employs binomial nomenclature; not until 1758 appeared the first one (the tenth edition) to do so. The 1740 and 1748 editions list many species of animals, but not of plants with which Linnaeus was then dealing in other works. They are, however, essentially concise synoptic treatments of genera, making no pretence to a detailed treatment of species. In 1753 and 1758 he covered the species as well.

Thus by 1758 Linnaeus had built up a system of classification embracing the whole living world as then known and had defined its classes, genera, and species, with such economy of words that he sometimes dealt with 20 species on a single octavo page. The merit of the work lies indeed in its efficient comprehensiveness rather than any originality of design. The notion that resemblances in certain organs are more important than differences in others goes back to Andrea Cesalpino's *De Plantis Libri* XV (1583), which is primarily concerned with fruiting structures, and its acceptance leads almost automatically "into an assemblage of divisions and groups successively subordinate the lower to the higher, like the brigades, regiments and companies of an army, or the provinces, towns and parishes of a kingdom," as described by Whewell. Cesalpino (1519-1603) himself wrote: *"Cum igitur scientia omnis in similium collectione et dissimilium distinctione consistat; haec autem distributio est in genera et species veluti classes secundum differentias rei naturam indicantes."* Linnaeus did not accept the classification of plants set forth by Cesalpino (cf. Bremekamp, 1953) and other pre-Linnaean authors but grouped the genera according to his own admittedly artificial "sexual system" based on the number of stamens and pistils. For his primary divisions of the animal kingdom he adopted the characters used earlier in John Ray's *Synopsis methodica Animalium* (1693). Although Ray swept aside the old unsatisfactory classification of animals derived from Aristotle, he nevertheless "adopted certain Aristotelian criteria, the structure of the mammalian foot, for example, and by strict application of the principle of the 'Excluded Middle' (everything is either A or not A) produced a series of essentially dichotomous keys, which were remarkably successful in achieving a workable method of classifying animals" (Hopwood, 1905b: 46). Thus Ray's work, like Linnaeus's derived from it and Cesalpino's preceding it, was based on the general principles of classification as laid down in Aristotelian logic. Even if Linnaeus himself made no direct study of these, he could have learned their essentials from his teachers, J. S. Rothman (1684-1763) and the younger Rudbeck (1660-1740), and his erudite ill-starred collaborator Petrus Artedi (1705-1735). Since these principles have been well expounded by Cain (1958), it is unnecessary to do more than summarize them here.

Logic of Classification

In terms of logic, arranging subjects into classes is classification; distinguishing divisions of classes is logical division. The same principles apply to these upward and downward processes. One is that co-ordinate classes must be mutually exclusive. The group to be divided is the *genus;* the parts into which it is divided are the *species.* The characteristics which the species possess are of several kinds, i.e., (1) those which every member of the genus possesses but which are also possessed by members of other genera; (2) those which every member and only a member of the genus possesses; (3) those which only a given member possesses. Investigating the characteristics of a group and determining to which kind they belong is a fundamental taxonomic procedure, but not confined to biology. Every species is what it is and not something else because it is an expression of its essence; as expressed by Maritain "it is by and in its *essence* that a thing possesses being or *existence.*" The definition of the particular species must provide a statement of the characteristics, arising out of its essence, that make it that and not something else. The *definition* thus covers the characteristics which the species shares with other member-species of its genus which is implied by giving it and them the same generic name, and those characteristics which distinguish it from these other members, its *differentiae.* This process of definition is described as being *per genus et differentiam.* Simply to know this about something merely enables it to be recognized and is preliminary to other investigation. Nevertheless the definition of some 6000 species of plants and 4000 species of animals in the *Systema Naturae* is a monumental achievement. Whatever Linnaeus failed to do that later people with lesser burdens think he should have done, his definitions and classification of all these organisms stands out as something that no one else could do then and no one else has been able to do since.

Linnaeus's Treatment of the Genus Fulica

After Linnaeus's death his student, the entomologist J. C. Fabricus (1745-1808), said of him that "his greatest asset lay in the co-ordinated arrangement which his thoughts took. Everything that he said and did was orderly, was systematic, and I can hardly believe that Europe will produce a more systematical genius." That is indeed the impression that these works give. To illustrate the system employed almost any two pages of the *Species Plantarum* of 1753 or the *Systema Naturae* of 1758 will suffice. Thus at the top of the page of the *Systema Naturae* (1758) relating to the genus *Fulica* (Fig. 5), is the heading *Aves Grallae.* This places the genus in relation to a major division, *Aves* (Birds), and a subdivision of this, the *Grallae* (Rails, Coots, etc.). Then comes the generic number and name and then a concise statement of generic character:

82. FULICA, *Rostrum* convexum: Mandibula superiore margine supra inferiorem fornicata; Mandibula inferior, pone apice

152 AVES GRALLÆ. Hæmatopus.

81. HÆMATOPUS. *Roſtrum* compreſſum: apice cuneo æquali.
Pedes tridactyli, fiſſi.

Oſtralegus. 1. HÆMATOPUS. *It. œl.* 83. *Fn. ſvec.* 161. *Bell. av.* 18. *Aldr. orn. l.* 20. *c.* 31. *Will. orn.* 220. *t.* 56. *Raj. av.* 105. *Alb. av.* 1. *p.* 74. *t.* 78. *Catesb. car.* 1. *p.* 85. *t:* 85.
Habitat in Europæ, Americæ *ſeptentrionalis littoribus marinis; victitat conchis.*

82. FULICA. *Roſtrum* convexum: Mandibula ſuperiore margine ſupra inferiorem fornicata; Mandibula inferior, pone apicem gibba.
Frons calva.
Pedes tetradactyli, ſublobati.

atra. 1. F. fronte calva, corpore nigro, digitis lobatis.
Fulica fronte calva æquali. *Fn. ſvec.* 130.
Fulica. *Bell. av.* 36. *b. Geſn. av.* 390. *Aldr. orn. l.* 19. *c.* 13 *Will. orn.* 239. *t.* 59. *Raj. av.* 116. *Marſil. danub.* 70. *t.* 33. *Alb. av.* 1. *p.* 79. *t.* 83. *Haſſelqv. act. upſ.* 1751. *p.* 22. *itin.* 262.
Habitat in Europa; *hybernat in Gallia.*
Edit Semina, Herbas; natat ſupraque aquam currit.

Chloropus. 2. F. fronte calva, corpore nigro, digitis ſimplicibus.
Gallinula Chloropus. *Alb. av.* 2. *p.* 66. *t.* 72. & 3. *p.* 86. *t.* 91. *Raj. av.* 113.
Habitat in Europa.

Porphyrio. 3. F. fronte calva, corpore violaceo, digitis ſimplicibus.
Fulica major pulla, fronte cera coccinea oblongo-quadrata. *Brown. jam.* 479.
Porphyrio. *Alb. av.* 3. *p.* 79. *t.* 84. *Raj. av.* 116. *n.* 13. *Edw. av.* 87. *t.* 87. *Dodart. act.* 3. *p.* 30?
Habitat in Aſia, America.

ſpinoſa. 4. F. fronte caranculata, corpore variegato, humeris ſpinoſis, digitis ſimplicibus, ungue poſtico longiſſimo.

Galli-

AVES GRALLÆ. Fulica. 153

Gallinula alis cornubus donatis. *Edw. av.* 48. *t.* 48.
Habitat in America *auſtrali.*
Unguis poſticus rectus, digito longior. Pollex unius articuli inſiſtens. Remiges virides.

FIG. 5. Text of Linnaeus, *Systema Naturae*, 10th ed., vol. 1; 152-153 (1758), relating to the genus *Fulica.*

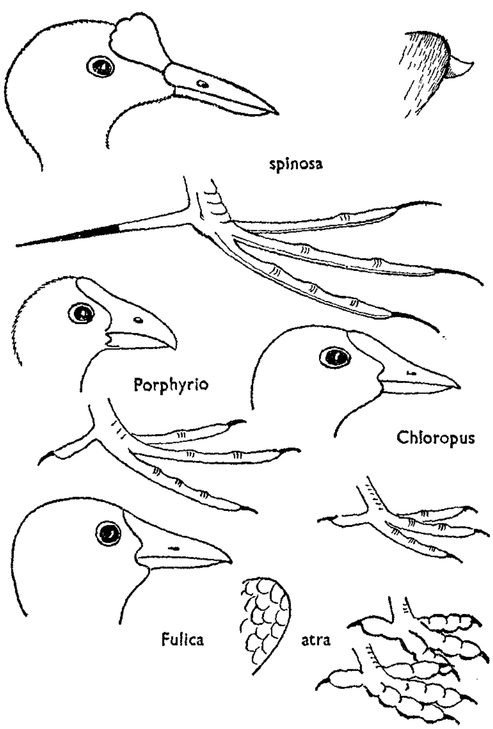

FIG. 6. Specific differential characters in the Linnaean genus *Fulica* as portrayed by pre-Linnaean authors cited by Linnaeus: *Fulica atra* (lectotype of the genus *Fulica*), after Albin, 1738, Hist. Birds 1, t. 83; *Chloropus* (= *Gallinula chloropus*), after Albin, 1738, Hist. Birds 2, t. 72; *Porphyrio* (= *Porphyrio porphyrio*), after Edwards, 1747, Hist. Birds 2, t. 87; *Fulica spinosa* (= *Jacana spinosa*), after Edwards, 1743, Hist. Birds 1, t. 48.

gibba. *Frons* calva. *Pedes* tetradactyli, sublobati.

Within the genus *Fulica* Linnaeus distinguished four species, each provided in the margin with a specific epithet or trivial name—(*atra, Chloropus, Porphyrio, spinosa*)—as well as a species number. Next to this comes the name of the genus (*Fulica* abbreviated to F.) followed by the definition or differentia (*nomen specificum legitimum*) and then below this synonyms, references to literature, statement of distribution, and sometimes other information. The account of each species given at first publication is conveniently termed its protologue (cf. Stearn, 1957: 126, footnote). The most important elements of these protologues are the differentiae:

atra	1. fronte calva, corpore nigro, digitis lobatis
Chloropus	2. fronte calva, corpore nigro, digitis simplicibus
Porphyrio	3. fronte calva, corpore violaceo, digitis simplicibus
spinosa	4. fronte carunculata, corpore variegato, humeris spinosis digitis simplicibus, ungue postico longissimo.

Such differentiae provide all the material needed for simple keys to the species:

Frons calva Corpus nigrum vel violaceum. Humerus non spinosus: Ungues aequales:
Digiti lobati .... 1. *atra*
Digiti simplices:
Corpus nigrum.... 2. *Chloropus*
Corpus violaceum. 2. *Porphyrio*
Frons carunculata. Corpus variegatum. Humerus spinosus.
Unguis posticus longissimus .. 4. *spinosa*

An alternative key using the same information is as follows:

Digiti lobati .... 1. *atra*
Digiti simplices:
Frons calva: Humerus non spinosus; Ungues aequales:
Corpus nigrum.... 2. *Chloropus*
Corpus violaceum. 3. *Porphyrio*
Frons carunculata. Humerus spinosus. Unguis posticus longissimus .... 4. *spinosa*

These keys show the use of both essential and synoptic characters. An essential character (*nomen specificum essentiale*) is a single character enabling the species to be recognized by it alone, e.g., the flanged or lobed toes (*digiti lobati*) of the coot (*F. atra*), the violet plumage (*corpus violaceum*) of the purple coot (*F. Porphyrio*), the very long hind-claw (*unguis posticus longissimus*) and the spur on the wing (*humerus spinosus*) of the jacana (*F. spinosa*). A synoptic character (*nomen specificum legitimum*) mentions several features which are diagnostic when associated but not so when taken singly, e.g., the non-flanged toes (*digiti simplices*) and black plumage (*corpus nigrum*) of the moorhen or gallinule (*F. Chloropus*).

Such diagnostic phrase-names are completely in accordance with the traditional Aristotelian procedure of definition *per genus et differentiam.* Together with the references to the works of Gesner (1516-1565), Belon (1517-1564), Aldrovandi (1522-1605), Ray (1628-1705), Willughby (1635-1673), Marsigli (1658-1730), Edwards (1694-1773), Albion (c. 1720-1759), and Patrick Browne (c. 1720-1790), they made it easy to distinguish the birds concerned.

Comparison of Linnaeus's definition of the genus *Fulica* with the definitions of the species reveals some surprising discrepancies. According to the generic definition all the species should have *"frons calva,"* yet the fourth species (*spinosa*) is distinguished from the other three in having *"frons carunculata."* In choosing a lectotype for the genus *Fulica* this species can be at once eliminated. The generic definition also calls for *"pedes sublobati"* but the second and third species (*Chloropus* and *Porphyrio*) are defined as having *"digitis simplicibus"* and thereby distinguished from the first species (*atra*) with *"digitis lobatis"* (Fig. 6). Linnaeus's first species (*atra*) is in fact the only one which agrees with the generic definition. It is also the species called *Fulica* by earlier authors. It would also seem to be the only species with which Linnaeus himself was well acquainted, judging from his reference to the *Fauna Suecica* and his note on its habits. Hence *Fulica atra* is to be accepted as the type-species of the genus *Fulica* and retained in *Fulica,* as it always has been, when the Linnaean genus is divided.

In this way Linnaean genera are to be typified. Linnaeus should, of course, have framed his generic definition so that it applied to all the species. The above kind of discrepancy shows, as Pennell pointed out in 1939 for the Scrophulariaceae (cf. Stearn, 1959: 37), that Linnaeus took a species well known to him and based his generic character on this species. The character once drafted, it generally stayed unaltered from edition to edition. When Linnaeus later came to know other species which he felt to be congeneric with the original one by their general appearance or the sum of their characters, but which diverged from the stated diagnostic characters of the genus, he put them in the same genus but often left the generic description as it was. He ought, of course, to have redrafted the generic description to make it agree with the characters of all the species included. Probably he intended to do so. In fact, however, he was too busy and thus left these significant pointers to the bases of his concepts and his manner of working. They are, indeed, valuable for purposes of nomenclature as indicating lectotypes for Linnaean genera.

Conflict Between Logical and Empirical Approach

On a higher level the interest of these discrepancies is the hint they give of conflict or lack of harmony in Linnaeus's mind between the *a priori* approach of logic and the empirical approach of modern science. The question implied is: (1) should things be put together because they conform to a definition already framed or *vice versa* separated because they do not do so, irrespective of other resemblances and differences, or (2) should they be linked to things with which they agree in their characters generally, despite lack of agreement with the definition?

This is a basic matter in taxonomy. Linnaeus, by the methodical cast of his mind, was biased to take the first course, that of the *dispositio theoretica* as he called it (cf. *Phil. bot.* no. 152), and usually did so with classes, orders, and genera. This way leads, of course, to artificial systems of classification often very useful for determination of names. On the other hand, Linnaeus's poetic feeling for Nature, his aesthetic sensitivity, which is closely linked to taxonomic insight, and his experience led him in dealing with species and varieties another way, to what he called the *dispositio practica,* the empirical method of modern science. Whewell (1847) noted this by observing that "upon the whole, however, he inclines rather to admit transgression of art than of nature."

Another manner of expressing the same divergence or conflict is to ask: should things be classified by definitions or grouped around types? In practice Linnaeus did both, as modern systematists still do. Thus, when anyone determines material by means of a key which gives him a series of clear unambiguous contrasting statements and he then accepts the name to which continuous exclusion of non-applicable statements has led him, then he has used the Method of Logical Division based on definition. When he determines material by going through a set of specimens or pictures to find which it matches best or he determines it at sight by memory of material seen before, then he follows the Type-method. H. W. B. Joseph in his *Introduction to Logic* (1916) has shown how "the problem of distinguishing between essence and property in regard to organic kinds can be declared insoluble" and that "for definition such as we have it in geometry, we must substitute classification," concluding that "a type classification attempts to establish types" and "it will be the description of the type, drawn up on such principles as these [already enunciated] that will serve for definition." The relevance of this to biological taxonomy has been pointed out by Cain (1958). We must be careful in considering these matters to remember that the word "type" as used in formal nomenclature, in morphology, and in logic has not completely coincidental meanings and applications. Without going any deeper into this question it seems safe to say "that within every main entry in the *Species Plantarum,* as in the *Genera Plantarum* and also the *Systema Naturae,* 10th ed., there is, or was at some stage of its development, a tangible element, either an illustration or a specimen, with which his strong visual memory could associate other material" (cf. Stearn, 1957) and that Linnaeus regarded this element as exhibiting the characteristic features and qualities of the concept involved. His taxa never began as abstract concepts based simply on analysis of descriptions in the literature.

Division of Linnaean Genera

Typification is important because later workers have often found Linnaeus's concepts of genera and of species too comprehensive. Thus his four species of *Fulica* already mentioned are now put in as many genera:

1. *Fulica atra,* the coot=lectotype of the genus *Fulica.*
2. *Fulica chloropus,* the moorhen=*Gallinula chloropus.*
3. *Fulica porphyrio,* the purple coot= *Porphyrio porphyrio.*
4. *Fulica spinosa,* the Middle American jacana=*Jacana spinosa.*

The same process has happened in botany. Thus the 13 species recognized by Linnaeus in his genus *Bignonia* are now referred to 15 genera (cf. Sprague, 1922)! However the interests of science are sometimes better served by bringing a diversity of species with certain common characters together under the same generic heading than by separating them under many small genera.

Linnaeus's Contributions to Systematic Biology

The deficiencies of Linnaeus's work are, of course, painfully evident to anyone assessing his work against modern knowledge. It can only be properly understood against the needs of his time. Even so some features of the Linnaean method retain their value. Among them may be noted:

(1) the orderly clear arrangement of material and the uniformity of style;
(2) the precision of terminology consistent to the knowledge of the time; this involved the introduction of new terms and the redefinition of old ones (cf. Stearn, 1955);
(3) the use of an international language, Latin, and an international binomial nomenclature for species based upon it;
(4) its world-wide scope.

All these features concern matters very relevant to the biological sciences today with their immense expanding literature: the *Referativnii Zhurnal* (Moscow) in 1957 carried abstracts of 103,445 articles relating to the biological sciences alone!

Linnaeus's contributions to systematic biology were thus something more than the mere publication of so many new names for plants and animals. He could not have published these names and persuaded the world to accept them and his system of naming unless he had first developed a method of recording conveniently the salient distinguishing features of the organisms concerned and applied it successfully to all the organisms then known. And in turn he could not have done that unless he had first developed efficient ways of work and economical clear methods of summary and publication. Admittedly the basic logic and philosophy were not of his invention, for they were part of the scholastic heritage of Europe. Admittedly most of his material came from others; he owed no small part of it to the overseas expansion, the colonization, trade, and imperialism, of the Dutch and the British peoples. Nevertheless all this he turned to good use, thereby providing not only a foundation on which other men could build, but stimulating them to further exploration and research. Thus one can link Linnaeus through his student Solander and the Forsters to Humboldt and the founding of biogeography, through Solander, Robert Brown, and Humboldt to Darwin, J. D. Hooker, Huxley, Wallace, and the establishment of the theory of evolution. Linnaeus carried on a tradition in taxonomy derived from the English naturalist John Ray and modern systematists carry on a tradition derived from them both. By summarizing what was known they made it easier for others to investigate the unknown. These two men of humble origin achieved what they did because they had great ability associated with great industry and intense inner conviction. It seems fitting that on the celebration of its tenth anniversary the Society of Systematic Zoology should be reminded of this background to its studies.

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The Status of Botanical Nomenclature

H. W. RICKETT

THE present status of botanical nomenclature is—in brief—the general acceptance by botanists of a code of rules. I make this apparently meaningless statement only to emphasize that in the recent past various botanists have adhered to various codes or to no code at all. Botanical nomenclature has attained its present status through a series of conflicts and compromises. There have always been and perhaps always will be dissidents to whom the idea of law agreed upon by a majority smells of authority exerted by a dictator. But our current code seems in the main satisfactory to plant taxonomists.

The *International Code of Botanical Nomenclature* begins with a "Preamble" which is followed by a set of "Principles"; on these the rules and our interpretation of them are based. The rules themselves form 75 Articles, which are retroactive except when otherwise qualified. The Articles are grouped under such headings as "Ranks of Taxa"; "Priority"; "Limitation of Priority" (which refers to starting-points and conservation); "Effective and Valid Publication"; "Retention, Choice, and Rejection of Names" including "Retention of Names or Epithets of Taxa which are Remodeled," "Choice of Names when Taxa of the Same Rank are United," and so forth; and finally "Orthography and Gender of Names." Many of the Articles are followed by Recommendations, which are not prescriptive like the Articles but certainly express the usage that botanists are expected to follow. Both Articles and Recommendations are followed by illustrative examples. In practice, application of the Code is held to be automatic: every botanist is expected to be his own policeman, jury, and judge (with certain exceptions to be mentioned later). The Code also contains provisions for its modification, and several Appendices which include the methods of naming hybrids, special provisions for the naming of fossil plants, and a guide to the selection of types.

I shall not weary you by reading the provisions of the Code and adducing "case histories" to exemplify them. I propose to discuss briefly some of the principles expressed in the introductory parts and to call attention to some surviving difficulties which result partly from the past his-