Svenska Linnésällskapets Årsskrift

ÅRGÅNG 1978

YEARBOOK OF THE SWEDISH LINNAEUS SOCIETY

Commemorative Volume

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EDITOR

GUNNAR BROBERG

UPPSALA

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CARL LINNAEUS (CARL VON LINNÉ) 1707–1778.
Painting by Alexander Roslin 1775 (K. Vetenskapsakademien, Stockholm)

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Editor's note

In commemorating the bicentenary of the death of Carl Linnaeus on January 10th 1778 The Swedish Linnaeus Society and The Linnean Society of London jointly arranged a symposium entitled *Research on Linnaeus—progress and prospects.* It was held first in London and then moved over to Uppsala and Stockholm, where, in addition to The Swedish Linnaeus Society, also The Royal Swedish Academy of Science and Uppsala University acted as hosts. For all participants those days in May will be memorable, particularily on account of the beautiful weather. It seemed as if Nature herself wanted to celebrate one of her greatest lovers.

This volume contains most of the papers read at the Symposium. Some appear here in somewhat extended versions while others have been or will be published elsewhere and one paper unfortunately can not be printed at all. The manuscript of William T. Stearn's initial lecture was stolen during the banquet in Uppsala, a loss which is much to be regretted.

However, these papers offer a survey of the Linnaean scholarship of today. We hope that they will not only summarize progress to date but will also give prospects for further research in years to come, with or without any Linnaean commemorations.

STEN LINDROTH

Linnaeus in his European Context

Carl von Linné—or Linnaeus, as I am forced to call him—never learned any foreign modern language. In his youth, he lived for three years in Holland, where he entered on his path to glory and power, but throughout his life he was quite satisfied with the Latin that he had learned at school and his own Swedish dialect. In his maturity, when he was firmly placed on the botanical throne in Uppsala, Linnaeus corresponded with natural historians all over the world and received their specimens. He was a man for Europe and the international scientific society; everbody knew his name. But he never left Sweden and in later years not even Uppsala, except for short trips to Stockholm in order to visit his friend Abraham Bäck or the royal natural-history collections. His life was his work—his botanical garden, his herbarium, his lecture room, and Hammarby, where foreign students flocked around him on beautiful summer days.

In short, I think that we have to confess that there is something slightly provincial about Linnaeus. We have to judge him in his European context, from the broadest angle of view possible, but, in doing so, we shall discover that in many respects he is very different, in a way, non-European, alien to his own time. Linnaeus was a man of tremendous originality and power of mind. He had, he himself tells us, reformed a whole science, namely, botany, and inaugurated a new epoch. His enormous influence in the botanical world springs from the marvellous clarity and energy of his works, and the fact that they were so many; you could hardly resist them. His main achievement, his botanical system, was, of course, born out of earlier attempts to create order in natural history by Ray, Tournefort and others. But Linnaeus as a taxonomist worked with a consistency, an almost fanatical one-sidedness unheard of before and this chief characteristic of his—I would say, his whole mental constitution—isolated him in a way from his contemporaries abroad but not, perhaps, to the same degree (and that will be my first point) from his Swedish fellow-countrymen.

In working on his material—thousands and thousands of plants and animals—Linnaeus had just one thing in mind: order must prevail. If he could not find it in nature, he had to introduce it himself. To this end, he elaborated his own tools, a world of concepts which enabled him to construct his system of classes, orders, genera and species. We all know today—and we ought to have known it from the days of Sachs—that in this tremendous undertaking Linnaeus was strongly influenced by Aristotle and scholastic philosophy. There is a kind of paradox here. As an observer of natural specimens—alive or dead—Linnaeus had no equal; from his horse's back or at his working desk, bent over his herbarium sheets, he saw everything and stored the details in his excellent memory. He was an empirical genius, he loved sensual reality, and a motto from Francis Bacon very appropriately opens the *Fundamenta botanica* of his youth. But the very intensity with which he experienced the multitude of different species forced him to abandon empiricism in putting them into some kind of system. He must create cosmos out of chaos, otherwise he might get lost. And so Linnaeus began to construct his cosmos, with the help of ready-made concepts, lika a scholastic philosopher in the Middle Ages. He knew very well what he was doing—that, *inter alia,* his sexual system for the plants was an artificial one, not corresponding to nature. But he was under the influence of an almost demoniacal possession. He could not grasp anything, he said, which was not brought into order and his talent for organizing everything around him, like soldiers on a battle-field, in groups and sub-groups did not show itself only in natural history.

So, the *eye* and the *order* represent what may be called the two faces of Linnaeus—Linnaeus the masterly observer and Linnaeus the scholastic philosopher, who may seem strange to us. But this latter Linnaeus of the *Systema naturae* and *Philosophia botanica* was no stranger in his Swedish intellectual environment, which is what I should like to show to you. The urge for completeness and order, the talent for describing vast amounts of empirical facts and putting them into neat systems, in short, scholasticism of some kind, has always, in a peculiar way, been characteristic of Swedish intellectual life.

It seems, in this connection, revealing that once, in the Middle Ages, when Sweden was first incorporated into European higher civilization, French scholasticism was the main intellectual influence dominating the scientific community—we unfortunately missed the humanism of the twelfth century. It seems as if Swedish science has ever since been characterized by this beginning. And look at the period when Sweden was a great political power, the seventeenth century! At that time, when Sweden emerged from obscurity and entered the European scene in order to fight the Pope and the Emperor, it really gave proof of unexpected talents for organization and discipline. The Swedish triumphs of the Thirty-Years War were made possible by an almost overwhelming gift for order and practical solutions, in the civil government at home and in the conquering armies abroad. And how illuminating was the new Swedish ecclesiastical law of 1686, which introduced the well-known parish registers, in which every Swedish citizen was documented from his birth until his death. In the middle of the eighteenth century, these registers were fundamental as source materials for Swedish population statistics, founded at that time under the direction of the astronomer Pehr Wilhelm Wargentin and in their completeness a model for the world. No other nation in Europe now had a more thorough knowledge of its population than the Swedes; the one and a half million Swedish citizens were all annotated in the proper statistical columns as born, dead, married, sick and so on.

You may ask what I am getting at and my answer is this: it seems as if there was something in the Swedish mind or cultural or bureaucratic tradition which was connected with the Spirit of Order and Organization. You may call it, if you wish, a practical, very extrovert spirit, whose sole aim is to tackle the innumerable, specific facts or entities of outward reality and to bring them under some kind of control or system.

I hope you see my point. This Linnaeus, the taxonomer and system-builder. Only substitute the Swedish population for the children of Flora, and you have him! And not only Linnaeus. As I hinted above, Swedish science, and especially natural history, has always been marked by this same spirit of organisation and systematization. Take, for instance, mineralogy and chemistry, two sciences in which Sweden from the middle of the eighteenth century excelled as one of the leading countries. Two contemporaries of Linnaeus, Johan Gottschalk Wallerius and Axel Fredrik Cronstedt, made Swedish mineralogy a pattern for Europe, by publishing excellent hand-books in which all known minerals were described and registered in systematic order. Wallerius, especially, had as systematic a mind as Linnaeus, whose declared enemy he was, by the way. In his *Hydrologia* or "the kingdom of water", he even distributed all kinds of natural waters into classes, orders, genera and species in the most pedestrian Linnaean manner. And Swedish chemistry (born of the mineralogical research) showed much the same vein of painstaking observation and system-building. Its main purpose was to discover new specimens, new elements or substances, just as Linnaeus had enrolled new recruits in the armies of Flora. The list of chemical elements discovered by Swedes is quite imposing. The younger contemporaries of Linnaeus—Scheele and Torbern Bergman and his pupils—were masters of this kind of chemical analysis, and Bergman completed his life's work with his famous table of chemical affinity, in which, after making thousands of laboratory experiments, he organized the chemical substances in the strictest order, regulated by immutable laws. And then, one or two generations later, came Berzelius, with the tremendously important mission of bringing chemistry as a whole into a coherent, theoretical system based on the atomic theory of Dalton. What performance could be more Linnaean? Berzelius even, like Linnaeus for the living things, constructed a new chemical nomenclature, still in use. We may even, I think, venture to take a look into the quite immaterial world of theology or the fate of the human spirit after death. The person I have in mind is the famous Swedish prophet and visionary Emanuel Swedenborg, a distant relative of Linnaeus. The very strange spiritual world which Swedenborg described in convincing detail in his diaries after he turned prophet is so pathetically Swedish in its emphasis on order and the hierarchical system which reigns even between the immaterial spirits that, in short, one may call Swedenborg a Linnaeus in the world of spirits.

So far I have spoken not of Linnaeus in his European context, as I ought to have done, but of Linnaeus in his *Swedish* context. But this is part of my strategy. I have tried to show that in his Swedish milieu, as an exponent of the Swedish cultural or social tradition of the seventeenth and eighteenth centuries, Linnaeus the botanist was rather a normal or even representative scientist. He hated chaos, as all Swedes do. But he had to face the consequences. He worked for the benefit of the whole botanical (and zoological) world and the great question was, of course, could his ideas in systematics and taxonomy, his scholastic grasp of the problems, be accepted by natural historians in other countries? To what extent they *were* accepted, we have now a much better opportunity than before to decide. Dr Frans Stafleu (whose absence at this symposium we regret very much) has given us in his excellent book *Linnaeus and the Linnaeans* an overall survey of the fate of Linnaean systematics in Europe during the eighteenth century, and, of course, I have benefited from reading it.

Now, in order to understand the fate of Linnaean botany in eighteenth-century Europe we must make it clear what Linnaeus stood for, what it implied to become a Linnaean. It was not—and this is the important thing—a matter of embracing one or more new scientific facts or theories. Linnaeus did not make any important discoveries in natural history at all, nor tried to explain old discoveries in the light of new theories. Instead, he worked out a method of his own, *the* method, as he thought, for describing and arranging the plants of the world. You might be impressed by the lucidity and logical consistency of this method (including the sexual system) and consequently convinced of its practical utility, but you could *not* prove it or disprove it, because it had nothing to do with scientific verification or falsification. You were, from the theoretical point of view, quite free to adopt any other systematic arrangement, and so much for that. Linnaeus, in fact, considered himself to be and was the creator of what may be called a kind of religion, a system of botanical dogmas expressed in the *Philosophia botanica,* which was the work of a scholastic legislator, not of an empirical natural historian humbly searching for truth. And so, over the years, from his garden in Uppsala, he watched the progress of his botanical principles in Europe, like Swedenborg the founder of a new church. There were sudden conversions to his system—and he rejoiced—and there were the hard-hearted, who ignored him or even opposed him.

In a rather over-simplified way, we can make the following statements as to the fate of Linnaean botany: in England he was a great success, in France he was rejected, in Germany he met with a mixed reception. This is not the pattern we should expect and is not, perhaps, so easily explained. But the Linnaean tide or fashion in England, which started in mid-century, seems to have had obvious causes. At this time, academic, theoretical botany had no high status in England. This means that, consequently, the Englishmen could have had no real interest in the deeper, philosophical or scholastic implications of the Linnaean method. They were a practical and pragmatic people, and the philosophical tradition they cherished was the empirical one, in which Francis Bacon and John Locke were the domestic gods. And hence it followed that they were impressed by the immensely practical and easy-to-learn basic principles of Linnaeus's sexual system and other reforms of botany. With them in mind you could easily identify and name an unknown plant in your herbarium or your garden. In England, Linnaeus seemed to have been sent from God as an indispensable help to every lover of flowers and, as a matter of fact, it was the amateurs of various kinds among the Englishmen who prepared the way for him—gardeners and apothecaries, the landed gentry, ladies and gentlemen. During the latter half of the century, there appeared the most devoted and useful of all the Linnaeans in Europe, an amateur, too, of the most genuine English kind, namely, Sir Joseph Banks. In the circle around the extremely wealthy Sir Joseph, in which Linnaeus's pupil Daniel Carl Solander was the foremost expert, the fame of the Swedish master was extolled even more than in Sweden. One may even say that, after the death of Linnaeus, the London of Banks and Solander and not Uppsala was the centre of Linnaean studies. In Banks' apartment in Soho Square one could meet botanical visitors from all countries, looking through his magnificent herbarium and finding every book of natural history that they wanted in his equally magnificent library.

Yes, Linnaeus was, above all, a man for the non-professionals. The amateur writers of floras, the gardeners and the keepers of natural-history collections used his handbooks every day. Who was (and now I am crossing the Channel) the greatest admirer of Linnaeus in France? Probably Jean-Jacques Rousseau, the half-crazy philosopher who made Nature his Gospel. For the rest, as I already have said, the France of the Enlightenment was not a good country for Linnaeus. His own colleagues, as a rule, dismissed him, at least in the predominant centre of French culture and learning, Paris, where the powerful members of the Académie des sciences directed the development of French science. Two of them—the great Buffon and that strange man Michel Adanson—were everywhere known to be his main enemies. The reason was simple enough. One could not, or ought not, they thought, to force Nature into the narrow categories of ready-made, classificatory concept. Buffon even declared that one should not classify at all. In every respect, he appeared as the antipole of Linnaeus—an eloquent grand-seigneur in the salons of Paris, a philosophical thinker more than an observer of little things in nature. And yet, oddly enough, of the two men, Buffon had the more empirical mind, at least in his earlier years. Much has been written in recent years about Buffon and the Buffon–Linnaeus controversy. I should like to mention an excellent, very recent article by Phillip Sloan. It seems to me that, on the whole, the sympathies in this controversy are nowadays rather on the Frenchman's side, which of course, I regret! He (like Adanson) could not stand the scholastic spirit of the great Swede. The worst thing one could do was to "impose on the reality of the

Creator's work the abstractions of our mind", and by this Buffon meant classes, orders and genera. They were just "entities of reason", simply not true. Buffon was, as you will easily realize, a fervent nominalist. In the first volume of his enormous *Histoire naturelle,* in which he launched his attack on Linnaeus, he even denied the existence of species. In Nature, there existed only innumerable individuals, which merged into each other by almost indiscernible gradations. Hence it followed, according to Buffon, that all classification in the Linnaean sense of the word was in principle impossible, a meaningless task which did not tell us anything about Nature. But the gulf between the two leading natural historians of the time went deeper than that. To Buffon, and to everybody who reasoned like him, Linnaeus had killed living nature, whose real essence was dynamic force, change and everlasting movement in time and not empty abstractions eternally stuffed into the pigeon-holes of a conceptual system. It is this standpoint which makes Buffon in a way a forerunner of modern biological thought.

And all this was said about Linnaeus, who had a sharper eye for the empirical wonders of God's creation than any other man in his time and, perhaps, in later times. It is, indeed, paradoxical. As a matter of course, the pupils of Linnaeus, who fought his battle on every occasion detested Buffon and his heretical countrymen. Buffon, said Anders Sparrman (who sailed round the world with Captain Cook), interpreted nature with the aid of a kind of "spiritual vision" and in a "grandiloquent and pompous French language". When Sir James Edward Smith, the Englishman who bought Linnaeus's collections, met Adanson in Paris, the latter accused Linnaeus of being a scholastic. And Smith reported: "I was contented with smiling." He knew better—was he not the happy owner of a Linnaeus manuscript called *A Journey to Lapland,* and what was more alive with sparkling, splendid, empirical facts than these wonderful pages?

In order to establish by contrast the main features of Linnaeus as a natural scientist, however, we need not turn to his French opponents. As a matter of fact, there lived in Sweden a contemporary of Linnaeus and a friend of his who was an excellant natural historian in his own right and yet did not belong to the Linnaean or peculiar Swedish tradition of order and classification. His name was Charles De Geer and he was the richest man in Sweden at that time and the owner of the prosperous Leufsta ironworks in northern Uppland. As an amateur, De Geer was one of the leading entomologists in Europe during the eighteenth century and the author of a huge work in seven volumes called *Mémoires pour servir à l'histoire des insectes.* There we encounter a scientific spirit of investigation which may be considered European and continental, even Buffonian. Even in his social position, De Geer was of quite another type than Linnaeus, an aristocrat who had spent his boyhood abroad, in Holland; he spoke and wrote French better than Swedish. In his entomological work, he did not bother about taxonomy and systematics, because he did not like them. Meaningless catalogues and useless descriptions of "dead insects", De Geer argued, were of no great interest. Without hesitation, he could name and identify butterflies from their habits of life. It is revealing that he entered into correspondence with the famous Charles Bonnet in Geneva, who discovered the non-sexual propagation of aphids and, like Buffon, denied the existence of clear-cut species in nature. As an entomologist, De Geer found his models and his inspiration not among the classifiers but among anatomists and experimenters like Malpighi, Swammerdam and Réaumur, whose great *Histoire des insectes* he continued. His own books were filled with painstaking descriptions, often made with the aid of an excellent microscope, of the inner structures of insects, their ecology and, above all, their transformations. In these fields, Charles De Geer was a master—the only man in Sweden who made a modern, truly biological approach to the problems of natural history.

Everything I have said so far has been said with one single purpose—to try to demonstrate the originality of Linnaeus from a European point of view. Twenty or thirty years ago, it was not possible to paint a picture of Linnaeus like this. It is thanks to the research on Linnaeus and contemporary biology during the last few decades that this has been made possible. Linnaeus was unique in a way that was never realized in former times, when he was universally considered the gentle king of flowers in secret alliance with Nature. In one essential respect, he ended an epoch in the history of botany; partly he was, so to speak, very behindhand. That is true also as regards his personal feelings and secret innerlife. The strange annotations made in his old age, *Nemesis divina,* are indeed documents from a very archaic mind, brought up in the unenlightend world of the Old Testament. In Linnaeus's enraptured hymns to nature and the wonders of the Swedish summer, he borrows heavily not only from the Old Testament but also from the poetry of an earlier age, namely the seventeenth-century Baroque, with its love of paradoxical expressions and the gods of classical antiquity. In other fields, too, it seems to me that Linnaeus was deeply rooted in the dying world of the Baroque period. I think that it applies even to his life work—the system of nature. In his magnificent constructions of the kingdoms of animals, plants and minerals, there is a bold and pure grandeur which was born of the rationalistic seventeenth century, it reminds me of the great musical compositions of Johann Sebastian Bach.

In my last remarks, I touched upon an aspect of Linnaeus which in his own time was unknown in the great European world. I am referring to Linnaeus as a writer in the Swedish language. *The* Linnaeus, whom it was my task to deal with in this lecture, the man of international fame, the bold reformer of systematics, the target of Buffon's arrows, wrote, of course, in Latin. But his countrymen, in Sweden, knew and still know another Linnaeus, *the other* Linnaeus—the traveller in the Swedish provinces, the incomparable speaker, the writer of letters charming beyond all description. I do not know if Buffon or Adanson would have liked him, probably not, but we do. The tremendously important place which Linnaeus has occupied in the Swedish cultural tradition up to the present day (I think that it has no counterpart in the history of science) is due I believe, almost entirely to his giving expression, in writings accessible to all his fellow-countrymen, to the wonders of Swedish nature. Writing or speaking in his mother tongue, without any heavy responsibility, he felt easy and happy, he was just the observer and describer, the empirical genius whom nothing escaped. If you know and love this Linnaeus (and all we Swedes do), you will always recognize him again, even in his driest catalogues, like *Species plantarum* or *Systema naturae.* Walking in God's wonderful nature, over the flowering fields, he was himself a great lover and he had the marvellous gift of communicating this love to his pupils. Scholasticism was far away when he made his famous botanical excursions in the neighbourhood of Uppsala, to the delight of hundreds of students, who gave expression to their happy feelings when in the evening they left the master at the door of his house. "Vivat Linnaeus", they shouted, and there is no reason why we should not today, two hundred years after his death, use exactly the same words: "Vivat Linnaeus." They may, I think, very fittingly introduce today's pleasures.

KARL-GUSTAV HILDEBRAND

The Economic Background of Linnaeus. Sweden in the Eighteenth Century

It has already been demonstrated, in the first contributions to our symposium, how strongly Linnaeus was influenced by his country and his environment. It is certainly meaningful to ask, even in regard to economic and practical matters, what eighteenth-century Sweden meant to Linnaeus and what his work meant to eighteenth-century Sweden. But it is not easy to give a concise and definite answer, and the following remarks should be regarded as very tentative.

Linnaeus's Sweden was a poor and predominantly agrarian country. Less than 10 per cent of the population lived in the cities, which were small and, of course, very unhealthy, as all cities were in those days.

Most things in Swedish society were adapted to its agrarian character. As part of their pay, officers, soldiers, clergymen and many civil servants had the use of landholdings, big or small, and it often happened that these holdings were more interesting to them than their official duties. The leading, and internationally important, export industry of the country was iron production. The iron came from more than 300 small ironworks scattered over many parts of the countryside and heavily dependent on the surrounding peasantry for charcoal and transportation.

The type of government and administration that was built up on this somewhat primitive basis was in some respects astonishingly advanced. The bureaucracy was unusually powerful but also relatively—and the blessing of European bureaucracy were certainly relative in the eighteenth century—enlightened and even honest. There was a good deal of interesting political experimentation and debate among the Swedish *élite* and, as we know, the century was one of the great periods in the history of Swedish natural science.

The economic condition of the country was not quite as static as might be expected. Some agricultural change was necessitated by the population growth: between 1720 and 1815, the increase was 70 per cent or one million people. This caused difficulties but not catastrophe; fortunately, there was a considerable amount of land reclamation and there was also every reason to introduce improved methods of agriculture. Both in this respect and in all other fields of economic life, not least in ambitious plans for import substitution, the new rational thinking and the typical optimism of the century led to an unexampled enthusiasm for innovation. The results were not always what had been expected, but the powers of change were evidently beginning to work, at least to pave the way for future development.

Instead of digressing on these points in general, I shall mention a few results and ideas from recent or relatively recent research which may illustrate and confirm or, in som cases, modify the conventional picture.

One of these contributions comes from the history of price fluctuations. It has been demonstrated that grain prices were remarkably different in different regions and also changed differently. The dispersion is so pronounced that it shows a lack of integration in the economy. To mention one instance, bad harvests were often a regional phenomenon, and the economic mechanism for relieving the consequences by deliveries from better-provided parts of the realm was evidently too slow and generally inefficient. The impact of this is easily seen when the eighteenth century is compared in this respect with the nineteenth. And the whole problem is more important for the general theme than one may think at first. It is evident that Sweden was not an economically unified country in the way modern nations are. And if it was difficult for goods and prices to move rapidly from province to province, then it must have been difficult also for people and for ideas to do so (2).

Another important result stems, astonishingly, from British research. The Swedes may have contributed something like half the amount of bar iron used in early eighteenth-century England. The fact that we could compete with English ironmasters in this way has generally been explained by our more abundant forests; it has been assumed that it was literally impossible for the British to get enough timber for charcoal production, that the crisis was a dramatic one, and that our virgin forests provided the only possible solution.

We certainly had more forests and fever consumers than the United Kingdom, but British scholars have shown, quite convincingly, that there was no dramatic fuel crisis in England around 1700, that charcoal prices did not rise in any significant way, and that the British interest in experimenting with coal instead of charcoal in iron production was motivated, in those days, not by the scarcity, of fuel but by the higher labour costs in charcoal production. If that is so—and I really think it is—it seems very difficult to avoid the conclusion that the most important comparative advantage of the Swedish ironmasters may have been not the abundant forest resources, valuable though they were, but the low cost of labour, i.e. the modest demands of the Swedish peasant population, for whom charcoal production and transport were side-lines in comparison with the work on their own, generally insufficient landholdings. We were, thus, in a situation that is well known in many developing countries today: if we could compete at all, it was because of our low wages or, in other words, because of our poverty (3).

The third instance is from the history, economic and social, of the Swedish peasantry. An interesting and provocative book by Professor Herlitz, of Göteborg, has both accentuated the old truths in a new way and opened up some new vistas on the panorama of the eighteenth century. His most important observations are based on something which may not sound very exciting, namely, a systematic study of land values and the land market. He makes one remark which should have been self-evident to all of us but really was not. The price of the peasants' land, which was heavily taxed, was naturally far below the price of the land belonging to the nobility and gentry, which had the benefit of extensive tax exemption. As a very considerable part of the agricultural land in Sweden was peasant-owned, we have always instinctively imagined a sort of relatively even balance between the different owner groups, but if one asks for the land value and not for the area of the land, the picture is quite different. In a part of western Sweden which was used as a test case, one-third of the holdings were owned by peasants, but tax evaluations from the beginning of the century yield the result that the peasants' share *in the ladn value* was only a small percentage. This illustrates, much better than before, the enormous gap between rich and poor in the traditional agricultural society (4).

But this constructive re-arrangement of old knowledge goes together with something which is, as I said, totally new. By a comparison of sale prices from two decades, Herlitz has demonstrated that the difference in price between privileged and unprivileged land decreased quite dramatically between the 1730s and the 1770s. If prices are expressed not in money but in grain—a device by which one avoids the effects of inflation—it turns out that the privileged land kept its value, in real terms, while the value of peasant land nearly trebled.

This is a result from one specific period and one part of the country, but the result is so pronounced that it must have some sort of a general significance. Something important—we cannot with any certainty say exactly what—occurred in the agricultural sector, and it occurred in the dark and unknown world of the peasants, not in the world of the educated landowners.

There are several factors that may have contributed to this. In the region that has been particularly investigated by Herlitz, an unusually large part of the taxes was fixed in money, and the general inflexibility of land taxation, together with a good deal of inflation, led to a reduction of the real value of the taxes. But this can only explain a small part of the change. A more important factor is that the peasants who owned their land were far more interested in land reclamation than the peasants who were tenants of privileged land—and the newly cultivated areas were not taxed in the beginning. But it is impossible not to conclude that land reclamation in this period, even among the "ignorant" peasants, must have been combined with some sort of technical progress in agriculture.

And this runs counter to some of our predominant traditional assumtions. It was a commonplace in most contemporary writings, and it has been accepted in the greater part of later historiography, that the ignorance and conservatism of the peasants was the main obstacle to agricultural progress, that innovation was practically excluded in the old-fashioned world of the village community, and that education and energetic organizational measures from above were the only factors that could, at least in the long run, change anything in these circumstanses. It is certainly true that the spectacular agricultural reformers were to be found in the rural upper or middle classes. But the idea that nothing of a progressive nature could have happened among the peasants is only a special case of the general opinion that the lower classes are, for some reason, more stupid than other people. Even in eighteenth-century literature, protests against the prevailing view are to be met with: it has been pointed out that any relative slackness in the peasants' interest in reform might well have occurred for economic reasons—following from their restricted means and the difficulties in their situation—instead of being a sign of their innate backwardness (5).

It should also be remembered that progress on small and scattered landholdings is often more difficult to observe than changes in more extensive surroundings, and that even relatively small improvements among the majority may well mean more to the national economy than dramatic successes among the privileged few. Something of this sort has been pointed out as regards Norwegian economic progress, especially among the peasants, in the early nineteenth century (6).

The continued changes in the peasant world were to bring new problems and complications. The enclosure movement that became really efficient after Linnaeus's death caused a growing differentiation between the peasants who were better off and more successful and those who were poorer and maybe more enterprising. Peasants of the former type were able to keep and enlarge their holdings, ultimately achieving a higher status in rural society, while a good many of the others became proletarized. This new constellation may have been advantageous for economic progress, just as capitalism was in another sphere, but at a heavy price. This is, however, something that took place at the very end of the eighteenth century, and especially in the first half of the nineteenth, so it has only a restricted interest as regards the present theme.

The impression of growth—or of the potentialities of growth—in the agrarian sector is of some importance for our understanding of the general reform enthusiasm of the period. Especially the years between about 1720 and about 1770—which cover most of Linnaeus's active life—were an era when everyone experimented, everyone hade great and remarkable plans for the future of the economy, everyone was prepared to debate new ventures or new ideas. The government contributed by providing all sorts of subventions, privileges and regulations. Historians of the older moralistic and dogmatically liberal school used to stress that all this, or at least most of it, was either obnoxious or pointless.

At least during the last 25 years, there has been a revision of this view. The textile manufactories that were developed in eighteenth-century Sweden to produce costly brocades and other luxurious stuffs which would otherwise have been imported were certainly both over-ambitious and in many cases unprofitable, but it has been demonstrated that the entrepreneurs were not entirely misguided and that the manufactories were not only an artificial product of lavish government subventions Several of them were happily re-organized and continued with a revised production programme when the heyday of public subventions was over (7).

In another field of economic policy and its effects, the inflation of the 1750s and early 1760s, it has been convincingly argued that even this—which was, of course, anathema to the traditional historians—may not have been only for the bad. At least in its early and more innocent stages, the inflation must have encouraged land reclamation and other agricultural investment, possibly with important consequences for the future (8).

More important than these observations on particular points is, however, the impact of recent practical experience. Many of the activities in the eighteenth century are well-known features of modern economic practice, and not only in the more acute forms of present neo-mercantilism. Especially in the case of the developing countries, it is self-evident both that uninterrupted experimentation, for import substitution or for other reasons, is quite inescapable, that much of this is beyond the means of private investors, and that government assistance, in one form or another, is necessary. And as Professor Lindroth points out with reference to the eighteenth century in his great work on the Swedish Academy of Sciences, how could experimentation occur if not by trial and error? (9).

It may be added that one of the developments that ultimately led to the Industrial Revolution in Britain was the enormous interest in experiment and innovation, sometimes constructive and sometimes relatively senseless, that is so typical of the late seventeenth and early eighteenth centuries in that country. The awakening of the innovating spirit is always, quite independently of its success at the moment, one of the important events in the history of any country.

Just one more remark on the general background. In Sweden, as elsewhere, the younger historians are generally more apt than their predecessors to stress the role of social conflict as a main historical theme. Just as the political conflicts of the turbulent eighteenth century were of great importance for future political and ideological development, the tensions between different economic interests in society were not only interesting in themselves. In some way, they provided the energy, the dynamic force, that was to create a new and more expansive society.

It remains to discuss why all this is interesting with regard to Linnaeus. First of all, he has described the society which I have tried to characterize or, at any rate, he has given a whole series of impressionistic glimpses of its everyday life. The journals of his travels through different Swedish provinces in the 1730s and 1740s contain many odd and picturesque things, but a great deal of the content is representative enough, and it really does justice to the agrarian character of pre-industrial Sweden, in all its different aspects, from the hospitality and the interesting conversation in the manor houses to those smoke-filled cottages in some parts of southern Sweden in which there was no real chimney and the walls and ceiling were covered by thick layers of soot. Riding or driving was a slow business in those days. Linnaeus noted down his observations as he happened to make them and, as the peasants were to be found everywhere, he has much to say about their costume and their traditions, the way their houses were built, the systems of rotation, and the tools they used (10).

To choose one special field, we may ask what he has to say, in the travel journals or elsewhere, about pauperism and the social hierarchy. It would certainly be a mistake to depict him as any sort of revolutionary. But he was a great empiricist, and he often writes in a realistic vein, without any illusions. This is easily seen in some of his general reflections, with their irresistible mixture of ecological thinking and a somewhat naive proclamation of the ways of the Lord. When he specifies how miraculously plants and animals provide services for other plants and animals, he sometimes crosses the borderline to the world of man. The sailor, he says, risks his life not for his own sake but for the profits of the merchant; the peasant ploughs, sows and reaps the harvest, though the main advantage of all his toil will go to other people and his own share will be insignificant (11).

In a splendid passage, Linnaeus delineates the vegetable world as a strict counterpart to the social hierarchy. The trees and the flowering plants are the magnates and the nobility. The grass is the peasantry, more widespread than the other classes, and strives to grow and survive the more it is trampled on. The moss, finally, is the cottager class, those who have to use the poorest soil and who have undertaken to cultivate what everyone else regards as useless. Is there, or is there not, an undertone of irony or hidden protest in such remarks as these? We shall probably never know, but the analysis, as such, is perfect (12).

When he turns from sounds to things, in his rather unphilosophical travel notes, there are interesting remarks on the environmental problems of the workers. He describes the silicosis from which those who work in the stone quarry at Orsa in Dalarna suffer. He speaks of the smoke from the copper mine and the smelting-houses in Falun and its disastrous effects on the surrounding vegetation. And he depicts the world of the miners, who work in darkness, heat and smoke, naked to the waist, with the sweat running down their bodies and in constant danger of accidents. "The anxiety combined with such a depth, with darkness and danger, made the hairs rise on my head. I wished nothing more than to return to the surface again ... What is seen down here is the true picture of hell; no priest can describe it as frightfully as this." (13).

This is nothing more than a travel vignette, dramatically expressed but with no political application. But it has a very specific historical interest. Linnaeus visited the copper mine in 1734; nine years later, in 1743, the miners used somewhat revolutionary means, in connection with a big regional insurrection, to demand better economic conditions from their employers. Linnaeus depicts something of the background of their discontent.

His observations are often instructive in their precision, and they often give food for reflection. On one of his journeys, he happened to pass by a forge and saw the hammersmith and his assistants, "the shirted, pale sons of Vulcan". The shirts were worn because of the heat in the forge and were an ordinary part of the picture. But why were the workers so pale? (14).

In his Swedish environment, Linnaeus stands forth as a typical representative of contemporary reform enthusiasm. His travels were paid for by the government or by private people and institutions, but there was always an economic motive behind them. In one case, he was instructed to look for medicinal plants and plants that could be used in the dyeing of textiles; in both cases, it seemed important that Sweden should become independent of imports (15).

But Linnaeus's interest in improvement did not stop there. To mention one of the many instances, he takes part in the general discussion on the use of manure in agriculture. Grain production was increasing in Sweden, both absolutely and in proportion to animal production—partly, it is presumed, as a consequence of the land elevation. Less cattle-raising meant less manure, and this accentuated one of the permanent problems of traditional agriculture. Linnaeus's works abound with comments and advice in this respect. He stresses the manure problem as an obstacle to successful land reclamation, and he often discusses the possibilities of substituting different things for the invaluable manure. He is also interested, as every one was at that time, in the possibilities of using marl for improving the soil (16).

In his typical eighteenth-century way, he covers many other fields, too. He is interested in the textile manufactories, one of which was created by his colleague in the Academy of Sciences, Jonas Alströmer. He writes about a marvellous plant, mentioned in great secrecy by a rural dean in

Uddevalla, from which can be made a delicious beverage, tasting practically like China tea but much better for one's health. He tries to propagandize for the use of Nordic mead instead of the expensive and hurtful wines imported from the Continent. Of course, he is enthusiastic about the breeding of silkworms in Sweden (17).

All these suggestions, great and small, are, to Linnaeus, instances of a very important whole, the general impact of natural science on economic progress. This was the most spectacular motive for the Academy of Sciences in 1739. During his travels, Linnaeus tried to find out the part played by the teaching of natural teaching of natural science, if any, in the *gymnasier*, the provincial secondary schools. He was sorry to find that schoolboys generally learned very little botany, "though this is the first foundation of all private economy, which is and should be the first and last aim of every realm, every country, every society". He was nearly ecstatic when he learned, in 1746, that the Bishop of Västerås had got the provincial medical officer to undertake botanical excursions in summer, twice a week (18).

Linnaeus was, of course, passionately interested in the extent and status of the courses in natural science at the universities. In a famous speech to the academy of Sciences in 1740 he makes a few remarks which are rather illuminating as regards the general situation, and not only in Sweden. He points out that most students, after their years at the university, will end up in the rural clergy. If they all get some training in natural science, they will be able to appreciate what their parishioners tell them about things like newly found or supposed ore-deposits in the parish: no one will keep such things secret from his parish minister. And if the fields and meadows of the parsonage are sown with new and useful plants or otherwise used in new and interesting ways, the peasants will try to imitate this. The common man is often suspicious of new ideas, but he will accept what has evidently succeeded for his own parish minister (19).

All this agrees well with the general picture of the century. But there is, in fact, a paradox, or what looks like a paradox, here. For even if there is plenty of advice and information on economic matters in the travel journals, the main part of their content, and certainly the main part of the author's personal interest, is taken up by other things. In the journals, things like a flower that has not been observed or examined before, a rare bird of some sort or, the anatomic structure of a snake found at the roadside are always so much nearer to his heart than the economic problems of the day. And he is certainly interested in these other things for their own sakes or for the sake of increased or more systematic knowledge as such, not because of their potential usefulness, if any. The importance of science for economic progress is one of the grand themes of his speeches and his general remarks, but it was hardly decisive of the priorities in his everyday work. It may be added that his contributions in the economic field are certainly interesting and very representative of his era but are not at all paramount in the same way as many other parts of his work.

There may be several explanations of this. Of course, even Linnaeus may have felt the temptation that is known to most scholars, in our own days as in the eighteenth century—the temptation to over-emphasize the practical usefulness of one's work, in the hope of getting better grants in that way. But there are other, and far more rewarding, ways of looking at the problem.

In the journal of his travels in the province of Västergötland, he makes a very interesting statement. The knowledge of stones, plants and animals is, he says "the foundation of all the use we kan get from these things". But to know the thing, it is necessary to know how it should be properly named. "If I mention an eye, a birch, a perch, or a blackcock, and the reader does not know the meaning of those names, then it is impossible for him to advance very far in the text." In this elegant way, the problem of a scientific nomenclature and, thus, of systematized knowledge, *as such,* is represented as a necessary part not only of general scientific knowledge but of the knowledge needed for practical purposes (20).

As regards the immediate correctness of this, it may be underlined that we very easily become anachronistic in our evaluation of this type of statement. It must be remembered that the general knowledge of the flora and fauna of European countries was far less advanced two centuries ago than it is now; much that is self-evident or even trivial today was new and exciting then. If we go to countries in our own time, where the different species have not yet been systematically recorded and investigated in the way they have been in Sweden or in the United Kingdom, then we are explicitly told, by botanists and others, that such a recording and systematization should be given very high priority among the useful things which should be undertaken in developing countries. And a systematic recording must cover the whole field; even for the sake of the practical utilisation of resources, it is necessary that not only facts of immediate practical value should be recorded. By the way, the eighteenth-century endeavours to find new medicinal plants and suchlike have their counterparts quite naturally in the developing countries of to-day.

This point can, however, be taken a little further: it is, in the long run, scientific progress as a whole, the totality of its exact observations and its systematic thinking, and not any restricted area of applied science, that is the real foundation for all sorts of rational progress, including progress in the economic sphere. And it is evident that this fits in very well with what Linnaeus really thought: the secrets of nature have been obscured by ignorance and superstition through the ages, the "springtime" of science will give us new light, and we shall need all of it.

He was right, in a way, of course. His practical suggestions are generally forgotten today. No one cares about that patriotic drink which tastes like China tea but is better for one's health. What he has really done for the future, economically or otherwise, is something else—his contribution to general scientific development. He expressed something of the more general change in a famous lecture in 1759, given at Uppsala University in the presence of the King and Queen. He specified there, in his imaginative way, what would happen in a country without any science: "Wood-spirits would hide in all bushes, there would be ghosts in every dark corner, leprechauns, water sprites and other companions of Lucifer would live among us like grey cats, superstition, sorcery and witchcraft would cluster around us like mosquitoes." (21).

Or, less poetically, if science can do anything at all for society, it can do it by being science.

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GUNNAR BROBERG

Linnaeus and Genesis: A Preliminary Survey

My title may arouse expectations of rather diverse kinds and probably also some misgivings: my subject may seem too worn out. What I intend to do is to summarize earlier research, adding some observations of my own but also making some evaluations. This latter intention especially justifies the word "preliminary" in the heading. I should also mention that *Nemesis divina*—that strange and sombre religious theory of Linnaeus based on Mosaic law—is omitted from my account (1). My subject is, I think, big enough. I may claim that it partly explains Linnaeus's choice of occupation and also that it is of great importance for understanding problems in his science. What I wish to discuss is thus the impact of Genesis, the first book of the Bible, in a very wide sense.

Like other contemporary Swedish scholars and scientists, Linnaeus grew up in an orthodox Lutheran milieu. As his father was a clergyman, it seemed from the beginning self-evident that his first-born son should choose the same profession. Besides, Christianity was the first and last wisdom in man's life, being a closed system of comprehensive rules regulating man in all his sayings and doings. The clergy exercised their controlling powers zealously, but the Enlightenment and secularization, very much under the influence of science, were on their way.

Since Darwin, we have never been able to read Genesis with the same capacity for visualizing the sacred text. And in Linnaeus's time, there was not just the Bible. A special literary genre, Hexaëmeron, originating with the Fathers of the Church, described the first six days in the history of the world, not always in subtle poetry but often with great public appeal. In Sweden, Haquin Spegel wrote his charming *Guds werk och hvila* (God's Work and Rest) (1685), a rather bulky book filled with naive pleasures, giving, among other things, models for mural paintings in a manor-house as late as the 19th century in Linnaeus's Småland (2). It was all conceived in a most physical and realistic way—God creating plants, animals and man, the Fall, man and woman blushing at seeing their nakedness.

This literature was, of course, not unknown in Linnaeus's home. One should also include one of the most admired works on repentance of all time—Johann Arndt's *True Christianity*, from the early years of the 17th century. Its fame had partly to do with its rather unorthodox religious views, but more, perhaps, with its gentle, sometimes ecstatic literary style, completely different from the recommendations of the scholastic handbooks in homiletics. Linnaeus, no doubt, had read Arndt and taken note of his exhortations (3). Certainly, in his first three "books", Arndt strenuously admonishes man not to love either "this magnet of the world" or its creatures, but in the fourth book, entitled *Liber Naturae*, he changes his attitude: "The creatures are the hands and messages of the Lord, and they shall lead us to Him." Looking at the creation makes us understand God's greatness. Arndt quotes St. Matthew (6: 28): "Consider the lilies of the field, how they grow." This advice many priests who were interested in botany were liable to follow and, in this respect, Arndt must have been important for the spread of science. Botany thus became a part of theology and, in this sense, Linnaeus's father Nils may be considered to have been an excellent theologian, having an unusually plentiful garden. He gave his first-born a small part of it to cultivate and later on he supported Carl's plans to specialize in natural history and to aim at taking a medical degree.

So far, I have said nothing but what is very familiar. The reader will find more of it in any biography of Linnaeus, usually with a flavour of the flowery fairy-tale. But there is more to it than that.

For once, flowers were not merely supposed to prove, to some degree, God's infinite wisdom; gardens were sometimes called "paradises". The garden, rather than nature, was perceived as the essence of nature. In the garden, man could feel safe; he could admire beauty arranged according to the primordial, natural laws, not fallen into a chaos of untamed and unknown forces. In *Thet öppnade paradis* (Paradise Opened) (1705), after having described the glories of the original paradise, Haquin Spegel then turns to the Swedish palace-gardens, to the gardens of Drottningholm, Wänngarn and Stavsund, implying that gardening gives an impression of man's first happy surroundings (4). In *Hortus Cliffortianus* (1736), Linnaeus praises the pristine beauty of paradise in contrast to the hardness of later times, but, according to him, botany offers us an idea of this beauty (5). He states that paradise was the first and foremost garden in the preface to *Fauna svecica* (1746) and elsewhere (6). And in his youthful dissertation *De sceptro carolino* (1731), botany is called a *scientia divina* (7). Thus, in Linnaeus's mind, there was a close connection between Genesis and botany.

Here, I may remind the reader that in *Bibliotheca botanica* (1736) Linnaeus denominates different types of gardens, calling the "complete" garden, i.e. the one covering all the *Regnum vegetabile*, a *paradisus*. (Other types are *Adonis*, *Semiramis*, *Hesperis* and so forth (8). The perfection of paradise implied its completeness. Linnaeus's own ambition to achieve completeness characterized his work in "Hortus Upsaliensis", which was supposed to contain all types of herbs and trees. Thus, par définition, "Hortus Upsaliensis" was a *paradisus*. Strolling along the garden paths, Linnaeus could feel like Adam in paradise. The same may also be said of his tiny little garden at Stenbrohult. In the very beginning, as Linnaeus stated, God created two specimens of each species (or one hermaphrodite)—exactly the number of plants that young Carl got from his father—to see them "grow and multiply", as it was written in Genesis. Besides, to him, childhood was a paradisal state of life.

"Let the lad enjoy his paradise. He will be driven from it by care soon enough." (9) In this proverb-like phrase, Linnaeus has probably embodied something of his own history. Instead of "care", we should no doubt read "school". Linnaeus did not like either his tutors or the amount of classical literature he was supposed to learn. In this phrase, moreover, the myth of paradise is used not because of its historical factualness but as an illustration of individual development. As often in Linnaeus's writings, the appreciation of the child and of the simple life is explicit. He was a primitivist, believing that individual man, as well as civilization as a whole, had once enjoyed a happier life. He had a high opinion of the so-called primitive races, a subject which I pass over here (10). It will suffice to remind the reader of his enthusiasm about the Lapps. For instance, writing about Man's sinfulness, he questions whether the Fall really affected the Lapps, the Ostiaks and the Indians (11).

In *Diaeta naturalis*, Linnaeus's uncompleted work on dietetics written in the 1730s, he time and again returns to Genesis, explaining what man should eat and how he should behave for the betterment of his health. "Why is it that primordial man lived so long?" The answer is not the one given by Emanuel Swedenborg, that the astronomical year was shorter then; no, there was a different and healthier way of life in those days, and it is still to be found among the Lapps. They are shepherds in the manner of the patriarchs, and we should live as they do, according to nature and close to nature (12). Why, Linnaeus asks again, do gardeners grow so very old and look so healthy? Of course, the plants refresh them (13)! Thus, Genesis offers contemporary man a moral lesson to be followed cautiously.

But as Genesis, to Linnaeus, meant pristine beauty and happiness, it was a pleasant lesson. It was also something of a revelation. From personal experience, Linnaeus wrote: "When I had been ill in 1718 from winter until Whitsun and came out into green nature, it seemed like paradise to me, not like the world [i.e. the fallen world]. I saw it now in a different shape, everything was so high, so beautiful." Still, neither his nor any other mortal's experience could ever match the experience of Adam and Eve, "perfectly shaped, full of vigour and without prejudices, gazing at mountains and green valleys with rivers running in the most perfect climate, valleys covered with grass, herbs, trees of all shades of green, colourful flowers, all kinds of animals running about" (14). Linnaeus continues this inspired hymn to past glories, but this excerpt will be enough.

The words "without prejudices" are of interest. In an often quoted sentence written in 1730, Linnaeus reveals that he had decided to set "all prejudices" aside and to become a "sceptic", doubting everything (15). In so doing, his eyes had been opened. In this utterance, which is in fact a description of his birth as a scientist, scholars generally have heard an echo of Cartesian doubt; Descartes's philosophy had some decades earlier liberated the Swedish universities from scholasticism. However, it seems more probable that we should attach another meaning to "without prejudices", namely, that Linnaeus simply wanted to return to Adam's original sound reason. This interpretation is, I think, more in accordance with his general mode of thinking, without, perhaps, eliminating the possibility that he was alluding to Descartes too.

I have so far attempted to show how Linnaeus simply could not escape the influence of Genesis, that this influence supported his very high opinion of botany, and likewise that botany had an esthetic aspect to Linnaeus. I have mainly considered the emotional impact of Genesis on Linnaeus but so far not dealt so much with its consequences for Linnaeus's science—admitting that it is in fact impossible to separate the emotional and scientific elements in Linnaeus's thought.

God's creation was not just green meadows inhabited by sweetly singing birds. It was distinguished by strict order, unending variation and wonderful utility. Linnaeus never grew tired of reiterating these characteristics of the creation, nor was he ever short of proofs. It was his sacred mission as a natural historian to demonstrate the order of nature, thereby proving God's greatness and nature's beneficient order to man. This idea, inspired by the words in Genesis, that all creation was made for the sake of man, is central to Linnaeus's interpretation of nature, to which should be added, of course, the concept of nature's "chain of being" and a non-intellectual apprehension of the constant interplay in nature, all constituting his overall view of creation as a harmonious whole (16). Central to these matters are the important dissertations *Oeconomia naturae* (1749) and *Politia naturae* (1760). Reviewing nature, Linnaeus never forgot the original model, the myth of creation, as told in *Liber revelationis*, i.e. the Bible, but even more trustworthily in *Liber naturae*, i.e. what the study of nature told man. There was a tension between these two "books", but, to Linnaeus, there could not be any contradiction. And as man was ordered to study nature by the Lord, Linnaeus was fulfilling a sacred task.

It was Albrecht von Haller who—rather mockingly—called Linnaeus "the second Adam", referring to Adam's naming of the animals (Genesis 2: 19). Linnaeus hardly disapproved. Convinced of his great role and his unique capacity, he was rather patronizing towards the theologians, who, according to him, were simply not doing their job, if they were unable to read in nature's book. They, for their part, were annoyed at the intrusion of a professor of medicine and warned him for his incautious remarks in his dissertation *De curiositate naturali* (1748) (17). It is well known that Linnaeus was convinced of the religious importance of natural history, but no doubt he also felt assured by the new physics that God had created the world. This was not an unusual phenomenon, as historians of science have shown that the myth of creation acted rather as an inspiration than a counter-force in shaping the scientific revolution (18). However little Linnaeus knew about the Newtonian world picture, he at least knew that nature's laws had been proved to be few, universal and beneficient. Nature was not ruled by mysterious forces and it was man's present purpose to show the rationality of both God and himself.

To Linnaeus, the creation was the fundamental guarantee of order. He never doubted the central Christian doctrine of *creatio ex nihilo*, a momentary creation, otherwise there would have been no order, no reason in nature, such as he everywhere found displayed. Genesis gave the ultimate causal explanation necessary for all other explanations. This did not, however, mean that the Mosaic creation myth must be interpreted to the very letter.

The species concept of Linnaeus in its classical wording sounds almost fundamentalistic: "We count as many species to-day as were created in the beginning" (19). However, the Bible does not explicitly state that all the species came into existence during the first six days. Linnaeus's corollaries are all his own. That God created one couple of each species is stated only of man and that He made one hermaphrodite of certain lower organisms is not mentioned at all. When Linnaeus denies the possibility of spontaneous generation, he does so in consequence of his belief in creation having been finished by God, the warrant for reasonable and universal rules in nature (20). This is a rather late return of the scientist to the idea of nature's simplicity in contrast to the old and more sophisticated explanation: according to the latter, insects and "imperfect" organisms were not created *in actu* but *in potentia*. To Linnaeus, however, a perfect creation could contain neither anything imperfect nor exceptions from the general rule. And the original order prevailed, unaltered, until today.

This general opinion of a static order of nature underwent important modifications. Starting in the early 1740s, Linnaeus began to change his opinions about the fixity of the species. In addition, he was about to propound a very extravagant theory, stating that every organism consists of two substances, the marrow and the bark (*medulla* and *cortex*). The origins of these new ideas are too complicated to be explained in brief, but it should be mentioned that they were combined in *Genera plantarum* (4th ed., 1764), in which the old formula "We count to-day as many species as in the beginning" was replaced by a three- or four-stage order. "In the beginning", he now states, "the Creator of the universe covered marrow with one type of bark, from which one individual of each natural order developed." Secondly, God mixed these individuals, so creating natural genera, and thirdly, nature then mixed, *and still mixes,* these genera to form new species: new species are thus developing out of crossing (21). According to Linnaeus, every species was not created directly by God but by nature's laws; these laws, however, were designed by God, who seems to have withdrawn from direct interference with His creation.

Such a theory hardly seems compatible with Genesis. What Linnaeus is doing is to *use* Genesis as a basis for a hypothesis which explains what needs to be explained and which seems to be in accord with the latest findings in science and natural history, among other things, the appearance of new species. It is clear that Linnaeus was now trusting more in the accuracy of science than in Genesis, but it is also clear that he did not consider his ideas to be in opposition to the biblical myth of creation. And such a myth was still necessary to his scientific argument. But this new theory, which was admittedly a hypothesis, throws light on the earlier species formula, which is usually considered to be of a fundamentalist tendency. As it seems that Linnaeus left it without brooding it too much, it should likewise be considered to be an hypothesis, accepted only as long as it seemed to fit the supposed facts, otherwise to be replaced.

Belief in Genesis was, to Linnaeus, especially the vindication of the causality of the world. Genesis could therefore be made reasonable. Linnaeus's famous *Oratio de incremento telluris habitabilis* (Speech on the Growth of the Habitable Earth) (1743) exemplifies his adherence to natural history as well as to Moses. It is easy to summarize but more difficult to analyze.

In the beginning, the earth was much smaller than it is to-day, Linnaeus explains. It was an island situated in the huge ocean, close to the line, thus offering a very warm climate but also more chilly ones along the slopes of a high mountain at the centre. Each plant and animal could consequently find its right habitat. The Lord had in the beginning created of each species one pair—or a hermaphrodite—and at the same rate as the land area increased, their numbers had multiplied through constant reproduction. So it goes on. Evidently Linnaeus is proving his formula "We count as many species today" etc., but, in so doing, he starts less from the text of Moses and more from a presentist point of view. Looking backwards from his own time, he calls attention to the diminishing number of individuals, according to the laws of reproduction, ending in one single pair or hermaphrodite. By analogy, he then claims that the habitable earth is increasing from this small island. The source of his theory may have been the current discussion of the "diminishing of the water" of the Baltic Sea (we would say "the land elevation"), to which Linnaeus wanted to assign wider proportions (22). Less significantly, Linnaeus also offers theological arguments. He presupposes a kind of divine rationalistic economy: why should the benevolent God create such a multitude of animals only to drown them in the deluge? He also argues in the manner of a professional nomenclator: if Adam actually named all the animals, they must undoubtedly have been living in the vicinity and in a very limited space. (Critics, by the way, might have objected that the Arctic animals must have had a hard time waiting to be allotted their names in the queue winding up through sunny paradise (23).)

The idea of the paradise island may be traced a long way back in classical literature. Linnaeus may, for instance, have been thinking of the island of the blessed. Yet, without being original in particulars, he is remarkably free in his treatment of Genesis in his "Speech". But also elsewhere, in early drafts of *Fundamenta botanica* (*c.* 1730), he admits his ignorance as to whether every day of creation means "day" or "week" or "year" (24). Later on, he became convinced that the earth must be much older than the 6 000 years officially stated. Perhaps, Linnaeus suggests, the Chinese are right in teaching that the world is 30 000 or maybe even 75 000 years old. Nor did he believe in a universal deluge, on account of the geological evidence to the contrary. In some notes headed "all natural scientists have been free-thinkers", his opposition to the theologians is manifest, but when he himself tries to solve the old problem of how the sun was created on the third day, day and night being already mentioned on the second day, he offers nothing original (25). However, his discussion is another good example of his belief that there was no real contradiction between science and Genesis. To ask him which he believed in most would have been to ask an incomprehensible question. In his "Speech" he explicitly refers to three sources of knowledge on these matters—revelation (Genesis), experience (science) and common sense (the way of combining the other two).

It should be noted that there was nothing strange in a natural historian dealing with biblical subjects. Swedenborg, that singular man who worked in so many fields of science, also wrote in the 1740s a paraphrase in the Hexaëmeron tradition entitled *De cultu et amore Dei* (26). Otherwise, authors generally took up smaller issues. Linnaeus's teacher Olof Rudbeck wrote a long dissertation proving that the manna in the desert was, in fact, flying fishes (27). Young Linnaeus's patron Olof Celsius was an expert on the flora of the Holy land, and Fredrik Hasselquist went to Palestine with the blessings both of Linnaeus and of the Faculty of Theology at Uppsala University. At the end of the eighteenth century, Samuel Ödmann, an excellent ornithologist, was to write extensively on the flora and fauna of the Bible. That Linnaeus did not dwell more on the Bible may have had to do with his relative lack of interest and ability in philology. I should like, however, to mention a few scattered examples of his rather singular exegesis.

In *Musa Cliffortiana* (1736), in which Linnaeus triumphantly proclaims his successful growing of the banana in Clifford's garden, he, for once, attempts a more scholarly discussion (28). Among other things, he enumerates eight reasons why the banana must have been the tree of knowledge and proposes that its leaves could also have been used by Adam and Eve to hide their private parts. The divines, however, do not seem to have cared about these suggestions.

In *Diaeta naturalis* (1733 onwards), the tree of knowledge is interpreted in a remarkable way as a symbol of man's first encounter with sexuality. I shall not enter into the details, but Linnaeus's interpretation is not his own (see the Appendix). More should be said, I am sure, about Linnaeus's conviction that sexuality was the ultimate force in nature and its bearing on his attitude to Genesis, and Jahweh's exhortation to all his creation to grow and to multiply.

This case shows that Linnaeus was not unfamiliar with clandestine literature. We do not know if he had any detailed knowledge of Isaac La Peyrere's scandalous best-celler of the 1650s, *Pre-adamitae,* in which he asked if there were men before Adam and where Cain took his wife. In *Systema naturae* (tenth edition), Linnaeus seems to suggest that his second species of man, *Homo troglodytes,* which was his very own invention, could explain the old stories about the pre-Adamites. But, on the other hand, that solution would have meant marriage between different species (29).

Two more examples, now from Linnaeus's work on the Swedish Bible translating committee of 1771. His task was to interpret the names of plants and animals, but he also wrote a curious letter to Michaelis, the most famous philologist of that day, about the creation of Eve. Could it not be, he asked, that the Hebrew word "tsala" should not be translated "rib" but "marrow"? Michaelis was probably somewhat confused, and the answer was, of course, a negative one. For our part, we recognize here Linnaeus's theory of the marrow and the bark, briefly touched upon above. It is probable that Linnaeus wanted to get an ultimate confirmation of his own theory rather than to contribute something to theology (30). The same perhaps goes for a most interesting identification given in manuscript notes on the words "and God's spirit hung over the waters". Here, Linnaeus has written simply "ignis vitalis electricus" —God's spirit is a vital, electrical flame (31).

We find the widest possible prospects, finally, in the introduction to the twelfth edition of *Systema naturae,* the third part (1768), the little-known part dealing with minerals. Linnaeus appeals to Thales and Moses, claiming that the primary element was water, the origin of all life. The minerals came into being through the primordial "marriages" between the "fatherly" salts and the "motherly" sands in continuous crossings in a manner similar to the crossings between the higher taxonomic groups among plants and animals (32). Linnaeus writes all this with the obscurity of myth, and he speaks like an old prophet who has seen further into nature than anyone else. Perhaps he may be compared to one of the Ionic philosophers who first tried to give causal explanations of nature's history. Perhaps, also, reading his endeavours in natural philosophy, one feels tempted to call him something more than "the second Adam". He was not satisfied to be a simple nomenclator, though he had been given this task by God. Linnaeus was an ambitious man and perhaps would not have minded even the epithet "the second Moses".

It would be going too far to scrutinize Linnaeus's interpretation in depth. Still, it should be stressed that, to Linnaeus, God was hardly the traditional, old, white-bearded man. Perhaps he had been so before, but, as time had passed, science had effaced some of the letters in Linnaeus's copy of Genesis. Its spirit, however, remained alive to him. He did not really need many dogmas; he had enough with the idea of a creator, a momentary creation starting the whole thing off, an assurance of order and rationality in nature, and an explanation of why nature was so beautiful. But, taking everything into consideration, Genesis was of enormous importance to him: it had inspired him to find paradise in nature, it had given his profession the status of *scientia divina*, and it gave his science its ultimate foundation. To establish the interconnections between these different levels of influence and to evaluate their significance more precisely would need further inquiry.

Appendix: Linnaeus and the Fall

In *Diaeta naturalis*, Linnaeus's notebook on dietetics written in the 1730s, is to be found a parallel between the story of the Fall and the awakening of sexuality in man which runs like this:

Poma Adami testiculi fuere

The tree of the covenant, allegory	
in the middle of paradise	*in medio corpore Adami*
the snake deceived	*penis*

fons aspectu pulcher	*testiculi*
pleasing to eat	*usus titillans*
later felt shame	*a coitu tristitia*
witnessing their nakedness	*pudor*
were to die	*qui procrearunt* (33)

That this idea was not just a hasty suggestion is apparent from other passages in *Diaeta naturalis.* "What the tree of the covenant and the apple which Eve took and felt its pleasant taste was, if it was *poma Adami,* I do not want to discuss or decide here. Anyway, they soon hid their nakedness. And it is certain that the first command was *crescite et multiplicamini,* a law which is so deeply rooted in all bodies that one cannot rightly describe it." (34). Linnaeus goes on to show the powers of sexual love. One more quotation: "I know not of any female who *post conceptionem admittit marem* except for *mulieres, quae ad partum pomis Adami a vetita arbore scientiae boni et lai (salva allegoria) deletantur*" (35). The sexual impulse is obviously especially strong in man. Similarly: "But as soon Eve took *poma Adami,* she began thinking on other matters, she felt its good taste and she forgot the rest" (36).

Briefly, Linnaeus is suggesting that the story of the Fall is a description of the awakening of sexuality, sex being prevalent in all nature and especially in man. Considering his general conception of nature, this interpretation is hardly surprising. According to him, nature was ruled by sexuality, and man as a natural being and an animal obeyed the same laws. Linnaeus seems convinced of the truth of this idea, and was, of course, aware of its unorthodox character. And, moreover, he may have connected it more or less unconsciously, with his opinion of individual man, that each one of us is driven out of the paradise of childhood during puberty ("Let the lad have his paradise" etc. above).

Linnaeus was not the only one to interpret the Bible in this way. The authors of the older exegetic literature had to explain, among other things, when Adam and Eve started their wedded life. Some found it probable that it had commenced even before their expulsion from paradise while others hesitated to go into the problem (37). Bolder interpretations were also attempted, for instance, on the question of the sex of Adam. Perhaps under the influence of Plato's *Symposion* it was even suggested that he was a hermaphrodite. Jaques Duval, a physician in Rouen during the Renaissance, wrote a book about hermaphrodites and put Adam in as the first exponent and figurehead of his theme (38).

On a delicate subject like this, the Dutchman Hadrianus Beverland clearly went too far. In his book *Peccatum originale*, printed in "Eleutheropolis" (Freedomtown) at the "office of Adam and Eve", Beverland asserts that the Fall should be interpreted as the sexual act. The same theory had been suggested by Henric Cornelius Agrippa (*De peccato originali*, 1532) and by Robert Fludd (*Tractatus theologico-philosophicus*, 1617), but Beverland made much more of a good story out of it. Of course, he was notorious to his contemporaries, his book was no less than a scandal and he had to go into exile in England because of it. Living first in the house of Isaac Vossius, the famous philologist, Beverland went on writing stranger and stranger pamphlets. He was not allowed to return to his home country and died in poverty in 1716 (39).

Beverland's book appeared in several editions and paraphrases. Linnaeus could have heard about it in Holland and certainly even in Sweden, when he was working as a private tutor in the family of Olof Rudbeck, who despite being Professor of Medicine was more interested in the philology of the Old Testament. In his notes dealing with the snake in paradise, Rudbeck dismisses with disgust the theory of Beverland, "whose footsteps I would hate to follow" (40). Instead, he exhibits his customary, rather queer, philological erudition, which posterity may find much less interesting than Linnaeus's bold interpretation of the real meaning of this decisive turning-point in man's history.

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3. Cf. J. Sahlgren, Linné som predikant, *SLÅ* 1922, 40–55.
4. H. Spegel, *Thet öpna paradis*, Stockholm 1705, 14.
5. C Linnaeus, *Hortus Cliffotianus*, Amstelædami 1737, Dedicatio.
6. C. Linnaeus, *Fauna svecica*, Stockholmiæ 1746, Præfatio.
7. *Skrifter af Carl von Linné* utg. af K. Vetenskapsakademien, *4* 245.
8. Carl Linnaeus, Bibliotheca botanica. Amstelædami 1736, 64.
9. Caroli Linnaei Diaeta naturalis, utg. A. Hj. Uggla, Stockholm 1957, 42.
10. Cf. G. Broberg, *Homo sapiens* L. *Studier i Carl von Linnés naturfilosofi och människolära*, Uppsala 1975.
11. *Diaeta naturalis 1733*, utg. A. Hj. Uggla, Uppsala 1958, 133.
12. *Ibid.*, 16–17, 88.
13. *Ibid.*, 52.

14. *Ibid.*, 168; *Lachesis naturalis*, *Uppsala Universitets Årsskrift* 1907, 48.
15. C. von Linné, *Ungdomsskrifter* utg. E. Ährling, Stockholm 1888, 93.
16. Cf. C. von Linné, *Om jämvikten i naturen*, Stockholm 1978, Inledning: G. Broberg.
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19. *Fundamenta botanica*, Amstelodami 1736, § 132.
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21. *Ibid.*, chapter 2.
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23. E. Zimmermann, *Geschichte des Menschen und allgemein vierfüssigen Thiere*, 3, Leipzig 1783, 193 ff. Positive comments by T. Needham in L. Spallanzani, *Nouvelles recherches sur les decouvertes microscopiques*, London & Paris 1769, 133–156.
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25. Cf. Frängsmyr, 198 ff.
26. See I. Jonsson: *Swedenborgs skapelsedrama De cultu et amore Dei*, Stockholm 1961-
27. O. Rudbeck, *De ave selav*, Upsalis 1705.
28. *Musa Cliffortiana florens Hartecampi*, Lugduni Batavorum 1736. Cf. A. Hj. Uggla, Linné och bananen, *SLÅ* 1959.
29. Broberg (1975), 241 f.
30. *Ibid.*, 149.
31. *Ibid.*, 149.
32. *Ibid.*, 137 f.
33. *Diaeta naturalis*, 162.
34. *Ibid.*, 111.
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ALBERT JOHAN BOERMAN

Linnaeus and the scientific relations between Holland and Sweden

Sweden was the birthplace and homeland of Linnaeus and still conserves the surroundings where he lived. England has contributed to the preservation and extension of his scientific biological work. Thus he is still a living presence in Burlington House and at Kew, in Uppsala and at Hammarby. However, we should not forget that it was a third country which permitted the metamorphosis of the larva of his youthful ambitions into the butterfly of his adult, worldwide fame. This country was Holland, also the *secunda patria* of Linnaeus Pater, to a somewhat lesser degree of Linnaeus Filius and to a higher degree of their immediate successor Carl Petter Thunberg.

Before Linnaeus made his famous three-year journey to the Low Countries these had welcomed young Swedes to their universities for about 150 years. Wrangel (1) wrote a book on this phenomenon, which began early in the 17th century and concerned all academic disciplines. As for the faculty of medicine, according to another Swedish author (Grape (2)) from the middle of that century the majority of students preferred Holland for their more advanced studies or, if medical education could be obtained in Sweden, received it from teachers who themselves were highly influenced by Dutch universities.

These conditions must be seen against the political and economical background. Both countries were at the zenith of their glory as great powers by the time of Linnaeus' birth. However, whereas Sweden was a poor and spartan, rather landlocked nation with a militarised and highly centralised government, the Netherlands were a more athenian, seafaring nation with many colonies, great wealth and a rich cultural life. When Linnaeus was a schoolboy military greatness was in decline in both countries but their cultural ties were still very strong and of the same nature as before.

Linnaeus himself, and the men around him, first intensified these connections to the very highest degree and then showed themselves ideal disciples by surpassing their teachers and making Sweden independent for both medical and scientific education, converting it into one of the most modern countries in the world in that respect. I shall try to show the way in which Linnaeus contributed to this reversal of roles, proceeding in the true Linnaean way, i.e., methodically.

The oldest known Linnaean manuscript is the Book of Herbs or Örtabok in which, from the year 1725, the schoolboy who at that time was still expected to become a priest jotted down all he had come to know about various plants, drugs etc. As a priest in the Swedish countryside was often the only learned men available and had to advise the peasants in matters of health of the family, cattle and crops as well as in spiritual matters, this kind of natural history was a useful part of theological education. The manuscript was published in 1957 (3), by the late Telemark Fredbärj, who together with the late Arvid H. Uggla has done so much to make unpublished and Latin Linnaean texts available to the present Swedish public by stimulating their edition and/or translation and providing them with explanatory notes.

The very first of the anecdotal plant descriptions in this Book of Herbs is dedicated to the tulip, with a note on the "tulipomania", or botanical goldrush, caused by wild economic speculation in all kind of flower-bulbs in Holland in 1637–8. Thus, the tulip and the commercial life of its adoptive home country stand symbolically as an omen at the very beginning of Linnaeus' scientific writings and as a starting signal for his life as a botanical author. And indeed he could hardly have become the "flower king" without his contacts with the flower country: its interest in exotic plants and animals, its international trade connections *and* its eagerness to engage itself economically in anything new, even in such an uneconomic prospect as the renewal of biological science.

The first impact of Holland on the life and dealings of Carolus Linnaeus was, however, to be indirect and to concern not biology but medicine. It came about a year after the tulip annotation through Dr Rothman, the district physician who also taught natural history at the Latin school (gymnasium) at Växjö (4). On September 1st 1726, when Carl's father visited the school, all the teachers told him that his son had no future as a priest; "after all, he had had to repeat three classes and he ought to learn a craft instead of continuing academic studies". However, Dr Rothman felt that the boy's future might very well be more brilliant then that of all his companions provided he would study medicine, in which case he might become "a famous doctor". He also offered to take the boy into his house and give him private lessons if this proposal was accepted. The father did accept, though without enthusiasm, and Rothman proved to be as good as his word, teaching young Carl privately until the latter left the school to become a medical student in the summer of 1727.

According to his biographers (5), Rothman himself must be regarded as a very talented and scientifically interested physician who would have become a professor of medicine at Lund university but for certain academical intrigues.

He had completed his studies in Holland, where he took his doctor's degree in Harderwjk in November 1713 and thereafter stayed in Leiden for a year to hear Boerhaave, who long before in 1693 had also taken degree in Harderwjk and who now was "the leading physician of Europe". That title is given to him in an American journal (6). Which explains that Boerhaave besides being an excellent clinician had "systematized medical knowledge, and clarified and expounded medical theory". He published his results in books that obtianed such popularity that "not since Galen had a clinician achieved such a wide reputation as a teacher". His *Institutiones Medicae* had become a kind of medical Bible and this was also the first textbook Dr Rothman went through with Linnaeus. Thereafter further works of Boerhaave were discussed and important scientific notions taught from other sources.

Owing to the good care of the Linnean Society of London, Linnaeus' notes during the whole course of instruction have been preserved (7) and when comparing these with later manuscripts, especially those forming the base for Linnaeus' lectures as a medical professor on Diætetics, one finds that his entire general outlook in medicine had largely remained Boerhaavian. In modern terms it is patient centered, holistic, with a hippocratic stress on preventing of disease by healthy life principles rather than on curing, and a rational approach to therapeutic measures. The latter include drugs and on these Rothman quoted Boerhaave's *De viribus Medicamentorum,* which thus helped to arouse Linnaeus' interest for materia medica, eventually leading to his participation in the edition of the first Pharmacopoea svecica (8). Among the Dutch names figuring in early notes the best known are *Leeuwenhoek,* the greatest of microscopists according to his modern English biographer Clifford Dobell (9). Later in life Linnaeus was to remember Leeuwenhoek's "invisible world" several times and to express the thought that from it comes the cause of several diseases (10). Also *Swammerdam,* the first to make detailed studies of the anatomy of "bloodless small animals", who thus became the first to stimulate Linnaeus' interest in insects. By the way, Boerhaave had paid for the publication of books by both last-mentioned investigators; he was not only highly interested in new scientific developments but also acted as a Mecenas, which trait was to benefit Linnaeus himself also in course of time. And in this connection it should be mentioned that Boerhaave had also helped a French botanist *Vaillant* to publish the work on the sexuality of plants which through Rothmans lessons would induce Linnaeus to start developing his sex-based system of botanical classification. Rothman did not limit himself to teachings from Dutch books, however; he also became a propagandist for the country itself. Thus we find that when discussing Linnaeus' further studies he says: "you can learn as much in a month in Holland as in a year in Uppsala".

Thus Rothman would seem to have suggested to Linnaeus at an early state that he should visit Holland later on (14).

After the Latin school & gymnasium at Växjö, Linnaeus studied medicine in Lund 1727–28 and then in Upsala 1728–35. It would be tedious to follow step by step what impulses during those years came from which country and which source—in general it might be said that he studied everything of natural history interest he came across, in living Swedish nature as well as in herbaria, but never received much formal medical education as the professors both at Lund and Upsala were old and tired at that time. Outside these universities, however, he met some extraordinary teachers—Stobæus in Lund and Celsius in Upsala for instance—who helped him in his medical and botanical studies. But all these men, including Linnaeus' later father-in-law Dr Moraeus (11), had studied in Holland. The Dutch influence also can be seen from Linnaeus' library, of which he of course kept careful accounts, with price, date of acquisition etc., which now are available in print (12). Among those 219 books which he had obtained by buying or received as presents during his student years, we meet Swammerdam's *Historia Insectorum* and also old, classical Dodonaeus whom he was to quote often later on. On the medical side there are Hornius the surgeon, Henrius the clinical teacher and Blancard the lexicogapher from Leiden and Amsterdam, and then we find the pharmacopoeas of the latter city and of Leeuwar-

den. The last, of course, is not from Holland but from Friesland, but anyhow, the Low Countries were constantly present in the life of the Swedish medical student Linnaeus. And at the end of it all, when he had to go and get his doctoral degree in some foreign country in order to be acceptable as the husband of Sara Moraea, the choice was not difficult. Thus we come to the presence of Linnaeus in the Low Countries.
Before specifying what were the mutual benefits of his Dutch years for Sweden and for Holland, we might begin with a slight speculation on their general impact. When he arrived, Linnaeus was a poor student with lots of advanced ideas. It is true that he had in part worked out these already in the manuscripts he carried with him, but he had published no more than a few articles in a German pop-scientific journals, *Hamburgische Berichte von Gelehrten Sachen*. He had seen no more of the world than his own country, which he knew well indeed: he had travelled through it from South to North and seen various towns, including Stockholm. But even Stockholm had no more than about 50000 inhabitants at that time. Lund was an idyllic little place with some 4000 people and Uppsala had not many more; as for the former, the idyllic impression seems to have been disturbed by the great number of swine and cattle in the streets and the accompanying smell, sharply criticised by his majesty king Charles XII during a visit some years before Linnaeus' arrival (13). Compare this with Amsterdam for instance, a city of over 200000 inhabitants and according to Thunberg during his visit in 1770 (see below) "surrounded by so many ships and boats that it seems impossible to believe". The contrasts which Linnaeus saw on his journey were thus enormous, so that it is no exaggeration to state that when he came back to Sweden he had become wordly wise by meeting the wide world. And that world had begun to discover Linnaeus, too. Let us see what had happened.

Within a month after arriving in Holland, Linnaeus first took a written examination to become candidate of medicine and then defended his well-known doctoral thesis "on the cause of intermitten fevers" at the little university of Harderwijk (closed by Napoleon and never reopened afterwards) where Rothman and Boerhaave had preceded him. Unkind words have been said about the "cheap degrees" obtainable at this institution, but in 1735 it had recovered from its deplorable post-war state of seventy years before and Linnaeus was given two thorough examinations by professor Johannes de Gorter (14). Linnaeus made a favourable impression which no doubt was improved when he botanised locally with

David de Gorter, the son of Johannes, who still called himself Linnaeus' disciple when writing to him 12 years later. In 1754 both De Gorters became the Russian Tsarina's court physicians. They did not find an opportunity to visit Linnaeus on their trip to St. Petersburg, but David (15) compiled a Flora Ingrica or Russian Flora in 1761–64 and a Flora Belgica (the first Durch flora!) in 1767 along the lines laid down by Linnaeus. In the 2nd version of the latter book he expressly states that it owes its existence to the excursions with Linnaeus in 1735 in Harderwijk: hospitality had indeed been very advantageous to both sides!

Even before travelling to Harderwijk, Linnaeus and his companion Sohlberg had looked around a little in Amsterdam where they arrived. They visited the famous apothecary Seba and his new second collection of natural products; the first one he had sold to the Tsar (Peter) in 1717. The result, according to Dutch zoologist Prof. Engel (16), was that Linnaeus learned much and found specimens which served him in the preparation of his Systema. The fishes were first taken by Artedi whom Linnaeus had introduced to Seba but who was tragically drowned some time later when returning one night from the latter's house; Linnaeus saw to it that his manuscripts on ichthyology were published posthumously. Another negative, though less tragic, result of his contact with Seba may have been the initial coolness of his reception later on in England, where Seba had many influential friends. Dutch friends had warned Linnaeus not to be too triumphant about his discovery that the "hydra with seven heads" shown to him at Hamburg and described by Seba as real in his splendid Thesaurus, vol I, was a fake, but Linnaeus disregarded the advice and displayed a considerable lack of tact.

The second important visit during Linnaeus first stay in Amsterdam was to the professor of botany, Burman (17), his botanic garden and his herbarium. The reception here was not so liberal, but during a later visit, prepared for by Boerhaave whom Linnaeus had by then met personally, Burman showed himself so cordial that Linnaeus stayed with him for a time and helped him with his *Thesaurus Zeylanica*, thus getting to know many new exotic species. A lifelong friendship developed, which was continued and extended subsequently by the sons of both learned botanists who each succeeded his father, resulting in a stream of letters, seeds, and dried and living plants that were exchanged between Amsterdam and Upsala over a period of dozens of years. In general it was Upsala that benefitted most of this, but in turn Amsterdam University always had first hand advice in botanical matters from the highest authority. Eventually these relations came to be of even greater international importance as we shall see when we come to Thunberg.

When coming back from Harderwijk, July 1735, Linnaeus first of all had gone to see Boerhaave (18) and found the great man favourably disposed. This meant many useful introductions—to Burman, as we saw, and also to other botanists at Leyden as we shall see.

Moreover, Boerhaave made arrangements for him to extend his stay in Holland to 3 years instead of 6 weeks and finally Linnaeus visited his world-famous clinical lectures. Their friendship came to an end with the death of Boerhaave just before Linnaeus left for Sweden by way of Paris and the sea route from France in 1738: he had paid him a last visit shortly before.

In Leiden the most eventful meeting after Boerhaave was with Gronovius (19) a rich doctor who dedicated himself mostly to city politics, but made botany an all-consuming hobby. This man, when shown the concept of Systema naturae, grew so enthusiastic that he offered immediately to have it printed. He shared the cost with an acquaintance, the Scots medical student Isaac Lawson. It has been said that indeed only a native of Småland could succeed in having a Dutchman and a Scot pay his printers and thank him for it into the bargain. Anyhow, this became the beginning of a close collaboration between Linnaeus and Gronovius, the latter never tiring of providing encouragement, finance and correcting printing proofs, etc. A certain rivalry sprang up between Gronovius and his circle at Leyden and Burman at Amsterdam, who saw to it that further Linnaean manuscripts became books, and that the fame of the author increased accordingly.

To the Leyden circle belonged the botanical professor Adrian van Royen whom Linnaeus was to help with the renewal of the garden during his last winter in Holland 1937–38. Another member was Lieberkühn who contributed by interesting the others in his magnificent microscopes and during one of these meetings demonstrated the spermatozoa in dog's semen. Linnaeus looked, and then declared that these were nothing but "particles put into movement by the warmth of the fluid". On other occasions Linnaeus proved himself a study "ovulist". The controversy seems to have led to heated discussions (20), useful in preventing Linnaeus from getting onesided and in keeping him in touch with all that was new in the medical and scientific world of his days. His own contribution to that news eventually came to over 500 printed pages in folio and 1350 pages in octavo, all of the greatest interest for the further development of botany and zoology (21). This large number (14) of books published in Holland has made many a modern Dutch schoolchild believe that Linnaeus was, in fact, a Dutchman.

As so often happens, while the two parties (Leyden and Amsterdam) were quarreling a third party took the cause of dissention away... While working in the garden with Burman during his second visit there Linnaeus was visited by the rich banker Clifford, who then invited both gentlemen to his estate, Hartecamp in Heemstede, near Haarlem, and offered Linnaeus the position of *prefectus horti* there, which he accepted in the autumn of 1935 and was to keep for 2 years, preparing the bibliographically most magnificent of his works, *Hortus Cliffortianus*. From its preface, we can see what this period meant for Linnaeus: "My eyes were immediately delighted by so many masterpieces of nature put into relief by art—alleys, flower beds, statues, pools and artfully constructed hills and labyrinths. I was spellbound by your (i.e., Clifford's) menageries full of tigers, monkeys, wild dogs, Indian deer and goats, South-American and African swine; with their noises were those of a great quantity of birds ..." (whereafter some 20 species are enumerated) —Even more, of course, Linnaeus marvelled at the botanical collections: 'I was dumbfounded when entering the hothouses, filled with so many plants that a son of the North could not but feel himself enchanted and carried off to who knows that strange part of the earth." In the first hothouse he then describes a great number of plants from Southern Europe, in the remaining three the plants from Asia, Africa and "America with the remaining New World". No wonder that Linnaeus confesses it became his liveliest wish to help with the care of it all. And this he did in an effective way: already in January 1737 he had succeeded in getting the banana (Musa) to flower for the first time on the continent, which was considered so extra-ordinary that Boerhaave and Gronovius and Burman all came travelling to see it and a special little publication was dedicated to it. Most remarkable perhaps was the method used by Linnaeus; he imitated the circumstances in the tropical homeland of the plant by exposing it to hot showers!

In August 1735 Linnaeus had expressed a wish to visit England and had obtained a letter of introduction in English from Gronovius (Aug. 16th) to Philip Miller of the Apothecaries Garden at Chelsea, (21). Another letter of introduction, this time in Latin, was written by the generous Gronovius in July 1936 (22) when Linnaeus actually set sail to England, where he was to obtain new seeds and plants for the Hartecamp by the order of Clifford who also provided the means for this summer excursion. It has been described by a far more apt author (23); let us just mention the fact that the Dutch introductions to Philip Miller (by Gronovius) and Sir Hans Sloane (by Boerhaave) were hardly more suitable or initially successful than Linnaeus' own letter to Dillenius at Oxford. Perhaps this was a blessing in disguise: the initial coolness might have made Linnaeus slightly less hyperbolic so that his superior botanical knowledge was then shown in a more favourable light.

At the end of his Dutch stay Linnaeus felt the impact of the damp climate. He also had a severe attack of malaria and was treated for it by the best clinician among Boerhaaves pupils, Gerard van Swieten, who later became court physician and professor in Vienna. He was then offered a convalescence period at Hartecamp and thereafter returned to Sweden, never to leave his home country again until his death, 200 years ago. On his way he paid a short but successful visit to de Jussieu and Les Jardins du Roi at Paris, but this does not belong to our subject; let us just point out that the work on dichotomous determination done there has kept its value and met with Linnaeus' great approval. It certainly contributed much to the practical value of his system for the public.

During the first three years after his return Linnaeus practiced medicine in Stockholm where he also became the driving force in and the first president of the new Academy of Sciences (24). Perhaps the scientific circle at Leiden served him as a model, he certainly did not forget some of the subjects he had dealt with. From 1743 onwards Linnaeus served his country as a Professor of medicine in Upsala (25) together with Rosén von Rosenstein (26) who also had studied in Holland; they taught the theory and practice respectively. They reformed medical education after the model of Boerhaave, with such success that foreign student now started travelling to Upsala—among the Dutch ones young Burman in 1769 (young de Gorter never made it, as we saw). The relations with Leiden and Amsterdam remained strong and frequent: we noted the stream of letters and biological material in both directions. In general, however, and even if Holland through Linnaeus remained a window on the exotic world for Sweden and continued to be the favoured party with respect to his authorship, both countries gradually drew more apart now that Sweden had become self-sufficient in matters of scientific education. And yet once more the Linnaean tradition was to bear rich fruits for both countries, and also for the world at large.

Linnaeus had adopted the habit of using his international connections to send his pupils, his "apostles", botanizing in the most remote parts of the world: for instance, one was with Cook on his first voyage, another on the second one etc. These apostles extended the field of botanical exploration, rather limited until then (27), until it covered many coastal regions and some parts of the interior of all the continents (28). They did excellent work but many of them paid with their lives and others stayed in foreign countries. The greatest of them all, however, survived and eventually returned to Sweden after nine years to become, in 1783, the successor of Carl Linnaeus Jr who in turn had succeeded his father to the chair in Upsala. This Peter and Paul all in one was Carl Petter Thunberg (29), the last bearer of the classical Linnaean tradition before the beginning of the Darwinian era. Carl Petter Thunberg had studied under Linné and Rosén in Uppsala in 1761–70; afterwards he travelled by Amsterdam to Paris, which by then had become the foremost medical centre. In Amsterdam both Burmans had received him most cordially, as had Gronovius and van Royen at Leyden. Thunberg noticed that he had made a good impression but was wrong in his assumption that this alone was sufficient for the suspicious Dutch to make him the flattering proposal that he soon enough was to receive. In fact the elder Burman first wrote to Linnaeus and asked whether Thunberg was as good as he seemed to be, and only after receiving a confirmatory answer invited the latter to return to Holland, become a ship's physician in the service of the Dutch East Indies Company and sail to Japan, a country at that time botanically virtually unknown. This was a project dear to the hearts of a group of rich Dutch flower-lovers, among whom we meet several of Linnaeus' earlier acquaintances.

Thunberg accepted and first sailed for the Cape of Good Hope in December 1771. There he collected literally some thousands of plants (among which were over a 1 000 species), sent them to Holland and Sweden with adequate descriptions and thus prepared the ground for his later Flora Capensis (1807–23). By March 1775 he reached Batavia, now Djakarta, and on the 20th of June he sailed from there to Nagasaki where he arrived on the 13th of August, staying until Dec '76 when he returned to the Indies and travelling by Ceylon, the Cape and Holland, reached Sweden in March '79. On the basis of the material collected in Japan he wrote his Flora Japonica, the first to be written in the Western manner, which was published in Leipzig 1784 and made him internationally famous. In other respects as well he became a worthy successor of Linnaeus at Upsala.

These dry facts must be seen against the following background. In the first place, Thunberg was taking a great risk when he accepted the offer to serve as a ships physician on a Dutch vessel sailing for the Indies, as is proved by the deathrate among his many compatriots who had done so before (30). Secondly, a remarkable thing about Thunberg is that the otherwise very suspicious Dutch permitted him to make several excursions to the interior of South Africa, accepted him as a first physician on a ship as well as during the annual procession from Nagasaki to Jedo, and gave him several special privileges during his stay in the Indies. The no less suspicious Japanese permitted him to talk freely with the Japanese interpreters to whom he conveyed much appreciated "Dutch medicine and other western knowledge". Thirdly, it should not be forgotten that the Japanese were very well aware of the dangers of European colonialism to their own identity and independence ever since they had had painful experiences with Iberian Jesuits over a hundred years before. They then closed their country and it remained closed until after the middle of the 19th century. The only exception was made for the Dutch, a nation traditionelly inimical to the Kings of Spain and Portugal in the first half of the 17th century. The English were excluded because of links between their dynasty and the Portuguese one. Thus for over two hundred years the Dutch trading post on the isle of Decima in the bay of Nagasaki remained the only direct contact between Japan and the Western world, the Dutch language the only Western idiom known to a growing group of interested Japanese intellectuals.

Coincidental with the Japanese voyage of Thunberg the latter had started a major breakthrough for Western medical knowledge by making a Japanese translation (1774) of a Dutch translation (1731) of J. A. Kulmus' *Tabulae Anatomicae*. These intellectuals served as interpreters and it was with them Thunberg collaborated, which made it possible for him to give the outside world the first Japanese flora as well as the first adequate information about the country and its people. On the other hand he taught what he knew to his Japanese friends and lent them his own books, thereby introducing knowledge about botany, medicine, geography, ethnography and numismatics and thus becoming one of the sources of Western knowledge in Japan. An academician from that country, Prof. S. Iwao (31), who thus specified Thunberg's importance for the national culture, considered him to be "the first great personality from Europe to visit our country after Francisco Xavier (in the first half of the 16th century!), and Thunberg still holds a place of honour in Japanese cultural history. In this way the work of a Swedish scientist in

Dutch service and bearing the tradition of Linnaeus as well as of Boerhaave marked the peak of Dutch–Swedish cultural and scientific collaboration by introducing these traditions in far-away Japan and knowledge about that country in Europe, through both the Dutch and the Swedish languages.

We have seen that Linnaeus was attracted to Holland as many Swedes were before him. Turning the tide later, he sent out his apostles, not to beg for education but to distribute it to other countries, including the original donor, Holland, as well as far-away Japan. And he also started attracting people from other countries to Sweden and Upsala—all of you are the living proof of that. So am I: exactly 25 years ago at Utrecht I defended a doctoral thesis on Linnaeus as an intermediary between Holland and Sweden (7b); I spoke about him as a medical student at this very place in 1957; and then I emigrated to Sweden to become a Swedish physician, thus trumping even young Burman and Thunberg in transitional capacity. Thus I am and you are also, the proof that Linnaean magnetism is still very much alive. And while not forgetting that the phenomenon of Linnaeus was first announced to the world in a German scientific review and owed some essential ideas to the "science française", matured in Hollands favourable climate and is still well-known to us owing to an English scientific society, let us also remember the fact that he was a Swedish phenomenon. Let us be grateful, then, in all countries for what Sweden gave to Linnaeus and Linnaeus to us all.

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GUNNAR ERIKSSON

The Botanical Success of Linnaeus

The Aspect of Organization and Publicity

In recent years, many studies have been devoted to the old-fashioned and unscientific presuppositions underlying the systematic work of Linnaeus. Sometimes they tend to hide the obvious fact that the systematics of Linnaeus was very successful. If the long-lasting impression which he made upon botany was detrimental, as many seem to believe, it was at the same time a necessary step in the development of science. In this paper, I shall not inquire whether the theories and arrangements of Linnaeus were up to the standards of contemporary Newtonian science or not. Instead, I want to indicate some answers to the question why his contemporaries, and for that matter his followers in the century to come, accepted his principles and hailed him as the king of botany. Apparently his work was very useful—otherwise it would be impossible to explain its evident success. It was also in some respects unique—no other botanist could claim to be his serious rival. At the same time, we know that his achievement had serious shortcomings or at least a content very different from that of first-class science. Linnaeus, it has been said, did not discover a single fact by way of empirical investigation which could have justified his world-wide fame (1). Even if this is an exaggeration, it is not so very far from the truth.

Instead, Linnaeus did so much more for the *shape* of botany, for its terminology, nomenclature and standards of description. All this is evidently a natural consequence of the fact that he was a systematist. But his systematics was successful only because he understood better than any one else in his time how to tackle a long series of problems associated with systematics in its broadest possible sense. Linnaeus was the ingenious and authoritative organizer. I want to stress this point, and I want to try to make it clear that his way of organizing botany had both an inside and an outside of utmost importance to its success.

First with regard to the inside, to the structure of the systematics that Linnaeus introduced. His most famous introductions in this field are his sexual classification and his binomial nomenclature. That they are the most famous does not imply they were the most important among his botanical principles. The binomial nomenclature is, as is well known, a late introduction, exhibited to the international public of botanists only in his *Species plantarum* (1753). It is an excellent example of Linnaeus as an organizer, being a practical device aiming at economy of expression. But its success in the world of botany postulated that its inventor had already gained authority and fame. The sexual system is also, in its way, a device in the service of botanical organization, not only because it is an effort to organize the kingdom of plants according to the order of nature, but also because it represents the organizational virtues of clarity, simplicity and universal applicability. It was the dream of young Linnaeus that, with his method, it would be possible for anyone who had learned the system to place any plant anywhere in the world in its right class and order, if not in its right genus, whether the plant was previously known to science or not (2).

But these well-known examples in no way exhaust the aspect of organization of the work of Linnaeus. In fact, the same organizational character is still more evident in Linnaeus's method of plant description, as it is codified in the *Fundamenta botanica* of 1735 (and partly in the extremely important *Genera plantarum* (1737)) and in its magnificent younger sister, the *Philosophia botanica* of 1751. There he presents his ingenious method of characterizing genera and species with the help of a selection of organs and organ characters. For the description of a *genus*, Linnaeus insists that it is sufficient to consider the organs of fructification, as they appear in flower and fruit. In these organs, Linnaeus finds the very letters of nature—so he calls them—26 in number, not all of them appearing always together but to be found in combination in lesser groups everywhere among the genera of the flowering plants. To each of these organs or letters, Linnaeus allocates a name, a term, which should be used always and without ambiguity for that particular organ and no other. Even though the terms in many cases were taken over from older botanists, they had never been applied with the same strictness or so generally to the whole of the plant kingdom. These letters comprise organs like the sepals, the petals, the stamens with their anthers and the pistil with its stigma, stylus and ovary; they also include more deviant varieties of these organs and different kinds of appendices. In order to create a satisfying description of the genus—in other words, to indicate the genus character, is suffices, according to Linnaeus, to pay, regard to the most remarkable group of those organs/letters in the genus. Each of the selected organs must be described according to what are strikingly called "the four mechanical principles". They are (1) number, (2) form, (3) position and (4) relative size or proportion—no more, no less. For the second principle, form, Linnaeus gives all adjectives necessary for the adequate description of the figure and shape of the organs, for example, "cordate", "lanceolate", "hastate", "ovate" and so on. As we can see, this way of describing a plant genus means a great economy of words. For the description of a species within the genus, Linnaeus has to consider not only the fructification but the whole of the plant, including the root, the stem, the leaves and their appendices. He does not call all these organs letters—in fact, they are too manifold for the simile of the alphabet to be applied—but, in each case, he selects the minimum number of organs necessary to distinguish the species in question from all other species within the same genus and he regards them from the point of view of the same four mechanical principles. Thus, Linnaeus everywhere minimizes the number of terms necessary for the descriptive botanist and for his reader to know, making all descriptions short and readable. His rules for the description of plants are indeed the achievement of an ingenious organizer.

This is also the case in an even more important way. If every botanist pays attention to these rules, always looking for the same 26 letters, always counting their number (or the number of their parts), observing their form, considering their position in the flower and measuring their size, we shall soon have order and clarity in generic taxonomy and we can proceed with success to describe all species, following the same basic principles. The old curse of botanical books will be gone, the curse of never knowing for certain whether two authors are talking about the same plant or different plants when they use plant names of their own and describe their genera and species in different words and with regard to different details and organs. These idiosyncratic habits had made of botany an almost impenetrable wilderness, a jungle of confusion and anarchy. Linnaeus commands order by standardizing the language of botany, teaching his colleagues and pupils always to use the same phrases and to look at reality with the same eyes.

We must ask ourselves why Linnaeus, among all botanists, could claim to have his own standards made general to the whole of plant science.

Why should the botanists listen just to him and to no one else? If you had asked Linnaeus, you would have received the answer that his way of describing was the one natural way, following the aims and thoughts of God Himself when He created the plants. But this kind of argument is undoubtedly dear to all authors, and it is hard to prove that one system is more natural than another. A better answer is that Linnaeus understood the values of order, clarity, simplicity and economy of words better than any other contemporary botanist. This gave to his mind a determination and a consciousness of what to do which was unusual, not to say unique. He also knew how to formulate his ideas and make them explicit without cumbersome digressions and explanations. Above all, he immediately applied his principles to actual plant descriptions, indeed, to an overwhelming number of such descriptions. In *Genera plantarum* (1737), he defined all known plant genera of the world, in *Flora lapponica* and *Hortus Cliffortianus* (of the same year), he described a great number of species, known and hitherto unknown, according to his principles. These voluminous works were all published within two years of the publication of the book of rules, *Fundamenta botanica*. Who could resist this flood of knowledge and this array of precise arguments?

We know fairly well how the sexual system and the botanical nomenclature made their breakthrough in the scientific world. The history of how his principles of generic and specific description were received still remains to be written. According to Linnaeus himself, they were accepted by all, but this we cannot take for granted. However, we need not know the details to be able to appreciate its immense effectiveness. Most important of all is that Linnaeus himself, with the aid of these principles, was able to complete the extremely large number of descriptive works that he actually did during his lifetime. No other botanist could rival his productivity, the result of his immense industry but also without doubt, of his resolute and efficient principles of description. In this way, he made for himself the tools by which he achieved his scientific success.

Linnaeus worked in science just before the beginning of the industrial revolution in Europe. There are some striking similarities between his way of writing and the principles which emerged in manufacturing. We have stressed that he was a standardizer. All plant descriptions were based on a very limited number of terms and prescribed phrases, the same organs and characters were considered in one genus after the other, the same words—only in different combinations—could fit a great number of different plants. It is suggestive of the principle of standardized parts which at about the same time was beginning to be introduced into the manufacture especially of fire-arms. We can also see that to a certain degree his thousands of specific descriptions were fabricated according to the principles of serial manufacture, thus allowing mass production. Perhaps Linnaeus and the industrial manufacturer were inspired by a common source—military organization. As Lewis Mumford has stressed, the soldiers were first to standardize, with their uniforms, exercises and strict discipline (3). Linnaeus seems to have loved military order and very often used similes from this field. In the same way, the manufacturer achieved greater efficiency by applying the principles of military discipline and standardization to industry. And he was the conqueror of the market, as the soldier was the conqueror of the battlefield and Linnaeus the conqueror of botany.

So much for the inside aspect of Linnaeus as an organizer. His reforms of systematics and descriptive botany, however efficient, would have had little chance in their struggle for existence, had not his talent also comprehended the marketing of his ideas in the international republic of letters. In this respect, his early stay in Holland, including the journeys to England and France, were decisive. Superficially, his journey to Holland may seem to have been planned as a trip for a month only, in order to obtain a medical degree at the University of Harderwijk, before settling as a physician in Sweden. Although he had studied medicine at Uppsala, he had to go abroad to obtain his degree, for the simple reason that medical degrees were almost never awarded at the Swedish universities. But he had higher intentions in mind; the journey to Holland was part of a many-sided strategy for obtaining international renown (4). This strategy was perhaps in part unconscious, created by his stupendous salesman's instinct, but to a surprisingly high degree consciously planned and carried through.

This can be seen in many ways. Very early, he had been in touch with a journal in Hamburg devoted to news from the learned world, the *Hamburgische Berichte von gelehrten Sachen,* which was apparently read in many corners of Europe, not least in Holland, the goal of his journey. As early as 1732, the journal several times contained notes about his manuscript works in botany and natural history and, even more sensational for the continental reader, about his adventurous journey to Lapland. His return was reported in 1733. In 1734, the journal announced that Doctor Nettelbladt, of Greifswald, was seeking a publisher for the *Fundamenta botanica* of Linnaeus. And in 1735, a very detailed notice told of Linnaeus's stay in Hamburg during the journey to Holland and the young Swedish naturalist was presented in the most positive and flattering way (5). Very significantly, all the manuscripts that he brought with him on the journey were mentioned and presented in a way that would make the mouth of any scientific publisher water.

Nowadays, it seems to be generally thought that Linnaeus himself was to a very large extent responsible for these notices and was actually the originator of much of the wording. They undoubtedly made an impression upon their readers, creating the image of a young genius of extraordinary insight, who had, in addition, the merit of having visited one of the most exotic parts of the world, Lapland, the country next to the North Pole, inhabited by a mysterious and happy people with strange customs. This image was strengthened with the aid of his Lapp dress and drum, mentioned as an important part of his luggage in the *Hamburger Berichte*. In Holland, Linnaeus often dressed in this garment when he was invited to family evenings at the houses of his learned hosts, imitating the Lapp way of singing and demonstrating the use of the magic drum. He also had his portrait painted, appearing as a Laplander with drum in hand. Indeed, he made his name known in ways that seem very modern and quite in line with the principles of advanced publicity.

To these attributes of genius and exoticism, he added his personal charm. His character was a strange mixture of attractiveness and repulsiveness. He was very suspicious, he readily gave up when confronted with hostile opinions and he never forgot an injury. But these negative traits were combined with vivacity, outbursts of overwhelming joy and the kind of naïvety before which everyone capitulates. In his youth—and he was still young when he arrived in Holland—these positive features predominated, and it seems as if every Dutch scientist he met was immediately spellbound by his charm. Otherwise, it is impossible to understand all that they did for him, spending a good deal of their time in reading and correcting his many manuscripts, full of dubious Latin, and using their money and influence to publish his books, often richly illustrated with expensive copperplates. Foremost among these generous Dutchmen ranks Johan Gronovius, as has been clarified by Johan Nordström in an important paper in the *Year-book of the Swedish Linnaeus Society* (1954–55) (6). Gronovius and his friend, the rich Scottish student Isaac Lawson, had the folio sheets of Linnaeus's *Systema naturae* printed. He made unselfish and laborious efforts in publishing the voluminous *Genera plantarum*. Also other parts of Linnaeus's massive output during his time in Holland went through the hands of Gronovius. In fact, most of what Linnaeus published at this time was, in one way or another, communicated to his friend in Leyden, who was eager to drive him onwards from work to work and at the same time cared about his health. As Nordström has shown, Gronovius was the main driving force behind Linnaeus's employment in the service of the wealthy merchant Georg Clifford (7). The story of this employment is typical of how Linnaeus consciously made use of the influence of his friends, in order to obtain the best possible conditions for his scientific work. In his autobiographies—most of them written late in life—he says that Clifford was the initiator of the employment. In fact, Gronovius had hinted to Clifford—at the express suggestion of Linnaeus—that he knew a young botanist of extraordinary ability, who might perhaps be persuaded to accept the post of supervisor of Clifford's famous garden at Hartecamp.

Linnaeus's scheme included conquering the great authorities of contemporary science. Among the Dutch, the greatest in this respect was Hermann Boerhaave, the famous Professor of Medicine at Leyden, known as *praeceptor Europae*. We know that Linnaeus had difficulties in attacking this noble target but that at last he succeeded quite well, if not as well as he later pretended, in creating the image of Boerhaave in his last days transferring his leadership of science to the young man (8).

In the same manner, Linnaeus confronted Jacob Dillenius during his stay in England in 1736 (9). Linnaeus has stated that Dillenius, the German botanist who had been appointed professor at Oxford, was the leading scholar in systematic botany at this time, having been preceded during the 1720s by William Sherard (10). This means that in admitting Linnaeus, Dillenius at the same time admitted the pretender to the throne.

I think that this point is worth while pondering on a little more. Nowadays, Dillenius's fame rests mainly upon his substantial contribution to cryptogamic botany, a field which never attracted the attention of Linnaeus to any considerable degree. It was certainly not the systematics of the mosses that made this visit important to Linnaeus. Instead, what concerned him more than anything else was that Dillenius was planning a new edition of Caspar Bauhin's classic survey of the plants of the world and their synonyms, the *Pinax theatri botanici*, originally published in 1623 and edited anew in 1671. This work, though old-fashioned, was the only survey of the plant kingdom that had won general acclaim and that appeared to offer any a kind of guidance to the troubled botanical nomenclators. The man who successfully brought Bauhin's work up to date would evidently be regarded as a first-class authority in the very field that Linneaus was trying to conquer, the systematics of the whole of the plant kingdom. This was why Linnaeus had put Dillenius at the top of his list of contemporary botanists and why Sherard, who had begun the undertaking, was placed as the predecessor of Dillenius in the 1720s. It is also of interest to note that, even in Sweden, Linnaeus had been aware of how important it was to work upon the foundation laid by Bauhin. Two Swedish botanists of the age before Linnaeus could claim a kind of world fame—the Olaus Rudbecks, father and son. The latter—admittedly the lesser of the two—was still working as Professor of Medicine at an advanced age when Linnaeus was studying at Upsala. He became his friend and patron and very much influenced Linnaeus in his decision to travel to Lapland. The great project of the two Rudbecks had been to illustrate Bauhin's *Pinax,* making natural-size woodcuts of each plant (or of parts of each plant) that was mentioned in the work. This gigantic task, which involved the cutting of thousands of wood blocks, was at an advanced stage, when in 1702 practically all the blocks were destroyed by fire. If it had been completed, the project would have been of the utmost importance in the arranging of botanical nomenclature. Even in its destruction, it served as an inspiration to young Linnaeus, who must have early been made aware of its fate and of its grandiose aims.

Linnaeus told about his visit to Dillenius in a letter to Olof Celsius in Upsala late in 1736 (11). He had prepared the visit by sending in advance the already printed half of *Genera plantarum,* which Dillenius had read without much approval. In fact, Linnaeus had radically altered the names and the scopes of many of the established genera, especially those created by Dillenius. So the Oxford botanist met the young Swede with much reserve, hardly admitting him to his rooms and sarcastically commenting on his work. After three days in his company, Linnaeus, in the presence of Dillenius, paid in advance for the coach by which he pretended that he was going to leave Oxford. Dillenius bid him a cold farewell, and this was enough for the young botanist. He could endure no more of the gibes of Dillenius. He began his old arguments anew, then pleaded for judgment by what he liked to call autopsy, and then, suddenly, they became friends. After that Linnaeus wrote, "we were not apart for two hours during all the time I spent in Oxford, and when at last I left, he let me go in tears" (12). This is an excellent example of the working of personal charm, not without elements of sophisticated marketing methods.

Linnaeus certainly knew the importance of being on good terms with Dillenius. Had he been able to persuade his friend to adopt his own generic concept, that would automatically have led to its approval in wide scientific circles. Now we know that Linnaeus did not succeed to such a great extent (13). But it was important enough that he had secured the friendship of such a man. We also know that Dillenius was never able to complete his edition of Bauhin. In fact, we can guess that the very work of Linnaeus made this new edition less interesting. But Linnaeus could know nothing of that in the summer of 1736.

Space does not allow me further to exemplify the conscious strategy by which Linnaeus conquered the scientific world. I have said enough, I guess, to show that Linnaeus made the most of his time in Holland to establish himself in the top rank of botanists. His genius as a systematic writer was combined with skill in marketing and public relations that was certainly not alien to the rest of the contemporary scientists but was developed in him to the highest perfection. This made his life's work possible. As I have already stressed, it was very unlike that of most other scientists of equal fame. It did not rest on discovery or advanced mathematical theory, but on organization, standardization and the formulation of rules for the formal treatment of vast masses of empirical material. We can say that Linnaeus alone did a job that nowadays would be a heavy task for not one but many big botanical congresses.

References

1. See S. Lindroth, Linné – legend och verklighet. *Lychnos* 1965–66, p. 90.
2. See, for example, "Inledningsord vid Linnaei första botaniska föreläsning i Stockholm 1739" in Th. M. Fries, *Linné lefnadsteckning,* Part I, Stockholm 1903, Appendix, p. 25.
3. In his *Technics and Civilization* (many editions), *passim.*
4. In his autobiographies, Linnaeus often indicates that only lack of money detained him in Holland after he was made doctor. But in a notice in the *Hamburgische Berichte* of the 10th of June 1735 we read that Linnaeus had just passed through the town on his way to Holland "um daselbst sich einige Jahre aufzuhalten, und durch den Umgang dasiger berühmter Männer, vornemlich des Hn Boerhavens ... seine obschon zu einer grossen Vollkommenheit gebrachte Wissenshcaft in medicis, physicis und botanicis,

noch höher zu treiben. Anbei gehet seine Absicht dahin, dass er die in seinem Vaterlande, nach und nach zu Papier gebrachte Ausführungen, ... über deren Anzahl, Belesenheit und ungemein mühsame Zusammentragung wir uns verwundern müssen, auf eine ihm nicht unvorteilhafte Art in Holland zur Presse bringe ..." (*Hamburgische Berichte* 1735, p. 386; reprinted in F. Bryk, *Linnaeus im Auslande,* Stockholm 1919, p. 102).

5. *Hamb. Ber.* 1735, pp. 386–90; Bryk, op.cit., pp. 102–6
6. J. Nordström, Linné och Gronovius, *SLÅ* 1955, pp. 7–22.
7. Nordström, op.cit., pp. 11 *et seqq.*
8. Vita III, in *Vita Caroli Linnaei.* Ed. by E. Malmeström and A. Hj. Uggla. Stockholm 1957, p. 110.
9. See further A. Hj. Uggla, Tvenne nya dokument till kännedomen om Linnés engelska förbindelser. *SLÅ* 1938, pp. 85–94.
10. Uggla, op.cit., p. 85 *et seqq.* The list of "Principes Botanicorum" that Spencer Savage found hand-written in Linnaeus's private copy of *Philosophia botanica* (1751) and which he published in *Proceedings of the Linn. Society,* 148, Sess. 1935–36.
11. Uggla, op.cit., and Linné, *Bref och skrifvelser,* Första afdeln., del V, Stockholm 1911, pp. 255 *et seqq.*
12. Linné, op.cit., p. 256.
13. As we can see from the letters of Dillenius, he very often in later years disliked the descriptions and definitions of Linnaeus. He also avoided giving too much information about the progress of his work on *Pinax.* See *A Selection of the Correspondence of Linnaeus and Other Naturalists,* ed. by J. E. Smith, Vol. II, London 1821, pp. 85–129.

J. L. LARSON

Linné's French critics

Between 1749 and 1753 three French thinkers, Buffon, Daubenton, and Diderot, published the general outline of a purely descriptive study of nature. The charter of the new science was Buffon's preliminary discourse, "De la manière d'étudier et de traiter l'histoire naturelle", in the first of the three volumes of his *Histoire Naturelle* published in 1749. Buffon's collaborator, Daubenton, contributed the article "Botanique" to the second volume of the *Encyclopédie* and two dissertations in the fourth volume of the *Histoire Naturelle*, "De la description des animaux", and "Exposition des distributions méthodiques des animaux quadrupèdes". During his imprisonment at Vincennes in 1749 Diderot read Buffon, and the first fruits of his reading are found in the article "Animal" in the first volume of the *Encyclopédie*. His *Interpretation de la Nature*, published concurrently with the third volume of the *Encyclopédie* in 1753, contains, among many other things, a justification of the new science.

The hallmark of the new method is its resolutely secular character. Buffon's preliminary discourse confronts an older systematic dogmatism with a new analytical and critical spirit, and concerns itself centrally with different conceptions of procedure, evidence, and truth. And of course Daubenton and Diderot were not content simply to echo Buffon. Their articles and essays, reflecting very different intellectual temperaments, restate the common program, often in more radical ways. On the basis of the altered orientation in research, some modern specialists have described the new method as a decisive turning point in the history of science, comparable in some ways to the great innovations of the preceding century (Cassirer, 1951, pp. 73–80). Certainly the pronounced secularity of the method produced many points of incompatibility with the natural history taught and practised elsewhere in Europe; but considered as a whole, the program of Buffon, Daubenton, and Diderot is better described as an alternative strategy for realizing a project common to all eighteenth century natural history, the faithful representation of nature's own plan.

Strategic differences between the old natural history and the new are readily seen in the redefinition of systematics. Since the late Renaissance, naturalists had tried to represent the plan of creation in terms of the tree of Porphyry, and had established systematics as the central discipline in natural history. The new method, considering the order of nature solely in relation to human capacity for knowledge, simultaneously divested systematics of its dogmatic claims, and freed natural history from its preoccupation with classificatory detail.

Other factors, personal, professional, and historical, entered into the demotion of systematics. Advocacy of a purely descriptive study of nature reflected the general French tendency to replace the rigor of a universal rationalism with regional structures. The French scientific establishment reinforced this pluralism by de-stabilizing associations and societies which championed single methods and doctrines (Hahn, 1971, pp. 112–114). In this scientific context, classification occupied a small place in French zoology in 1749 (though not in botany). French naturalists proposed to subject nature to human goals, and the experimental study of physiology and behavior offered a utilitarian potential greater than that offered by systematics (Daudin, 1926, pp. 117–125). The botanical and zoological systems then current, chiefly but not exclusively Linnæan, were flawed by inadequate theories, deficient definitions, and arbitrary groupings. These factors simply reinforced a distaste for intensive systematic work particularly marked in Buffon and Diderot. Both men were temperamentally hostile to a discipline dependent upon counting and memorization; they seem to have felt something very like repulsion for the arid nomenclature and monotonous characters of Linnæan formalism.

Their attitude did not imply that natural history could dispense with system and method, but it did reslut in a polemical tone which led to misunderstandings. Diderot, echoing Buffon, stated flatly, that life, far from being a metaphysical degree of being, was a physical property of matter (Diderot, 1976, p. 400). "Voilà", answered Chaumeix, "that which Locke made... a problem, which he did not presume to resolve... The ever so much bolder Encyclopédistes have resolved this problem" (Diderot, 1976, p. 400). Buffon seemed to argue that systems are bad in themselves and negligible in relation to everything else—opinions received by many contemporaries as a rejection of science itself (Sloan, 1976, pp. 360–361). And Daubenton's anatomies, for all their intrinsic merit, were limited by Buffon's program, and therefore fit neither to guide science nor to render it much service (Daudin, 1926, pp. 153–156).

Echoes of these misunderstandings still reverberate in French scholarship. Diderot's *Interpretation* is read, if at all, for the warmth of its style and the audacity of its ideas. Daubenton has been relegated to footnotes, a figure of merely historical interest. And Buffon, it is said, knew little about the subject matter of his discipline, less about the thought of his adversaries. The generality of his ideas concealed, at first, the superficiality of his discussions. Later, Buffon discovered that his initial plan could not be carried out; he was obliged, by the undeniable resemblances among animals, to establish divisions, form genera, and indicate the characters of species—exactly as other naturalists did (Daudin, 1926, pp. 125–128).

Recent American scholarship has challenged this construction, at least with respect to Buffon. By emphasizing the coherence of Buffon's methodological position, specialists have arrived at a very different estimate of Buffon's thought on system and method. The most important of these arguments is a paper by Professor Phillip R. Sloan, "The Buffon-Linnæus Controversy". Sloan suggests that Buffon's argument is part of a broader issue, the relation of universals to an underlying biological reality. Buffon's reflections on system and method are one element in this problem. Sloan argues, "that a highly conservative estimate of the degree of development of alteration of Buffon's taxonomic thought is to be presumend and... that a consistent methodological position is to be discerned throughout the *Histoire Naturelle*" (Sloan 1976, p. 358). Sloan's paper provides a rationale for many otherwise inexplicable shifts in Buffon's attitude toward systematics. What has for so long appeared as a reversal in Buffon's fundamental position actually involves a complex relation between preliminary and final assertion and physical fact. "[The] apparent discrepancy between speculations held privately and *prior to* the all-important empirical research, and those asserted often dogmatically in print after Buffon had satisfied himself on the real as opposed to the purely abstract relations of organisms, is fully in keeping with the methodological canons that can be traced through virtually all of Buffon's scientific writing" (Sloan, 1976, p. 375).

This morning I want to add detail to Professor Sloan's argument. I will limit myself to statements of Buffon, Daubenton, and Diderot on system and method between 1749 and 1753. Within this time span I will concentrate on two problems, the relation of natural order to the scientific observer, and the nature of the affinities which define natural groups. I think I can show, in connection with these two problems, that the general polemic conducted by these men against artificial systems does not exclude the compatibility of their method with the overall project of eighteenth century natural history, the construction of a genuinely natural system.

Buffon's discussion of systematics opens with a commonplace: the large number of natural objects is the first obstacle to the study of natural history. A student confronted with this multitude faces two dangers: the first is to have no method; the second is to relate everything to one particular system. Systems abridge work, aid memory, and offer the mind an interesting sequence of ideas, but they also lead us to judge wholes on the basis of parts, assemble arbitrary groups, and divide nature at points where she is indivisible. When applied dogmatically, a system insinuates a false structure of relations in the midst of the productions of nature, and produces a spurious and straitened regularity.

Linné's artificial system in botany, for example, based solely upon the parts of fructification with special emphasis upon the stamens and pistils, wrongly brings together diverse plants. Similarly, the orders of quadrupeds in the *Systema,* determined on the basis of feet, teeth, and mammaries, group animals arbitrarily, and violate likenesses and differences which justify other divisions (Buffon, 1749*a*, pp. 18–20, 37–40). These criticisms, if taken at face value, are not different from those of Heister or Klein, or even of Linné himself, who repeatedly protested that he had never spoken of his harmless artificial system as a natural method.

But Buffon's criticism rests on different principles, and rejects some of Linné's basic assumptions. Linnæan concepts, for all their modest appearance, pretend to penetrate the essences of natural objects, and Linnæan natural history aspires to be a science of Being. But by the mid-eighteenth century it was well-established that the logical substance of Linnæan science, if it ever existed, had long since disappeared, leaving only the semblance of rational justification. Buffon rejected Linné's science of Being, and with it a long tradition of empty verbiage and barren scholasticism.

> "First causes are forever hidden from us; the general results of these causes are as difficult for us to know as the causes themselves; all that is possible for us is to apperceive some particular effects, to compare them, and to combine them, and finally to recognize an order relative to our own nature, than convenable to the existence of the things which we consider" (Buffon, 1749*a*, pp. 11–12).

"An order relative to our own nature" is, of course, the operative conception in Buffon's discussion. The naturalist, he argued, establishes relations with living forms through observation. His ideas of these objects differ from the reality, but their arrangement is not therefore arbitrary. Relations among ideas are true or false as they answer or not to relations among the objects signified. When the relation among ideas is invariable and always the same relative to himself, the naturalist need not doubt its truth, for truth consists in the connection of signs answering to the real and necessary connection of objects (Buffon, 1749*b*, pp. 4–5, and 1749*a*, p. 57).

Professor Sloan has shown how Buffon, with this relational theory of knowledge, evaded one of the snares concealed in any purely descriptive approach to natural objects. If natural history is to reflect the order of nature as accurately as possible, every generalization seems to lead away from fact, to diminish verisimilitude, and to weaken certainty. By establishing parallel orders of succession between ideas and events, Buffon could found scientific generalizations upon real—formal and successive—relations among objects.

"Physical truths are not at all arbitrary, and do not depend upon us; rather than being founded on suppositions we have made, they rest on facts; a sequence of like facts, or, if you prefer, a frequent repetition and uninterrupted succession of the same events constitute the essence of physical truth; what we call physical truth, then, is only a probability, but a probability so great, that it is equivalent to certainty" (Buffon, 1749*a*, pp. 54–55).

This theory enabled Buffon to penetrate the surface of immediacy, and to study the constant and general order of phenomena without falling into strict phenomenalism, and without advancing dogmatic claims for his results. Whatever its merits as epistemology—and it is surely superior to Linné's casual assumption of harmony between natural order and the canvas of his own ideas—Buffon's conception of relations is crucial to any understanding of his thought on system and method. It provides a key, not only to his belief in an intelligible natural order, but to the alternative approach to natural history advocated in the opening discourse.

Artificial systems such as Linné's substitute a network of arbitrary relations for those of nature. When followed slavishly, they constitute a danger. It is essential first to furnish the head with facts and ideas, and to delay as long as possible the formation of reasons and relations. The naturalist must look and look again, without prejudice and without an idea of a system. Buffon asks his readers to imagine a man without preconceptions set down in the midst of nature. After a short time he would distinguish inanimate from vegetative and animate matter, and so arrive at a first division, animal, vegetable, and mineral. A second division of animals on the basis of habitat would result in quadrupeds, birds, and fishes. A parallel division of plants on the basis of size, substance, and figure would result in trees and herbs. "This is what a simple inspection must necessarily give him, and what with even the slightest attention he cannot but recognize; this we must regard as real and respect as a division given by Nature herself" (Buffon, 1749*a*, p. 32). Of course this division establishes clear-cut groups where nature exhibits nuances, but we are considering here only the broad aspect of things, not their ultimate realization.

Within these "real" or "natural" divisions, Buffon proposed a convention alternative to the Linnæan conceptual hierarchy. Buffon wished to begin by studying natural forms which interest us because of their relations to us. Necessary and useful forms come first, because we know best what is familiar. Under this arrangement the order of knowledge parallels the order of acquisition. This approach is preferable to the Linnæan method, Buffon argued, because it is not more arbitrary, and it is certainly easier and more useful to consider things in relation to ourselves than under any other point of view. Admittedly, the order of familiarity is subject to the objection against all artificial systems: it groups heterogenous objects. But method exists for purposes of study, and considers things only in the order in which they are ordinarily found. In this framework the best way to advance science is to give a complete description and exact history of each thing in particular. Things exist for us, not when we have a name or descriptive phrase for them, but when we know their actual relations and properties. The error of the Linnæan method is the assumption that a natural form can be judged by a single, constant part. When Linné characterizes whole classes on this basis, he renounces the possibility of knowing nature, for only what is exactly described can be clearly known. To describe an object exactly, the naturalist first examines and compares it without prejudice and without a system. His description includes the outer and inner structure of the species, while his history turns upon the relations of natural objects among themselves and with man.

The study of nature limits itself at first to such descriptions. Only later does the naturalist begin to generalize facts, connect them by means of analogy, and exhibit the dependence of particular effects upon those more general. This method guides thought, sustains the order of things, clarifies and extends the view—and all without misleading the observer. The most delicate and important point in the study of a science is to recognize what is real in the subject without adulterating it. That is the aim of the preliminary method recommended by Buffon, and the basis for his criticism of Linné's artificial systems. Linnæan formalism imposes abstractions upon natural productions, introduces arbitrary relations among them, and finally reduces the order of nature to the limits of human analogies.

It is clear, I think, that Buffon's controversy with Linné chiefly concerned an alternative approach to the study of natural forms. It is also clear that Buffon believed in the existence of a system of nature, and the possibility of a natural method.

In spite of the tentative nature of his preliminary discussion, Buffon had a great deal to say about the actual order of natural objects. Much of it, however, was either so traditional or so abstract, that it barely indicated his conceptions.

Natural order can be approached by proceeding from the particular to the general, or from the general to the particular.

When we begin with the particular, we confront phenomena, "which succeed and repeat one another without interruption, and in all cases are the foundations of our physical knowledge. It is enough that a thing occur always in the same fashion for it to become a certainty or a truth for us; all the facts of Nature which we have observed or can observe are so many truths, such that we can augment this number as much as we please by multiplying our observations of them; here our science is bounded only by the limits of the universe" (Buffon, 1749*a*, p. 59). Here Buffon's discussion rests upon his epistemology, his conviction that knowledge is relational. But the connection between this epistemology and the subject matter of natural history is not obvious.

If, on the other hand, we begin with the general, we confront Nature in the process of unfolding herself according to the law of cintinuity. Man finds himself at the head of created beings, a little apart from the others, and discovers that he can descend by almost insensible degrees from the most perfect creature to the coarsest mineral. The law of continuity, used in this way, is what Kant later called a principle of formal purposiveness, i.e. an heuristic principle of unity, and Buffon's use of the idea is wholly traditional. Nature passes from the animate to the inanimate by degrees so fine that man discerns her transitions with difficulty. And because there are no cleavages in nature, our systems are not hers. A system has little or nothing to do with those combinations, nuances, and relations which alone establish physical truth.

The sketch of classificational procedure based upon these ideas is equally vague. Buffon proposed "an instructive and natural method"—bringing together those forms which resembled one another, and separating those which differed. "If the individuals have a perfect resemblance, or differences so small we can scarcely perceive them, these individuals are of the same species; if the differences begin to be sensible, and at the same time there is much more resemblance than difference, the individuals are of another species but of the same genus as the first". Buffon pursued this division to the level of classes, and concluded. "This is the methodical order that we must follow in the arrangement of natural productions; it is understood, of course, that the resemblances and the differences are taken not just from one part, from the entire ensemble" (Buffon, 1749*a*, p. 21). Buffon did not execute this vague program, nor did he mention is total resemblance to the natural method pursued by the Linnæans.

These three ideas—physical truth, continuity, and the natural method—occupy a considerable place in secondary literature on Buffon, and they have an almost fatal appeal for historians of ideas. Anyone who has read at all widely in eighteenth century natural history will find the attraction inexplicable. Buffon's presentation of these ideas is cursory, even perfunctory, and as ideas they do not translate his thought adequately. Buffon's conception of the real affinities among natural forms is better understood in relation to a different set of terms.

The most important of these specifically scientific ideas is implicit in Buffon's criticism of Linné's class concepts. Those concepts are artificial because they lack real content; the projected unity has no objective correlative. By implication, then, a class concept, to be meaningful, must indicate a real physical identity with determinate physical effects.

The model for this real physical identity is furnished by a group of individuals of the same species. In the preliminary discourse species are "real" or "natural", but grounded somewhat indecisively upon relations of both similarity and succession. The history of an animal, for example, is not the history of an individual, but of "the entire species of these animals", and the "real" order of nature is seen not only "in sizes and forms", but in "the movements, in the generations, in the succesions of all kinds".

Work on the problem of generation, undertaken by Buffon and Daubenton between the first versions of the preliminary discourse and the printing of the second volume of the *Historie Naturelle,* resulted in the theory of the *moule intérieure,* upon which Buffon based his subsequent thought about species (Roger, 1971, pp. 542–558; Sloan, 1976, pp. 369–372). By 1749 Buffon was convinced that in the matter of species criteria, reproduction took precedence over the formal resemblance of contemporary systematics. In 1753 he stated that the real existence of species is a chain of successive existences of individuals who reproduce and interbreed among themselves. "... it is in comparing the Nature of today with that of other times, and actual individuals to past individuals, that we arrive at a distinct idea of what we call species, and the comparison of number or the resemblance of individuals is only an accessory idea, often independent of the first idea..." He continued, "The species, then, is nothing more than a constant succession of like individuals, who reproduce one another.." (Buffon, 1753*c*, pp. 385–386). In other words, the "reality" of the species consists precisely in that " frequent repetition and an uninterrupted succession of the same events" which is "the essence of truth".

Buffon's belief in the natural reality of the species implies a similar belief in the reality of more inclusive groupings of natural forms. We have seen that he attributed reality to the first great division of nature, animal, vegetable, and mineral, and to the first division of animals on the basis of habitat, quadrupeds, birds, and fishes. Both the specific and the most general classes were real for Buffon, and the point of his provisional method was to prevent the substitution, between the level of class and species, of a system of artificial connections for the real affinities found in nature.

Buffon's later reflections on the system of nature, with Daubenton's amplifications and qualifications, often returned to formulæ corrent among systematists. In the opening discourse, for example, Buffon observed that an exact description, to be intelligible, must follow a single plan, and Daubenton returned to the problem in his attempt to realize Buffon's program. Uniformity in description is important, not only for purposes of clarity, but for the comparative consequences to be drawn from it. The naturalist satisfies these needs most readily by following in each case a single descriptive model. Daubenton wrote, "It is, then, absolutely necessary to agree upon principles and rules which are exactly followed in all descriptions.." (Daubenton, 1753*a*, p. 114). The procedure does not differ greatly from Linnæan practice, where uniform characters at every level of the class hierarchy define all subordinate forms. The characters bring to light a uniformity of plan, but the rules for their composition are conventional and use only a small number of external parts. The result is a dessicated scholasticism which substitutes a formal apparatus for the examination of living forms. The only remedy is to return to complete descriptions which include the information of all systems, but are neither arbitrary nor subject to human convention. The description results, first, in a complete portrait of a single kind. "We propose", wrote Daubenton, "to make known the qualities essential to each animal ...". But the object of these uniform descriptions is not limited to information of this individualized sort. "... we must compare [resemblances and differences] to one another, to learn to distinguish them... There will result from this comparison, not only the distinct knowledge of each animal, but general knowledge of all animals, which is the principal knowledge we may derive from Natural History" (Daubenton, 1753*a*, p. 130).

Remarks by Buffon in this same volume indicate clearly the nature of this general knowledge. When we compare the human body with that of an animal, we find that the inner parts which act continually, the heart and the lungs, are nearly the same, but that the exterior part, the envelope of the body, is very different. If we take the heart as the center of the animal machine, man resembles animals perfectly in the economy of this part, but as we move away from this center, the differences gradually become considerable and a slight difference at the center of the animal economy is always accompanied by a much greater difference in the external parts (Buffon, 1753*a*, pp. 10–13).

These remarks, if translated into the languge of system and method, establish the fundamental divisions of the animal kingdom upon the ap paratus of circulation and respiration—as in fact many systematists had done, and as Linné was to do. But the procedure followed by Buffon and Daubenton forbade the prejudice of research on the basis of speculative insights. On this point Aristotle's work furnishes the pattern of research: privileged importance could be given common patterns only after close and repeated study, never in advance of observation (Daudin, 1926, pp. 134–135).

Another example of the coordination of Daubenton's research and Buffon's speculation is furnished by Daubenton's comparative study of skeletal concordances between man and horse. The two bodies, so different outwardly, nevertheless resemble one another inwardly point by point. When, for example, Daubenton analyzed the foot of the horse, he found that the bones correspond completely with those of the human hand —Daubenton, 1753*c*, pp. 337–367). As Diderot rather grotesquely summarized this analysis, "Imagine the fingers of the hand reunited, and the matter of the nails so abundant, that in extending and distending itself, it envelops and covers the whole; instead of the human hand, you have the foot of a horse" (Diderot, 1956, pp. 186–188). The "prodigious resemblance" suggested to both Buffon and Diderot the idea of a prototype "a first design, upon which everything seems to have been conceived ...".

> "... and we may judge whether this hidden resemblance is not more marvelous than the apparent differences, whether this constant conformity and design followed from man to the quadrupeds, from the quadrupeds to the cetacea, from the cetacea to the birds, from the birds to the reptiles, from the reptiles to the fish, etc., in which the essential parts, such as the heart, intestines, backbone, the senses, etc., are always found, seems to indicate that in creating these animals the supreme Being wished to employ one idea, and to vary it at the same time in all possible ways, to the end that man must admire equally the magnificence of the execution and the simplicity of the design" (Buffon, 1753*c*, pp. 378–381).

In the same passage Buffon also questioned whether neighboring forms, too distant to allow crossing, might not descend from a common branch. The question led immediately to a related problem, the meaning of the general term family. Naturalists who had established families of animals and plants with such ease did not seem to have recognized the consequences.

> "If these families exist, in effect, they have only been able to form themselves by mixing, successive variation, and degeneration of the originary species, ... that each family, both animal and vegetable, has a single branch, and even that all animals have come from a single animal, which, in the succession of time, has produced, by perfecting itself and by degeneration, all the races of other animals" (Buffon, 1753*c*, pp. 381–382).

If general terms have a meaning, that is, if they have a basis in physical reality, they must signify community of origin. This new point of view, understood in all its extent, would interpret the unity of plan in animals as a sign of unity of descent, of common heredity.

As Daubenton extended the results of his anatomies, Buffon's thought returned insistently to "that plan always the same", which, when grasped by the mind, seemed "a faithful exemplar of living nature, both the simplest and the most general view under which we may consider her"

(Buffon, 1766, p. 28). Buffon's general meaning is clear. He regarded the unity of structural plan found in the animal series as a consequence and sign of descent, of common heredity; the idea is directly related to his insistence upon an objective correlative for class concepts, that is, a real physical identity with real physical effects. By giving to systematic distribution the genetic significance which alone seemed to him intelligible, Buffon redefined class concepts as expressions of a real process by which groups are constituted in nature.

On many points of course, Buffon's thought remained obscure. In the early volumes of the *Histoire Naturelle* he said little about the composition of the groups whose genetic unity he affirmed, their relations with other groups, or the process of their formation. He offered the new point of view as a subject for speculation, not as finished doctrine. He made use of traditional terms in his presentation—continuity, for example, and essential parts—which did not translate his thought. And although he considered class concepts intelligible only to the degree that they rest upon physical effects with physical consequences, he continued to represent those effects in a static and formal language. He questioned the reality, not the logical definition of Linné's class concepts; his scepticism as to the value of an abstract concept was accompanied by the assumption that scientific concepts represent common elements in a collection of similar or comparable natural forms.

Buffon's obscurity and equivocation hid from contemporaries the solidity of his fundamental insight—a solidity which, in any case, could only have been worked out by an exact study of genera and species in the Linnæan manner. And as for Buffon's adversaries, they continued their patient study of affinities—but without questioning whether such likenesses merely indicated or actually constituted the relation between forms (Eriksson, 1962, p. 13), and without investigating the physical basis of the relation.

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P. C. C. GARNHAM

Linnaeus' Thesis on Malaria in Sweden

It is strange that no English translation[1] has ever been published of Linnaeus' thesis on the cause of intermittent fevers (i.e. malaria), considering the immense literature that has accumulated over 200 years around the life and work of the Swedish naturalist. The best translation into the vernacular is probably that of Gustaf Drake[2] and this Swedish version is accompanied by a sympathetic introduction and critical notes. A German (Hoepfner, 1778) and a French (Sabrazès, 1917) translation also exist. The German translation is followed by no comments, but the more recent one by Sabrazès which was presented at a meeting of the Linnean Society of Bordeaux in 1917, though not literal, is interesting in that it expressed the doubt of the author of the wisdom of exhuming this "péché de jeunesse". Sabrazès concluded however that the immortal renown of Linnaeus could not be tarnished by a hypothesis which two centuries earlier was infinitely better than the preposterous ideas prevalent at that time.

When Linnaeus submitted the thesis to the University of Harderwijk in 1735, knowledge of the cause of the disease had advanced but little since the classical observation of Hippocrates[3] on its symptoms and periodicity. In the intervening millenia, attention however, gradually became concentrated on the association of the disease with swampy land from which unhealthy vapours were thought to arise. Thus, early in the 18th century,

[1] R. Pulteney, FRS gave a summary of the thesis in his book *A General view of the writings of Linnaeus* in 1781 while in the second edition prepared by Martin in 1805, there is a slightly longer version.

[2] Gustaf Drake was born in Sweden and qualified as a pharmacist in 1907 at the School of Pharmacy in Stockholm. He developed a strong interest in the history of drugs and translated several papers on Linnaeus' observations on the medicinal value of various plants including those in the Agerum Garden (*Svensk Farmaceutisk Tidskrift,* 21 & 22, 1921). From 1920 onwards he devoted much time to the Linnaean Literature. Finally, in 1933, he published his translation into Swedish of the M.D. thesis from the Latin original (Drake, 1933).

[3] *The Aphorisms of Hippocrates* (300 B.C.) *in the original Greek accompaied by a full version in English.* J. N. Underwood (1831) London, J. Sontip. Intermittent fevers, are discussed in many sections of this classical work. Aphorism 14 refers to the removal of the fluid of dropsy via the veins and into the intestine where it is released ("exhaled"); Aphorism 15 refers to the removal of the malady as the result of vomiting.

if not before, the condition became known as *mal'aria* (bad air) in Italy,[4] and in 1859 as *paludisme* (from *palus*, a swamp) in France.[5] Bruce-Chwatt[6] stresses that these two terms originally referred to the environmental conditions (marsh miasma and paludal poison). Linnaeus uses the term *febris intermittens* for the disease throughout his works, which is here translated as ague.

There seem to be two explanations for the neglect of the work. 1. The first part is devoted to a list of the old theories of the causation of the disease and their refutation; the ideas are as far-fetched as those which besprinkled the manuals of witchcraft in the preceeding two or three centuries. 2. Linnaeus thought on more scientific lines in that he based his work on observations in the field, but he was far off the mark and his hypothesis could not be sustained. The discoveries of Laveran,[7] Ross[8] and Grassi[9] at the end of the following century finally disposed of the Linnaean hypothesis, which became relegated as a historical curiosity.

The actual presentation of the thesis arose in rather peculiar circumstances (Hagberg, 1952), which were as follows:

In 1735, Linnaeus wished to marry Sara Lisa, the daughter of Dr Johan Moraeus, the wealthy town physician of Falun. The latter insisted that Linnaeus must obtain a doctorate in medicine before he would give his consent. Fortunately Linnaeus (1811) had made many observations

[4] See *Dizionario etimologico italiano* by Battisi (1950) Florence, Barbèra. Professor Augusto Corradetti, the learned Roman malariologist, draws my attention to the precise usage of the expression "mal'aria" in Italy in the eighteenth and early nineteenth centuries: for instance, a discourse by F. Jacquier was published in Rome in 1743 with the title *La mal'aria e le malattie che cagiona principalmente in varie spiaggie d'Italia e in tempo di estate* (Luigi Salvione, Stampatore vaticano, Piazza di S. Ignazio); a sonnet in the Roman dialect was written by the poet, Gioacchine Belli, in 1831 which contains the following lines:

"Che bella notte! Ma cquell'aria indeggna
M'attaccò ppoi 'na mmalatia maliggna."

Corradetti suggests that it was not until the middle of the 19th century, that the word "malaria" was introduced to indicate the disease itself.

[5] See *Dictionnaire alphabétique et analogique de la langue française* (1958) Vol. 4, Paris, S.A.F.O.R.

[6] Bruce-Chwatt, L. J. discusses the early use of names given to the disease in two recent papers: (a) John McCulloch, MD, FRS. (1773–1835): The precursor of the discipline of malariology. *Medical History* 21: 156–165 (1977) and (b) "Ague as Malaria": *Journal of Tropical Medicine and Hygiene* 79: 168–177 (1976).

[7] The causative organisms of malaria were first demonstrated by Alfonse Laveran in the blood of soldiers in Algeria in 1880.

[8] In 1897, Foss described the early stages of the development of human malaria parasites in the midgut of mosquitoes (*Anopheles*) and in the following year demonstrated the complete cycle of the avian parasites (*Plasmodioum relictum*) in culicine mosquitoes and their transmission to sparrows by their bite. *Indian Medical Gazette*, 33, 401–448.

[9] Grassi and his collaborators, Bastianelli, G. & Bignami, A., completed the description of the life cycle of *P. Vivax* and *P. malariae* in the body of anopheline mosquitoes after feeding them on patients in the Hospital di Santo Spirito in Rome. *Rendiconti dell'Accademia dei Lincei* 8 (1), 21–28.

on the incidence of ague in Lappland, Sweden and Finland, and had started writing up the results in 1732. He (Linnaeus, 1734; 1811) continued working on the material in the following two years and substance for a thesis on a medical subject was available.

At that time the nearest university which would confer a doctorate quickly was Harderwijk[10] in Holland. Accordingly, the suitor of the hand and of the degree travelled there armed with his notes and papers. He arrived by sea via Hamburg and Amsterdam on June 17th, 1735 and presented the treatise to the Rector Magnificus (Johan de Gorter). On the following day it was printed and on June 23rd, he defended it with honour before the University; it was dedicated to his patrons in Sweden.[11] The diploma was bestowed on him on July 9th in the following glowing terms: "he has given proof of great learning, great medical knowledge, and a virtuous and noble disposition, thus justifying his right to sit on the doctor's chair, publicly defend medical theses, lecture on medicine, pay sick visits, prescribe medicaments, confer doctor's degrees and practise his art".[2] During the course of the defence, he had to expound Aphorisms 14 and 15 of Book VI of Hippocrates.[3] He thus demonstrated his familiarity with the classical views of the Greek physician on the subject of ague.

Linnaeus was not usually averse to changing his ideas. He was finally driven, in spite of his religion, to accept the evidence of his own eyes that species were not immutable as the result of their divine creation. He seems to have been reluctant however to abandon the clay hypothesis as the cause of ague and defended it in February 1741 before the Medical College of Stockholm,[12] where another candidate for the Chair of Medicine in Uppsala, Wallerius (1741), had violently attacked it, and he included it in his lectures as late as 1748. Later he tacitly accepted the irrelevance of clay as a direct cause by passing the doctorate theses of his pupils, Boström (1757) and Petrus C. Tillaeus (1771). The former con-

[10] The University evolved from a "Latin school" in 1372, through a "gymnasium" in 1600, to an Academy and University in 1648.

[11] The patrons were as follows: The President of the Royal College of Medicine, J. H. Vollhun (Archiatro Regio Primario); J. Chr. Nordenheim, Professor of Obstetrics, Stockholm; K. Stobaeus (his old Professor at the University of Lund); O. Rudbeck (the son of the renowned botanist); J. Moraeus (his future father-in-law); J. Rothman (see Note 27); Constant. Some (later a fellow medical practitioner in Stockholm); C. Alstrin (medical practitioner in Stockholm) and N. Rosén (an earlier graduate of the University of Harderwijk and later famous obstetrician).

[12] B. D. Jackson gives a full account of this disreputable episode, which ended in the triumphant appointment of Linnaeus as Professor of Practical Medicine in the University of Uppsala and of his opponent, Wallerius, as Adjunct. (*Linnaeus*, 1923, London, Wetherby).

tended that the cause of ague was to be found in bad air or faulty sanitation. The latter was responsible with his teacher for the dissertation "*De varia de febrium intermittentium curatione*" in which it was suggested that the disease was caused by foul or acid air which interfered with "exhalation". This was not a new idea, for a century earlier, Leeuwenhoek[13] had considered and rejected it in a letter to Nehemiah Grew, Secretary of the Royal Society of London in the following words. "In the towns as well as in the country many people suffer from fever, and walking through the grass in the meadows, their shoes get a deep red colour; therefore the common man concludes that the air is infected and very fiery". Leeuwenhoek notes that he looked at his own shoes and found nothing, but when he examined the dew on the grass through his "magnifying glasses" he saw more than a thousand "globules" (some of which were clearly protozoa). He therefore suggested that the origin of the disease was to be sought, not in the air, but in the grass.

The new theory which substituted foul air for clay as the causative agent was even less scientific; clay at least was material while the noxious vapours were quite vague. Yet of course the marsh held the vital clue and Linnaeus, like others before and after him, was on the brink of success. If he had not been so obsessed with clay and considered what else lay in the marshes (the larvae of mosquitoes), he might have arrived at part of the solution of the problem.

Linnaeus in this thesis makes no attempt to distinguish between "intermittent fevers" and other febrile diseases, and until the aetiology of malaria was finally discovered in 1880, no certain method of reaching a diagnosis was available. McArthur (1959) points out the confusion that existed between such diseases as influenza, relapsing fever and typhoid, and malaria, but the striking periodicity and character of the paroxysms were usually enough to enable a correct diagnosis to be made.

The hypothesis rests entirely on the treacherous basis of circumstantial evidence; moreover Linnaeus does not carry out a single experiment. There are two principal ideas; the ingestion of clay whose particles are absorbed into the blood and the inhibition of "exhalation" as a result. He apparently never tried to verify that there *were* particles in the blood of patients with ague; if he had looked, he might have been surprised to

[13] See letter dated September 27th, 1678 from Antony van Leeuwenhoek, Delft, to Nehemiah Grew, Secretary of the Royal Society, London. *The collected letters:* 2 vols., Amsterdam, Swets and Seitlinger Ltd., 1941. It may be recalled that Grew was the first person to suggest that plants like animals possessed the function of sexuality; this was later confirmed in full detail by Linnaeus, probably as his most important discovery after his "systematisation of nature".

find, like Meckel (1847) a hundred years later, that the particles were not white (like clay) but black (like melanin) and of direct malarial origin.

But Linnaeus was more of a macroscopist than a microscopist like Leeuwenhoek; he measured in minims and not millimetres. He ignored Leeuwenhoek's globules, i.e. free-living protozoa (see p. 6) and named only three genera of protozoa in his whole *Systema* (see Dobell).[14]

A wide vision is necessary for appreciating landscape epidemiology and this is just what Linnaeus possessed to the highest degree. In his journeys in the malarious and nonmalarious parts of Scandinavia his keen eye was able to contrast the environment and habits of the respective inhabitants. Thus he arrived at the chain of circumstances: marshes—clay—ague. He was aware of mosquitoes, and among the genera of insects in the *Systema* (Linnaeus, 1758 a) he introduced *Culex* and among the species may have been an anopheline (the so-called *C. bifurcatus*). But neither their role in transmission, [8,9] nor the plasmodia of ague[7] had yet been discovered and without these essential pieces of the jigsaw puzzle, he could not discern the true picture.

The practice of writing a doctoral thesis in short numbered aphorisms as used by Linnaeus and other scientists of the 18th century and earlier has much to recommend it. All padding is omitted and the circumstances under which the observations were made are reduced to scarcely more than bare names. The number of words in any translation into a modern language almost inevitably doubles or triples the length of a Latin original. The result of this practice is in striking contrast to the heavy volumes often produced today!

How could a man with such a magnificent grasp of nature and able to synthesise the plant and animal kingdoms into a "*Systema*" which remains the Bible of biologists today, how could this man write with a naivété comparable to that of the old wives' tales that Linnaeus himself destroyed with such scorn?

The thesis represents the struggles of a brilliant man to solve a problem which at that time was insoluble.

[14] Clifford Dobell, FRS, comments on the meagre references of Linnaeus to Leeuwenhoek's "Little Animals" (London, Stales Press, 1932).

New Hypothesis on the Cause of Intermittent Fevers Submitted by Carl Linnaeus for the Doctorate in Medicine of the University of Harderwijk

Foreword

When I had to decide on a suitable and interesting subject for my thesis, I recalled the opinion of the illustrious Sydenham[15] who stated that "If there existed a man who, either by any sure line of treatment, or by the application of any specific remedy, can not only control the course of these intermittents, but cut it short altogether, he is bound by every possible bond to reveal to the world in general, so great a blessing to his race. If he withheld it, pronounce him at once a bad citizen, and an unwise man; since no good citizen monopolises for himself a general benefit for his kind; and no wise man divests himself of the blessing that he may reasonably expect from his Maker, when he girds his loins for the welfare of the world. Honours and riches are less in the eyes of good men than virtue and wisdom." It is therefore my opinion that the publication of my theories will neither displease the reader nor be of little or no use to humanity. Although this disease has been studied frequently, almost ad nauseam, by physicians, I shall, under a familiar title, publish something new which I have discovered and which represents in my opinion the true cause of ague.

I do not want to waste the time of the reader by repeating old theories, quotations or irrelevant thoughts, nor to present abstract remarks. Instead I shall describe my own observations and ideas, point by point, so that a true conclusion may be reached. Moreover, a physician by the rules of his profession must speak only from personal experience; therefore as my knowledge of ague is confined to Sweden, I must limit myself to a description of the disease in that country.

[15] See English translation of Sydenham's works by R. G. Latham, London, Sydenham Society, 1848, Vol. 1, p. 82. Thomas Sydenham discussed the symptomatology and treatment of ague at some length (*Observationes medici circa morborum acutorum et curationum.* London, 1676).

I. Incidence in Sweden[16]

1. Intermittent fevers are very common in Sweden, especially in the southern valleys.

2. The disease has become firmly established in Uppland where it is the commonouest illness.

a. Nearly all the students in Uppsala contract it,

b. Similarly the disease is common in Stockholm, especially amongst those people who are delicate or overworked.

3. In Södermanland, Öster- and Västergötland and Västmanland nearly everyone contracts the disease.

4. The fever is quite common in Finland in the valleys near Åbo.[17]

5. In the plains of Skåne outbreaks of intermittent fevers occur only in the spring, whereas continuous fevers.[18] are present at other times of the year.

6. In the woods of Skåne and Småland, ague is uncommon and occurs only in limited areas.

7. In Norrland (North Sweden) the disease is almost unknown.

8. In Dalarne and Hälsingland, the disease is very seldom found.

9. In Ångermanland, it is even rarer. At Härnösand (on the western border) a man on his return from Stockholm was attacked by ague and schoolboys stared at him thinking that they were witnessing the miracle of a person freezing in the middle of summer.

10. In Västerbotten, ague is unknown except among tradesmen and sailors who have been to Stockholm.

11. In Lappland, I was told by the inhabitants that no one had ever been attacked by the disease, with a single exception—a man who had been ill with ague for three weeks.

[16] The most recent analysis of malaria in Sweden is given in the following monograph: Bruce-Chwatt, L. J. & de Zulueta, J. (1978). *The Rise and Fall of Malaria in Europe.* Oxford University Press.

[17] Malaria, according to B. von Bonsdorff, was widespread in Finland. (1975, *The history of malaria in Finland* 1828–1918. Helsinki, Societas Scientiarum Fennica.)

[18] In the thesis and elsewhere Linnaeus emphasies the appearance of ague in the early spring. This is now recognised as being a striking feature of benign tertian malaria in Northern Europe as reported by Swellengrebel (*Bulletin de la Societé de Pathologie exotique;* 1929, 22, 642–59) and others, and ascribed by them to infection in the preceding late summer and autumn. The phenomenon was described in some detail by the Swedish malariologist, Professor Kling, at the First International Congress of Malaria in Rome in 1925. He quoted the statistics of Bergman for the decade 1863–1872 which clearly demonstrate an upsurge of malaria in Sweden in March each year with a peak in April or May, and secondary peaks between August and September. He ascribed the latter to the appearance of adult females of *Anopheles maculipennis* in mid-June, and to a second generation of this species later. The majority of infections were tertian, about 12 % were quartan but it is doubtful if indigenous malignant tertian malaria ever occurred. A special strain *(hibernans)* of *Plasmodium vivax* has become evolved in which the sporozoites remain dormant for prolonged periods in the liver. The delayed incubation periods are followed in the early spring by active malaria, the symptoms of which decline in the summer; however mosquitoes emerge in the late spring and early summer, bite the sufferers from malaria, and after some weeks infect other people who become ill in the later summer and autumn.

II. Old Theories

12. The physicians have expressed many different opinions about the essential cause of the fever, including amongst others:

a. badly cooked or raw food leading to anorexia,
b. lack of exercise in sedentary occupations,
c. prolonged anxiety,
d. phlegmatic temperament,
e. addiction to acid or alcoholic liquors,
f. cooling of the abdomen after food,
g. suppressed disease.

13. Laymen ascribe the disease to a number of conditions, as enumerated below (paras. *14–21*).

14. The blood becomes thickened during the intense cold of the winter; then in the warmth of spring it becomes thinner and circulates more freely.

15. In early spring, people are apt to become chilled for the following reasons: a) winter clothes are discarded (as in Uppland) too early and before the temperature has risen; b) thin clothing cannot protect the wearer from the cold winds of the spring although the sun may be quite warm; c) exposure to cold air after sweating, as is the custom of the students of Uppsala.

16. Excessive exercise during the spring, when the air is damp and cold, is followed by fever. As soon as the snow has melted the students of Uppsala proceed to the nearest meadows to play energetic ball games. Later they take off their clothes, drink cold water or fetch milk from the nearest house. Within a few days they all fall ill with ague.

17. The consumption of fresh fish during the spring is thought by many people to be responsible for the disease. They will not drink anything as they think they are sufficiently protected by imbibing fiery liquors. At the beginning of spring, a large quantity of fish (the smelt—*Osmerus eparlanus*) is caught and brought to the market of Uppsala. The unpleasant smell nearly stifles the whole city. This coincides with the ague season.

18. The consumption of milk during the chilly days of early spring leads to obstruction of the pores of the skin whereby the blood attains the viscous consistency of milk.

19. The consumption during the summer of various fruits such as apples, pears, cherries, plums etc. is followed by the deposition of harmful juices in the body. Merchants from Torneå sometimes spend the whole summer in Stockholm. They often contract ague and assert that fruit is the cause of the illness, because the only difference in their food while in Stockholm is that they eat fruit there and not at home.

20. Married women often allege that their sex life offers a protection against ague, pointing out that wives and husbands contract the disease less frequently than adolescents to whom this activity is forbidden.

21. Finally the winds are adduced as a cause: a. the very cold sea wind blows in Stockholm in the spring; b. winds reach Uppsala from the swamps and flooded plains around the city.[19]

III. Refutation of the Foregoing Theories

22. It is unnecessary to refute the theories of the physicians in detail (see *12* above) as the alleged conditions are all present in Norrland where even the name of the malady ["*frossa*" in Swedish] is almost unknown.

23. I cannot believe that the reasons either singly or together (*13–21* above) offered by the general public, represent the fundamental cause of ague. They would only be relevant if the cause were already present in the body. Thus:

24. Cold (*14* above) cannot be the actual cause for

a. ague is very rare in the coldest areas (*9–11* above),

b. such fevers are very rare in the winter, but they occur in the spring and sometimes in the summer.

25. Sudden chilling (*15* above) cannot be a direct explanation, because a. in the winter, one may leave a warm room for the severe cold of the exterior; yet, although frostbite and ulcerated chilblains may result, ague does not; b. in places such as Norrland where the disease is absent, the inhabitants discard their heavy clothing without harm early in the spring; c. in Österbotten, it is the custom of people to emerge, naked and dripping with sweat, from the bath [sauna] and roll in the snow outside. This procedure is not followed by fever.

26. Heavy exercise (*16* above) in the early spring cannot be an explanation, because a. the Lapplander, after hunting and becoming wet through with sweat, often drinks water which he gets from under the snow and is so cold that it makes his teeth chatter. I shivered with fright on my first visit to Lappland on watching this practice, thinking of the danger of phthisis or dropsy, but after a few months, I realised from my own experience that my fear was groundless, though I would not recommend the habit to others; b. similarly, the inhabitants of fever-free Norrland, work, sweat and drink icy water, both during the spring and at other seasons without getting fever; c. yet in Uppland, although the farmer does less hard work, he does not escape the disease.

27. The consumption of fresh fish cannot be an explanation because a. the inhabitants of Norrland (where ague is absent) eat large quantities of fish; b. fish is the only food of the Lapps in the spring; c. the inhabitants of Ångermanland and of other northern districts eat at least as much smelt as do the people in Uppsala. But in all these cases (a, b &c). the people are free of the disease (see *7–11* above).

28. Milk likewise cannot be a cause, for a. in Västerbotten (where there is no fever) the people use more milk than elsewhere in Sweden; b. in Ångermanland, the people consume throughout the year a special kind of whey, named "syra",

[19] Drake quotes Linné (Dietik, 1907, p. 31) who noted that in the year 1754, when fever raged most violently, a thick foetid mist covered the valley of Uppsala.

but ague is absent. The whey is the remaining part of the milk after the separation of the curd. The curd is kept in a cellar from two to six months, and becomes so viscous that force has to be applied to cut it with a spoon as if with a knife. It can be pulled out into strands several feet long; it has a sour taste and quivers in the spoon like jelly. You would swear that an ague was in the dish. Milk is avidly consumed daily by the inhabitants and without danger. This observation disproves the theory that ague is caused by the consumption of viscous and acid food.

29. The consumption of fruit (*19* above) is an equally invalid explanation, for a. fruit is a most suitable food for man, just as it is for orang utans and apes whose mouth, stomach and hands have a similar structure; b. I myself and many others have eaten fruit in large quantities without being attacked by fever; c. this experience is shared by the people who live in the woods (but not the plains) of Skåne, where so much fruit is produced that a surplus has to be sold to the neighbours, yet ague is very rare; d. one poor trader returned from Stockholm to his home in Torneå with ague—I asked him if he had eaten many apples, cherries or plums, but he assured me that he rarely ate fruit, and not at all during that summer.

30. Sexual experience (*20* above) has little to do with the comparative incidence of ague in the married and unmarried respectively, because a. both married and unmarried are affected by the disease. In Uppsala there are more students (unmarried) than townsmen (many of whom are married); therefore in the total population there is a disproportion of married and unmarried and the actual number of cases is higher in the unmarried, merely because there are more of them; b. ague is equally common in the chaste as in those who have frequent intercourse as is proved by the daily experience of newly married couples.

31. Wind coming from the sea or swamps (*21* above) has no causal connection. In places where there is no ague, there may be much wind: a. most of Norrland is exposed to sea winds; b. elsewhere in Norrland the swamps are more extensive than in other parts of Sweden; c. in Lappland in June, the heat makes the mountains steam with humidity and water, while the snow melts more quickly (8 to 10 days) than elsewhere.

IV. The Actual Cause

32. Items *12–31* disprove the old theories and the cause of ague therefore must be sought elsewhere.

33. Six basic rules on diet must be followed if health is to be maintained; when we reflect on these, a true answer to our problem on ague will be found.

34. The habits of the people in northern and southern Sweden are similar in regard to exercise, rest, sleep, excretion and temperature. Their food and drink are also alike. The climate is the same in both places, but the composition of the water differs according to the various soils with which it has come into contact.

35. When the water flows a) through iron pyrites[20] (ochre), it contains iron and becomes acid, as in springs, b) through other ochres, it turns a violet colour and is caustic and poisonous, as in the Falun mine, c) through sandstone, it deposits particles which accumulate in the lungs and cause phthisis, as in the Orsa quarry in Dalarne, d) through limestone and clay, it gradually throws down these substances in the form of "stalactites", as in the rivers on Mount Omberg in Östergötland.

36. Clay is very common in southern but exceptional in northern Sweden.

37. Clay is the clue to the prevalence of ague in the respective districts, as is proved beyond all doubt by the following observations.

38. In Uppland, particularly in the vicinity of Stockholm and Uppsala, and also in the plains of Skåne, clay is very common as is ague.

39. In Södermanland, Öster- and Västergötland, and also around Åbo, clay and ague are very common.

40. In the woods of Småland[21] and Skåne, the amount of ague varies with the amount of clay; where ague rages, as in Växjö, clay is always present.

41. In Dalarne and Hälsingland there is neither much clay nor ague.

42. In Ångermanland there is little clay or ague, less in Västerbotten and least in Lappland.

43. In Pennsylvania in America, the Reverend Dean Sandel, states there is both clay and ague.

44. When the frozen rivers thaw in the spring, the clay particles are set free and the water becomes turbid, white and opaque: this is the special season for ague.[18]

45. The river Sala in Uppsala becomes white and turbid also at this season. I have noticed that every family who used the water was more prone to ague than were those people who drank from springs.

46. During the winter the water is very clear even if it runs through clayey soil; therefore ague usually is absent during this season.

47. In the summer, the water is pure, and ague seldom occurs.

48. But during the autumn, the water again becomes turbid and dirty: therefore ague is more common.

49. The illustrious Professor F. Hoffman of Halle[22] states that certain high places were much stricken by ague because of the presence of stagnant water.

[20] Linnaeus uses the work "pyritam" or "tophus" for these substances, which are here translated as "ochre". Ochre is a native earth consisting of a mixture of oxides of various metals and clay; the commonest are iron and copper, but the violet colour referred to in subpara (b) was probably due to the presence of manganiferous minerals at the Falun Mine. It was here incidentally, at Christmas parties in 1734, that Linnaeus first met his future wife.

[21] In derelict buildings near the clay pits and swamps in the former ague-stricken plains of Skåne, we failed, in late September, 1977, to find hibernating strains of *Anopheles* though we collected numerous adults of *Culex torrentium* (identified by Dr C. Dahl, entomologist of the Zoology Department of the University of Lund). Pigstyes and cattlesheds elsewhere in Skåne are so hygienically maintained today that they are no longer the home of over-wintering mosquitoes.

[22] Drainage is an important weapon of mosquito control today, but the significance of these observations was of course not realised by Linnaeus or Hoffmann.

When a canal was dug, however, the water drained away and the ague disappeared. The water oozed through rich clay soil and polluted clean water below.

50. Water may contain clay although the material is absent in the river bed; the water acquired it elsewhere but the swift current had prevented deposition. The people who drink such water fall ill with ague.

51. The disease often persists for a whole year in patients in Stockholm in spite of treatment, but if they move to places where clay is absent, they immediately recover. The excellent Doctor Moraeus informed me that he frequently recommended such people to move to the province of Dalarne and that this change had always proved to be beneficial.

52. In Lappland an inhabitant told me that the ague from which he suffered was due to very bad water from a well near his tent. He showed the well to me and I found that it was in clay soil. It was the only clayey well that I saw in Lappland.

53. Potters who puddle clay with their feet and mould it with their hands acquire a special kind of "ague" in their hands and feet. This is known as "potter's disease".[23]

V. Pathology or Presumptive Causation

54. The smooth clay particles are present in both food and drink and on ingestion get into the blood where they eventually lodge in the smallest vessels. There they produce disease. The great Boerhave[24] refers to the viscous (clayey) nature of the blood, which under certain circumstances leads to obstruction. Ague is often followed by dropsy[25] or phthisis.

55. The body wants to reject this substance and the symptoms of ague (shivering and cold) are a manifestation of the need to get rid of a noxious product. Such symptoms occur also in the ordinary course of life: a. if micturition is temporarily prevented, shivering occurs; b. similarly, if defaecation is inhibited shivering follows; c. the youth who is sitting close to his sweetheart and is sexually excited, shivers; d. women, before menstruation and parturition, have cold and hot ague-like symptoms; e. on the second or third day after childbirth, the onset of milk induces similar symptoms in the mother; f. on emerging from a hot room into the cold exterior, the active sweat pores immediately become

[23] Linnaeus elsewhere states that the potters become pale and their legs dropsical (see p. 21 of Drake). "Potters' rot" and "Potters' asthma" were English names for the disease now recognised as silicosis, produced by the fine (argillaceous haematite) particles accumulating in the lungs—and thus, to use Linnaeus' expression, "inhibiting exhalation".

[24] Aphorism 755 runs as follows: "So that after a due Examin of the whole History of Intermitting Fevers it must be concluded that their proximate Cause is a Viscosity of the arterial Liquid, upon which succeeds any one of the Courses of the too strong and quick Contractions of the Heart, and a Resolution of what had been stagnated." Boerhave, H. *Aphorisms*. Translated into English. London, 1755. Innys & Richardson.

[25] It is well known today that quartan malaria causes a special type of nephrosis (Garnham, 1966) which leads to dropsy; quartan malaria certainly existed in Sweden and possibly the frequent references of Linnaeus to "dropsy" may sometimes be attributable to malarial nephrosis.

closed and shivering follows with the inhibition of perspiration; g. when we get angry we turn pale and shiver all over, owing to contraction of the pores and cessation of perspiration; h. from the above (a–g) I conclude that a paroxysm of ague is a sign of the retention of a noxious substance which the body should expel or excrete.

56. The following symptoms of ague prove that such matter has been retained instead of being got rid of by the skin, lungs etc.: a. dryness of the skin; b. pallor, indicating that the blood has accumulated in the internal organs; c. loathing of food, the bitter taste and a dirty tongue are known[26] to be the result of inhibition of transpiration; d. debility and loss of weight; e. headache; f. sweating is always the result of violent activity; g. frequency of micturition; h. yawning is a sign that transpiration has been hindered on waking from sleep; i.placing a cold article on the body is followed by a sudden drawing in of breath (suppression of exhalation); j. from the above I conclude that there is much interference with transpiration during attacks of ague.

57. Thus, if one is attacked by ague, transpiration in one way or another is impeded; in the absence of the principal cause (clay) of ague, it is not affected.

a. The cold blocks the seat pores, especially after heavy sweating and in humid conditions.

b. The following foods are responsible for a delay in transpiration: fresh fish, too rich food, fresh milk, eggs, pork and melons (see Sanctorius Sanctorinus).[26]

c. Beer (especially from Stockholm) leaves a bitter and unpleasant taste in the mouth. Newly brewed (i.e. not fully fermented) beer causes the deposition of tartar or an earthy sediment in the blood and increases the effect, which I can vouch for myself.

58. Thus, a brick-red sediment becomes deposited in the urine of people suffering from ague: this is a clayey powder which originates in the body.

VI. Natural Cures

59. When one knows the cause of the disease, the indications for its cure are obvious and it is necessary to carry out the following procedures:

i. Use remedies that will dilate the vessels and expel noxious products from inside the body.

ii. The sweat pores of the skin must be opened by heat,

iii. The clayey particles must be diluted,

iv. The intake of butter-milk should be limited.

60. These indications and rules are based on nature. It is a golden rule in the art of medicine to go with and never against nature.

61. Nature has its own special way for expelling noxious matter. Thus, ague begins with a cold phase and shivering, which interferes with expulsion; the blood vessels later become extremely dilated and on the onset of the hot phase the poision is released with great violence (cp. *59* i above).

[26] Linnaeus and others frequently quote Sanctorius Sanctorinus (1614) *Ars de Statica Medicina.* Padua. Regula Sanctorii (iv, 19).

a. a good example is given by Doctor and Assessor Johan Rothman[27] in his dissertation on plague in Stockholm. In November, 1710, the disease had killed all the inhabitants of a certain town in Russia except for one girl. A young farmer went to this town with the intention of marrying the survivor, but he contracted plague himself. The girl immediately took her suitor to the nearest well, stripped him and washed his whole body with cold water. She then wrapped him in a fur coat and took the half dead youth to a hypocaustum [a sauna bath] where she laid him on a bench. After an hour he sweated heavily and recovered. A little later, he had to apply the same treatment to his betrothed, who had eventually contracted plague herself.

b. People on the Niger are said (by Hoffrok) to be cured of smallpox by a similar method without the aid of any other remedy.

c. After a hot [sauna] bath, the Finns immediately go out into the cold and then return to the bath in order to continue sweating.

62. The application of external heat or the hot phase of the disease itself results in the opening of the outlets of the secretory apparatus which have become contracted during the cold phase. The clay particles then become less viscous, a crisis takes place and their excretion in the urine may be observed (see *59,* 2 above).

63. The sweat (see *56,* f above) quickly removes the mucous and viscous particles from the blood, but first they must be rendered as fluid as possible (see *59,* 3 above).

64. Anorexia is not harmful as the absence of food in the body means that there can be no obstruction (see *56,* b above).

VII. Cure by Diet

65. I have cured many people affected by this disease by modifying their diet, though it is essential to ensure that they refrain from using water containing clay.

66. Nutritious food should be strictly limited, and at the same time, the patient should avoid exposure to the cold, take more exercise and sleep longer than usual.

67. The regimen is thus as follows: a. dress warmly; b. fast as long as possible—I have cured patients solely by making them fars for three days; c. completely avoid nutritious food which prevents transpiration; d. drink as much as possible, but not too much at any one time and preferably drink pure water or ale mixed with Rhine wine; e. if you are used to exertion, take, before the anticipated hour of a paroxysm, a daily walk of about half a Swedish mile—but first drink a glass of good wine or other suitable sudorific to ensure that the whole body sweats; f. those who are not fit enough to walk, should rely on sudorific medicines fasting and baths.

[27] Dr J. Rothman (1684–1763) taught Linnaeus science at school. He had obtained his doctorate in medicine at Harderwijk in 1713, and this may have resulted in Linnaeus choosing this university 22 years later.

68. It is sometimes said that in ague one must avoid buttermilk like "dogs and snakes" [cp. like the plague], but I have not only allowed, but even secretly recommended its use. The patients have thereby been restored to health.

VIII. Authoritative Cure

69. Laxatives relieve ague because the (clay) particles are thereby evacuated, but at the same time transpiration is impeded. As a rule, ague returns before long after such treatment (see *59* above).

70. Emetics are more useful, for the convulsive movements during vomiting affect even the smallest vessels and the particles clogging them are often released. The action is enhanced if a powerful emetic is used; transpiration follows.

71. Sudorifics stimulate the natural cure (see *59*, 1, 2 & 3 above) and seldom fail, but if the patient does not fast the ague will still persist (see Sydenham[15] and Boerhave).[24] Baths can also be useful by causing dilution of the body fluids and relaxation of the muscles.

72. The practice of venesection is absurd in the treatment of ague, for it renders the solid parts inelastic and waste products cannot be expelled; this results in decreased transpiration. For patients with plethora such a prohibition would not apply.

73. Mineral water is very good for ague; it complies with the natural indications for treatment (see *59* above). It dilutes through its water content, it stimulates through its iron content, it dissolves through its quantity and it acts as a diuretic because of its low temperature. At the same time, attention should be paid to diet and exercise.

74. Hot beverages such as tea, coffee or ölost (a mixture of hot beer and milk) are sometimes recommended, but in my opinion this treatment is harmful in ague (unlike in other fevers) for the hot fluids enter the stomach, soften the solid parts and reduce transpiration.

75. Pungent remedies often turn an ague into a continuous fever. In Östergötland, I saw two peasants who hade been treated by a quack with a very acid medicine. Their tertian ague was thereby transformed into a double quotidian.

76. I agree with Waldschmid that all pharmaceutical preparations with a *clay* base (e.g. *bolus, terra sigillata* and *arena lemmia)* not only worsen the fever but lead to dropsy.[28]

[28] A bolus is a paste containing the drug, honey and a suspending medium (e.g. clay) of such a consistency that it can easily be swallowed. *Terra sigillata* and *arena lemnia* are other natural earths containing clay or fine sand and were employed as suitable media for the administration of drugs.

IX. Empirical Cure

The physician may be driven to seek other cures of ague if the classical methods have failed. Three types of remedies are to be noted: bitter, acid and noisome.

77. Bitter drugs act either by expelling the obstructive particles with great force or making them amalgamate so firmly that they can only be dislodged with difficulty. The drugs are harmful early in the disease when clay particles are numerous in the body; they cause constipation and dropsy. If the fever has persisted for a long time, these remedies are largely without effect. The list of drugs is as follows: a. cinchona bark, well known in medical texts[29] although the tincture is a secret remedy; b. ash bark is a poor substitute for cinchona; c. wormwood (*Artemisia*), centaury (*Erythraeum centaurum*), gentian and nux vomica (whose active principle is strychnine) are all bitter and can be prescribed as remedies.[30]

78. Acid or pungent remedies are prized by some people but I have never used them; they include alum and vinegar.

79. Noisome or rank products are only likely to be of use if they happen to possess a sudorific effect, e.g. a. Dippel's Oil of Hartshorn or purified Tincture of Hartshorn which is administered on an empty stomach before a paroxysm at a dosage of 30 to 40 drops and is usually followed by sleep for 24 hours. This is useful, as a person when asleep perspires twice as much as when awake (Sanctirous).[26] Moreover the body does not take up nourishment during sleep. b. I learnt of the use of asafoetida (Succus Cyrenaicus) from the writings of Sanctorius, and my experience has confirmed the truth of his recommendation; c. garlic was often used by peasants and is a substitute for the above; d. the excrement of mice, pigs and dogs: that of the dog is an established and well known remedy, that of the pig is used in Norway, and that of the mouse is considered by "wise women" as of great and unfailing value. Physicians do not approve of these substances which are only used by quacks.

[29] The wife of the Viceroy of Peru, the Countess of Chinchon, is said to have procured samples of the bark of an indigenous tree which cured people suffering from malaria; the bark was taken to Europe and from the year 1690 it became established as a sovereign remedy for the disease. In the following century, specimens of the tree were sent to Linnaeus, who called it *Cinchona officinalis*, mis-spelling the Countess' name. In the Latin text of the thesis, however, he used the name "china" for the bark; "*china febris*" or "*china china*" was the common name of the drug in the 17th and 18th centuries.

[30] To this list of herbs, Linnaeus in an unpublished letter to Boissier de Lacroix de Sauyages (1860), of Alais (=Alès—the capital of the Cevennes), recommended the use of his own special (and armorial) flower, *Linnea borealis*, whose action was possibly derived from its heavy perfume rather than from its bitterness. Linnaeus (1758) gave a detailed accunt of the origin and action of Peruvian Bark quoting the work of various authors including that of Torti's famous "Therapeutice specialis ad Febris Periodicas Perniciosas", which went through 6 editions from 1712 to 1750. Torti (1928) stressed that "Peruvian Bark" did not act on the fever but on the actual *cause* of the fever on which it had a specific effect, unlike the other so-called remedies such as white gentian, the lesser centaury, etc. etc.

X. Conclusions

80. Dippel's[31] theory of the cause of ague differs very much from mine. He believes that the duodenum is attacked by some corrosive substance and becomes inflamed. The ducts of the gall-bladder and pancreas are obstructed and dilated, and finally the contents burst through into the duodenum. The pancreatic duct opens first and discharges its accumulated secretion into the intestine in great quantities: in Dippel's opinion this occurs simultaneously with the first stage of the chills and shivering of ague. The bile is then discharged through its bent duct, and because it is especially bitter through accumulation, it irritates the inflamed duodenum; the second hot stage of the ague then ensues.

81. Post-morten examination of a person who has died of ague discloses that the duodenum is *not* inflamed.

82. The dark colour of the faeces in a case of ague does *not* resemble the pallor which is characteristic of obstruction of the bile duct.

83. Dippel's theory fails to explain the regular periodicity of the paroxysms of ague. My own theory (based on inhibition of transpiration) explains the periodicity of ague in addition to other periodic phenomena, e.g. menstruation in women and the appetite for meals.

84. Observation. A person fell ill with a tertian ague and used several remedies in vain. Vomiting became so severe that he was unable to swallow a single drop of medicine or a mouthful of food, while water was immediately vomited. I tried the usual internal and external remedies to stop the vomiting but without success. Finally the patient managed to keep down 25 drops of Dippel's Oil of Hartshorn; half an hour later he had completely recovered exept for the lassitude which persisted for some days.

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[31] Dr J. K. Dippel (1673–1734) came to Stockholm in 1727 and became physician to Frederik 1st. He was later expelled from the country on account of his radical religious opinions. (See note by Drake, 1933.)

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PATRICK SOURANDER

Linnaeus and Neurology

Linnaeus's life-long interest in the nervous system is well documented in the 10th and 12th editions of *Systema naturae* (1758–59, 1766–68), in the booklets entitled *Genera morborum* (1763) and *Clavis medicinae duplex* (1766) and in his comprehensive lecture manuscripts. In addition, the numerous published dissertations defended by his disciples and the notebooks of students who attended his lectures and private tutorials constitute important sources of information about his views on the origin, functions and disorders of the Encephalum. Linnaeus included in this dominating concept the continuous white matter of the brain, spinal cord and peripheral nerves.

The aim of this paper is to outline the background and the profile of Linnaeus's neurological ideas. Furthermore, I want to comment on the neuropsychiatric symptoms of the ageing Linnaeus and touch upon their possible significance for the interpretation of his personality. Finally, the relationship between the views of Linnaeus and those of the "neuropathological sects" at the end of the eighteenth century will be briefly discussed.

Anatomical background

In 1726, during his last term at the upper school at Växjö, Linnaeus received private teaching in the basic principles of medicine. The textbook used by his beloved teacher, Dr. Johan Rothman, was Boerhaave's classical *Institutiones medicae* (1708).

In the notebook of the 19-year-old Linnaeus, there are several pages dealing with the nervous system. One of the minute figures in the middle of a text page depicts in a very simple way the blood supply of the cerebral hemispheres through the carotid arteries and their ramifications.

In the autumn of 1728, Linnaeus commenced his medical studies at Uppsala University and at the beginning of 1729 he attended for 6 days anatomical dissections and demonstrations on human material in Stockholm (cf. Djurberg 1927). The building where these demonstrations took place is still preserved and nowadays serves as the Stockholm City Museum. The notebook in which the young Linnaeus wrote on this occasion contains a 4 000-word-long description of the anatomy of the brain, written from the lecture by the surgeon to the King, Ewald Ribe. The description of the structures visible to the naked eye is obviously based on the works of Vieussens and Willis and is surprisingly accurate even today. The microscopes in those days were very primitive and therefore rarely used. This was thirty years before the mathematical laws governing the spheric and chromatic aberrations of optical lenses were discovered by Samuel Klingenstierna and one hundred years before the corrections suggested by this prominent mathematician, who became a friend of Linnaeus, were applied to the constructions of the achromatic lenses of the compound microscope. So it is easy to understand that in the eighteenth century, i.e. during the life-time of Linnaeus, nothing was known about the structural elements of the nervous system, the neurones, and their patterns of organization and function. However, the injection technique for the demonstration of blood vessels was already highly developed at the end of the seventeenth century. The Dutch anatomist Frederik Ruysch was most successful in applying arterial injections of liquids containing coloured wax in order to demonstrate the blood vessels of the brain. In some of his pictures, the injected blood vessels of the meninges, including their finest branches and anastomoses, are beautifully illustrated. Tsar Peter of Russia bought some of these brain specimens and took them to his capital (now Leningrad), where they are still preserved. Concerning the cortical vessels, Ruysch stated: "They became so delicate and moist that, unless injected with a liquid, scarcely and not even scarcely, can they be investigated without danger of their destruction. These moist protuberant blood vessels seem to be comparable to the fibres or medullary tracts of the cerebrum, and I believe that they have the same functions that (some) authors describe to the glands." However, the glandular structure of the cortex proposed by Malpighi was rejected (cf. Clarke and O'Malley 1968). The opinion of Ruysch that the cortical substance of the cerebrum is "wholly vascular", presenting a moss-like appearance, was mentioned by Ribe in his lecture and most probably influenced Linnaeus's views on the brain.

The history of the white matter of the brain begins in antiquity. According to Plato, the marrow (*myelos*) represents a particularly stable structure in the human body. The *Timaeus* belongs to the last period of Plato's career as an author. According to the *Timaeus*, the immortal soul is "implanted" in the marrow of the head (cf. Regnell 1967). Linnaeus thought that "life", corresponding to the concept of *spiritus animales* according to Galen, resided in the white matter of the brain. Macroscopic tracing of the white-matter nerve bundles was carried out in the 17th and 18th centuries. In 1665, the young Danish anatomist Niels Stensen (Nicolaus Steno), who became one of the most outstanding scholars of the 17th century, read a paper in Paris entitled *Discours sur l'Anatomie du cerveau*. In this famous lecture, Stensen emphasized the importance of studying the nerve bundles of the white matter, their origin and their endings (cf. Sourander 1969). The individual nerve fibre, as we know it today, was not identified during the lifetime of Linnaeus. It is claimed to have been discovered by Felice Gaspar Fontana of Pisa in 1781. Stensen's lecture was printed in Paris in 1669 and a Latin edition was published two years later in Leyden by Guido Fanoisius. It is included in the collection of medical books owned by Linnaeus which was returned as a generous gift by the Linnean Society of London to the Royal Swedish Academy of Science at the end of the last century. Since it is not mentioned by Linnaeus in the list of medical books in his possession during his first years at Uppsala, we may conclude that it was a later acquisition, possibly dating to his stay in Holland (cf. Sourander 1978).

The demonstration in Stockholm of the anatomy of the nervous system took place on 11 February 1729. On 19 March, Linnaeus wrote his name on the front page of *Cerebri Anatome* by Thomas Willis, printed in London in 1664. Until the end of the 18th century, this book, with its excellent illustrations (particularly of the "base of the brain", drawn by Christopher Wren, who became one of the most famous English architects), remained the best description of the nervous system, although criticized by Stensen for some of its theoretical ideas. In Linnaeus's copy, preserved at the University Library in Uppsala (and previously at Hammarby), there are numerous underlinings and some short notes revealing his interest in the subject.

Probably the books of Willis and Stensen are the only ones on the brain owned by Linnaeus. This does not mean that he had no knowledge at all of new books relating to the nervous system. Surely he must have seen the "Speech" and the book on nerves published in 1763 by his disciple Roland Martin, a prominent professor of anatomy in Stockholm. However, there are no indications that Linnaeus, who could not read

English, was aware of the most important discovery of 18th-century neurology, i. e. the concept of the reflex elaborated by Stephen Hales and Alexander Stuart in the 1730s and finally established by Robert Whytt in Edinburgh in 1751 (cf. French 1969). Nor does Linnaeus seem ti have been influenced by the revolution in pathology inaugurated by the "anatomical idea" of Giovanny Battista Morgagni in his famous *De sedibus et causis morborum* (1761). He may had some, but obviously not very clear, knowledge of the Glisson–Haller doctrine of irritability or contractibility as the specific property of muscular tissue.

Dutch impressions and medical practice in Stockholm

In 1735, Linnaeus went to Holland. After having successfully defended his thesis on *Hypothesis nova de Febrium intermittentium causa* at the University of Harderwijk, he made a short visit to Amsterdam and then proceeded to Leyden. He arrived there on 29 June, only one day after Hermann Boerhaave had finished his last lecture on *De morbis nervorum* (Lindeboom 1968). For five years, Boerhaave had given courses on the diseases of the nervous system. These lectures, which certainly represented a quite new approach in medical teaching, were not published until 25 years later (1761) by one of his students, Jacobus Eems, in collaboration with Jacobus Hovius. In 1959, a Dutch translation based on the original manuscript of Boerhaave was published by Schulte. Although Linnaeus did not have the opportunity to attend Boerhaave's lectures on nervous and mental diseases, he may have received information when visiting the St. Cecilia Hospital with Boerhaave and he may also have had access to written notes by his fellow students. At least this is the impression one gets on comparing Boerhaave's writings with the lecture notes of Linnaeus's students during his time as Professor of Medicine at Uppsala. Boerhaave used to tell a story about a beggar in Paris, who had undergone a radical operation in which he lost the top of his skull. The poor beggar used his calvarium for collecting money and sometimes allowed people for a trifle of money to touch the skin at the top of his head either with a finger or with the whole hand. Depending on the degree of pressure exerted on the soft tissues covering the brain, the beggar either saw sparks, became giddy or lost consciousness (cf. Garrison 1969). Linnaeus in his lectures stated that a slight pressure applied to one cerebral hemisphere causes vertigo and a pressure affecting both hemispheres causes sleep. In Leyden, Linnaeus also met Jerome Gaub, who was his senior by two years, who later became Professor of Medicine and Chemistry at the University of Leyden and whose interesting psychosomatic medical ideas have been reviewed by Rather (1965).

In 1738, Linnaeus returned to Sweden. Until 1741, when he was appointed Professor of Medicine at the University of Uppsala, he was an industrious medical practitioner in Stockholm, at times seeing 40 to 60 patients a day. In addition, he was appointed physician to the Admiralty and was responsible for a hospital with some 200 beds. Certainly he must have had the opportunity to see many patients with diseases of the nervous system. Linnaeus also realized the value of post-mortem examinations and applied for permission to perform autopsies at the Naval Hospital. This was granted, but unfortunately no autopsy records have been handed down to posterity. In 1741, Linnaeus was appointed Professor of Medicine and Botany at the University of Uppsala. During the 36 years he held this chair, he saw patients only occasionally, limiting his medical practice mainly to members of his own family and to close friends and their families.

Early attempts to classify neurological symptoms

Scientific classification of disease is the result of a slow historical development. At the end of the 17th century, Thomas Sydenham and Georgio Baglivi suggested that diseases, like plants, could be described and classified by the Aristotelian method of noting similarities and differences. As the late Professor Fredrik Berg, an eminent expert on Linnaean medicine pointed out (1957) Linnaeus's unpublished medical notebook called *Vademecum* reveals his early interest in applying taxonomic principles analogous to those used in the first edition of his *Systema naturae* (1735) in classifying diseases. It has not been possible to decide whether the *Vademecum* was already written before April 1735, when Linnaeus left Sweden for Holland, or soon afterwards. Be that as it may, his classification shows independency and differs profoundly from that presented by François Boissier de Sauvages de la Croix in *Nouvelles classes des Maladies*, published in 1731. It is well known that Linnaeus later on adopted the nosology of Sauvages and became a correspondent and friend of his learned colleague at the University of Montpellier. In Linnaeus's *Vademecum,* considerable attention was paid to nervous disturbances. In the class *Morbi mentales,* Linnaeus included two disease groups of opposite functional significance. These were labelled with the old eponyms *Vigilia* and *Somnus. Vigilia* was further divided into spasmus, epilepsia, vigiliae mania and vertigo, while Somnus was divided into lipothymia, apoplexia and somnolentia. After having got to know the system of Sauvages in Holland, Linnaeus made a new classification of diseases closely resembling but less elaborate than that of Sauvages. Linnaeus wrote an outline of this new classification in a small notebook called *Genera morborum,* which was published in 1759 as a dissertation (defended by Johan Schröder, who later on became second medical officent of health in Göteborg). An enlarged edition was published by Linnaeus in 1763.

Clinical observations on patients with neurological diseases

The ideal of the 18th century physician was a doctor with the capacity to "observe accurately, reflect carefully, and reason soundly" (King 1963). In many respects, Linnaeus fulfilled those requirements. This is particularly obvious when one reads some of his relevant descriptions of neurological diseases.

Rabies, a frightful malady affecting the brain of wild and domesticated animals as well as that of man, has been known since antiquity. In the 18th century, it was well known in Sweden. In his lectures on *Systema morborum,* Linnaeus presented a vivid description of *Canis rabidus* and *Homo morsus.* Rabies was considered a contagious disease transmitted by the bites of mad dogs. When these dogs are furious, Linnaeus said, "a small worm can be seen below their tongue. It would be rather interesting to see it but one ought to be careful and avoid touching it with bare hands. An instrument should be used." (Wenman 1761.) We now know that the little worm postulated by Linnaeus is a virus with an affinity to the central nervous system and is transmitted by saliva. Rabies and hydrophobia, which Linnaeus considered to be a later stage of rabies, were included in the "Classes Mentales" of his *Systema morborum.* Linnaeus recognized the long incubation period, varying from a month to several years, and thought that also other pathogenic factors than contagions, for example extreme heat, cold, hunger and thirst, might contribute to precipitate rabies.

Linnaeus made several relevant observations on the symptomatology of patients with neurological illness. During his journey to Gotland in 1741, he had an opportunity to see a patient whose condition he characterized in Latin as "Corporis agitatio continua, indolens, convulsiva cum sensibilitate" (Hagström 1769). In his *Systema morborum*, this disease is presented as a variety of the genus Hieronosos. The point made clear by Linnaeus was that, although the patient displayed continuous distortion of the limbs, sensation was not affected. Furthermore, Linnaeus stated that this malady had nothing to do with alcoholic intoxication or epilepsy. When James Parkinson, a well-known London physician, published his *An Essay of the Shaking Palsy* in 1817, he quoted the above-mentioned brief Latin statement to Linnaeus. However, as Critchley pointed out (1955) the term "shaking palsy" is evidently inapplicable to the case described by Linnaeus. It is most probable that the patient briefly mentioned (without any further clinical details) by Linnaeus was afflicted with an extrapyramidal motor dysfunction called "athetosis" which means uncontrolled movements "without fixed posture" of the trunk and the arms, rather than Parkinson's disease (Garrison 1969).

The best known example of Linnaeus's capacity for accurate observation and description of neurological diseases is a paper entitled *Loss of Memory for Nouns, particularly Names*. In this short case report, published in the *Proceedings of the Royal Swedish Academy of Science* in 1745 Linnaeus records the pertinent clinical data of "a learned man at Uppsala". According to Hultgren (1916), this was a 58-year-old Professor poeseos. In conjunction with a "sleeping sickness (cataphora)", the patient developed marked difficulties in speech. The initial stage was characterized by paraphasic disturbances in speaking, "as it were in a foreign language, having his own names for all words, e.g. to drink To Ti etc". Later on, he forgot all nouns, including the names of his children, his wife and himself. If a name which he was apparently trying to express was spoken to him, he would say "yes", but he could not repeat the word, saying "cannot". In spite of this, he seemed to have preserved the ability to read and understand names: "When he wanted to mention the names of any of his colleagues, he pointed to the Catalogum Lectionum in which the name was printed." The speech difficulties were reversible and disappeared suddenly after about half a year, but soon thereafter the patient died. This remarkable paper has been translated into German (Külz 1875) and English (Viets 1943) and must be regarded as one of the classical descriptions of motor aphasia, i.e. the loss of the functions making up expressive speech. This condition which is a common result of a stroke affecting the left hemisphere of the brain, is often combined with right-sided paralysis of the limbs, but transient cases without hemiplegia, like that reported by Linnaeus, occur frequently.

There seems to be no doubt that the ancient Greek physicians recognized aphasia-like manifestations in patients with cerebral diseases. According to Benton and Joynt (1960) there are a few early descriptions of motor aphasia, the best one being that of Peter Rommel (1683). Thus, the claim raised by Antoni (1957) and Garrison (cf. posthumous edition 1969) that Linnaeus may have given the earliest description of a case of typical motor aphasia is not justified. Nor is it true that Linnaeus was the first to report on the coincidence of aphasia and agraphia (Benton and Joynt 1960). This is obviously due to a misinterpretation of the original Swedish text, in which nothing is mentioned about the patient's ability to write. It is of interest to note that another case report on aphasia (a mute individual with retained capacity for serial speech, for example singing) was published by the eminent Swedish humanist Olof von Dalin in the same issue of the *Proceedings* that contained the paper by Linnaeus. Linnaeus does not comment upon the case which was certainly unique in his experience. However, his criteria for what we now consider as motor aphasia have stood the test of time. His conclusions—"consequently he (the patient) had lost two things; firstly the memory for all nouns, secondly the power to be able to mention nouns by name"—grasped the essence of the phenomenon described.

Speculations on the nature and mechanism of nervous action

In *Generatio ambigena* (1759) Linnaeus stated that the cortical substance of the brain is able to regenerate itself after injury while the white matter ("encephalum") does not show this capacity. Consequently, there is a continuous substitution of the cortex by components of digested food and dietary errors may injure it (cf. Lindfors 1907). The white matter is accessible only to odours, Linnaeus said (1752). Later on, he thought that it would be sensitive also to electricity. The odours were considered to reach the nasal cavity and the membrane of Schneider, which separates it from the brain. According to Linnaeus the naked nerve endings of the olfactory nerves are so numerous in this membrane that one gets the impression that the brain or its soft substance is here widely expanded in order to facilitate the uptake of all the subtle things to which the human body may become exposed. This is the only place, Linnaeus remarked, where the naked nerves reach the surface of the body. It is interesting to note that recent studies have shown that labelled macromolecules instilled in the nasal cavity of laboratory animals may in fact be transmitted by a retrograde flow in the axons of the olfactory nerves to the olfactory bulb, i.e. to a part of the brain (Kristensson and Olsson 1971). Linnaeus emphasized the difficulties in studying the different effects of different odours on the "encephalum". Concerning the nature of these influences, he said:

"We still don't know for certain whether the nervous action is transmitted by a subtle juice which in a moment is transported from the nerve endings to the brain or by vibrations of the nerves. We don't know whether we should regard the irritation as the sole and sufficient cause or pay attention to the new opinion about the electric power ... May the noble reader kindly excuse me for not always having found the right way in such obscure matter but more light is needed than our time is able to provide."

In these critical remarks Linnaeus revealed himself as a true son of the Enlightenment.

Linnaeus displayed a keen interest in electricity; long before Galvani in Bologna published his treatise entitled *De viribus electricitatis in motu muscularis commentarius* (1781). According to the well known neurophysiologist Mary Brazier, "three lines of knowledge converged to meet eventually in the concept of animal electricity. One was the physical science of electricity, another was the knowledge that some animal forms, notably the marine torpedo and electric eel, produced intrinsic electricity and the third was the observation that animal tissue could be made to contract by electric stimulation."

Since antiquity and during the entire 18th century, only static electricity was known. In the early part of the 18th century it was empirically discovered that the human body could be charged electrostatically, provided it was isolated. Static electricity could be produced by a frictional machine or as electric shocks generated by the earliest efficient electric condenser, the Leyden jar constructed by van Musschenbroek. In the 1740s static electricity was widely used in Europe, particularly in Germany and France, for the treatment of neurological disorders, for example paralysis of fingers and whole limbs. At Uppsala, the mathematician Klingenstierna and the astronomer Strömer treated numerous patients with sparks and shocks. The patients were sent to them by the two professors in medicine, Rosén and Linnaeus. A disciple of Linnaeus Pehr Zetzell assisted in the therapeutic trials and defended a thesis entitled *Consectaria electro medica* (1754), based on his own experience of the mostly rather poor results of the treatment. As already mentioned, Linnaeus was also theoretically interested in the power of electricity. He considered the "animal spirits", well known since Galen, to be electricity taken up by respiration from the air and accumulated and stored in the white matter of the brain. Furthermore, Linnaeus thought that electricity was distributed by the nerves to all parts of the body and, what is even more surprising, he rightly assumed that it was also transmitted from the peripheral parts of the body to the brain (1754). In his opinion such electric phenomena in living animals including man, although closely related to physically produced electricity, were of a different character. Linnaeus's ideas on what we now call bio-electric phenomena were not based on experiments. However, they reveal a remarkable intuitive capacity to anticipate forthcoming research. Although there is little evidence of Linnaeus's ability to perform or conduct controlled experiments, he certainly had a sense of the value of true experimental verification. Thus, Linnaeus suggested to his friend Sauvages, who possessed better technical resources, that he should carry out experiments on the effects of various odours on the electricity of the encephalum.

Neuropsychiatric symptoms of the ageing Linnaeus

Several attempts have been made to obtain a coherent picture of the complicated and, in many ways, self-contradictory personality of Linnaeus (cf. Hagberg 1939, Malmeström 1964, Lindroth 1966, Wikman 1970, Broberg 1975). Since we have a good deal of information about the health and diseases of Linnaeus at various periods of his life, it is somewhat surprising to note that, in the analysis of his personality and its subsequent changes during ageing, medical points of view have been largely absent. This is particularly true of the neurological disturbances which started to plague him at the age of about 44 years and which finally, after many years of great suffering, destroyed him. In addition to his fundamental empiricism, mixed with 18th-century rationalistic medical thinking (cf. King 1963), Linnaeus displayed from his early youth a strong sense of the magic of life, the "mysterium tremendum et fascinosum" of the scholastics. In the light of the medical data extracted from his letters and dissertations and from the descriptions of his contemporaries, it seems justified to assume that the marked accentuation of this personality trait in Linnaeus in old age was influenced by a fairly well characterized neuropsychiatric illness of unexplained causation. In the context of the present paper, only the main course and the principal features of the malady affecting the nervous system of Linnaeus deserve mentioning (Table I). Further details and a critical discussion will be the subject of a separate study.

The quality of the symptoms listed in the table, combined with their temporal sequence, suggests that they may reflect certain aspects of an organic, extremely slowly developing, brain disorder. The leading symptoms of the primary stage, which lasted for more than 20 years were paroxysmal headache ("hemicrania" or "migraine") and recurrent visual hallucinations of physical duality ("autoscopy"). The secondary stage, of six years' duration was characterized by repeated strokes localized in the left hemisphere of the brain. The headache usually appeared on one side and was of a recurrent and at times extremely severe character, "comparable to pains at childbirth" or a feeling "like a nail boring through the left template". The attacks commenced early in the morning or in the evening, lasted for several hours and were rarely absent for more than eight days (Linnaeus 1763). They were precipitated by minor dietary errors, common colds and emotional stress. It is noteworthy and reminds one of histamine-induced attacks (Horton's disease) that "a flow of hot tears and venous congestion of the eye on the side of the headache" coincided with the paroxyms.

Since the 1930s, considerable attention has been paid to the fundamental fact that there is at the boundary of our consciousness the notion of our physical personality. This so called body-image can disappear or become distorted by various injuries affecting the nervous system. The best known example of such distortions of the body-image is the phantom limb of amputees (Jalavisto and Sourander 1948). In rare instances, the body-image may release itself from its material frame and become a hallucination, a perception without object (cf. Arieti and Meth 1959). This phenomenon, generally called autoscopy has been defined as "a complex psycho-sensorial hallucinatory perception of one's own body-image projecting into the external visual space" (Lukianowicz 1958).

Table I. *Linnaeus's neuropsychiatric symptoms 1751–1777*

Source of information	Date of record	Clinical characteristics
Letter to Tessin (Fries 1903)	1751 (27 Sept.)	Hemicrania on the left side
Letter to Bäck	1751 (Dec.)	Migraine
Letter to Sauvages (Hjelt 1907)	1756 (22 April)	Hemicrania
"Motus polychrestus" (*Valda avh.* 42, 1963)	1763	Hemicrania associated with ipsilateral flow of hot tears and conjunctival congestion
Quotations (Fries 1903, Olsson 1949, Wikman 1970)	Since 1768	Recurrent visual hallucination of physical duality (autoscopy)
Letter to Bäck	1772 (28 Febr.)	Giddiness, stumbling (to the right side), "callus in cerebro"
Letter to Bäck	1772 (17 March)	Constant use of velvet cap to prevent migraine
Vita Caroli Linnaei (Malmeström & Uggla 1957)	1774 (May)	Cerebral stroke (hemiparesis on the right side and dysphasia)
Linné, Vol. II (Fries 1903)	1775 (August)	Limping, dysphasia, dysgraphia
Linné, Vol. II (Fries 1903)	1776 (Jan.)	Progressive cerebral symptoms
Last letter to Bäck	1776 (24 May)	Almost unintelligible writing
Linné, Vol. II	1776 (August)	Recurrent stroke (hemiplegia on the right side, aphasia, multiinfarct dementia)
Linné, Vol. II	1777 (30 Dec.) (mors 10 Jan. 1778)	Cerebral convulsions

Autoscopy is a complicated experience including, apart from sensorial, emotional and cognitive "perception". According to Lhermitte (1951), the image of "the double", which may appear without preceding symptoms, is very clear but uncoloured, almost transparent. When the person tries to approach his double it draws back or fades away, after having copied the movements and facial expression of its "original". It is obvious from several sources that Linnaeus had repeated experiences of this kind. One of Linnaeus's students in later years tells that one day he followed his teacher up to his room and "when we had arrived at his museum, he looked at the table and chair where he usually sat when studying and said clearly and in a high voice, 'Aha, is it you sitting there, Carl? Sit in peace, I will not disturb you'. I asked him 'Sir, whom are you addressing?' 'I sometimes think that I am sitting there (he pointed to the chair) working', he replied" (cf. Wikman 1970). According to Lhermitte, "the apparition of the double should make one seriously suspect the incidence of a disease"; it may imply various kinds of focal lesions to the brain. Although Lukianowicz admits the frequently organic causation of autoscopy, he also recognizes a hypothetical "idiopathic autoscopy", interpreted in terms of compensatory or a wish-fulfilling mechanism. He also thinks that to some extent the hallucination may depend on "an egocentric and narcissistic type of personality combined with vivid visual imagination". Such personality traits were certainly present in Linnaeus!

The cause and pathogenesis of the postulated, organic, brain syndrome in Linnaeus can only be a matter of conjecture. Arterial hypertension has been proposed as a probable cause of the recurrent strokes (Strandell). In my opinion this is at the best a partial explanation, relevant to the terminal stage of the illness. Considering the entire protracted course of the disease, with its debut in middle life and with symptoms indicating involvement of the left cerebral hemisphere and regarding a recent extensive study on hemiplegic migraine with evidence of cerebral atrophy and infarction (Hungerford *et al.* 1976), another possible explanation may be contemplated. The hypothesis is put forward that the neuropsychiatric disease from which Linnaeus suffered was initiated by an anatomical and/or functional anomaly affecting the blood vessels of the left hemisphere of the brain. If anatomical, such an anomaly may have consisted in a congenital, vascular malformation which delayed clinical effects.

It has been said that the individuality of Linnaeus presented two aspects (Lindroth 1966). One was influenced by 18th-century empiricism and rationalism, while the other was marked by archaic and scholastic thinking. But there was also a strong touch of medieval mysticism in his thinking, which may have been facilitated by a deeply rooted constitutional trait and by recurrent autoscopic hallucinations, which made it difficult for him to see the difference between reality and the world of imagination and fiction.

The search for synthesis

At the end of his life, Linnaeus wished to make a synthesis of his systematic thinking in medicine. This he accomplished in the strange story of the double keys opening the doors of "the temple of medicine". *Clavis medicinae duplex, exterior et interior,* published in 1766 is the ultimate example of his characteristically concentrated and aphoristic style, his "nervosa brevitas". In this booklet which has been called "a visionary cataclysm" (Wikman 1970), the leading idea in most of the writings of Linnaeus since his youth, i.e. the sexual dichotomy of living Nature, was applied to the origin, anatomy and significance of the nervous system. The outer key was designed to open the door to the knowledge of the nature and treatment of the diseases of the cortical substance (producing blood, muscles, bones and visceral organs), while the inner key did the same thing for diseases of the medullary substance (consisting of encephalum, i.e. brain, spinal cord and nerves).

In recent years, there has been much discussion about the possible sources of inspiration which led Linnaeus to present his final synthesis in such a bewildering shape (cf. Lindroth 1965, Wikman 1970, Broberg 1975, Sourander 1978). Linnaeus's fundamental assumption that the medullary substance is of maternal and the cortical substance of paternal origin was, as we shall see, at least partially based on empiricism. However, considering that the human egg cell was not discovered until 1827 and that the fusion of male and female sexual cells was observed for the first time in 1879, it is easy to understand the inadequacy of the 18th-century embryological observations. Thus, for mammals including man, the phrase coined by William Harvey and adopted by Linnaeus "ex ovo omnia" was almost meaningless (cf. Singer 1959). For the purpose of explaining human generation, Linnaeus relied on thinking by analogy using the early development of the chick as an experimental model. In his lecture notes prepared during the winter of 1761–62 Linnaeus wrote as follows:

"If a hen sits on several eggs and if, after she has been sitting for some days, one opens an egg two white spots and a long streak are always found on the top, however the egg is turned over; again if a few days later one opens another egg, many small white threads are seen departing from these spots and from the streak. These threads are nerves leaving *cerebro* (the two white spots) and *medulla spinali* (the long streak) thus *Systema nervorum et cerebrum* constitute *primum stamen vitae* of the animals, and therein exist *motus et sensatio* and not *in sanguine, fibris et ossibus; motus et sensatio* are subjected to fevers and thus fevers reside in *cerebro et medulla*" (Kar. Inst. MS. 467: 1, cf. Berg 1957).

The primary importance which Linnaeus attached to these observations is reflected in the design of his coat-of-arms, presented by him probably late in 1761 (Fries 1903, Volume II). This multicoloured design, preserved by the Linnean Society of London, is dominated by one half of a divided, fertilized, hen's egg depicted in a life-like manner. Close examination of the picture allows one to discern a white streak and radiating white threads on the top of the yolk (observation by the author). In addition a corona of tiny blood vessels is visualized in the picture. The question whether Linnaeus's claim that the initial stage of the nervous system (encephalum) appears before the heart and the vessels emerge is based on his original observations or on Swedenborg's writings (cf. Broberg 1975) has not been clarified. Be that as it may, later research has proved that the time sequence of the developmental events postulated by Linnaeus is the right one.

Linnaeus was obviously not an adherent of the extraordinary doctrine of preformation, implying that generation signified the growth of a "homunculus" contained either in the ovum (ovulist view) or in the spermatozoon (animalculist view). He thought that the initial white streak representing the first stage of the evolving encephalum was generated by the caudal part of the spinal cord and transferred by the ovarial nerve to the egg. The subsequent development of the encephalum as well as the emergence of the cortical substance were in some unknown way induced by the sperm. Linnaeus, like many of his contemporaries, thought that the spermatozoa, discovered by Leeuwenhoek (1679), were nonliving particles containing, however, "the active substance of the male sperm" (Linnaeus 1759).

Much has been said about the "impenetrable Pythagorizing mysticism of numbers" (Lindroth 1965) dominating the entire tabulated content of *Clavis*. While not denying the importance of the early acquired mental impressions and constitutional traits of Linnaeus, it may be suggested that a strong motive was to create "a canon" for medical practice. At the end of the 18th century, the population of Sweden was rapidly growing and the need for more physicians was urgent. It is well known that Linnaeus felt his responsibility and made serious efforts to educate an adequate number of able doctors possessing practically useful medical knowledge. In this undertaking, he was extremely successful. That he failed in his attempt to construct a theoretical framework, a useful general pathology, may at least partly have been due to personality changes caused by neuropsychiatric illness associated with impaired capacity to renew and enlarge his medical knowledge.

Linnaeus and the neuropathological doctrine

As we have already seen, Linnaeus paid much attention, both in his nosology and in his general pathology to the nervous system. Therefore, the possible relations of his views to the prevailing line of medical thinking at the end of the 18th century, i.e. to the neuropathological doctrine, are of considerable interest. Since antiquity, motion and sensation had been ascribed to the nervous system as its proper functions. Motion was given the highest rank among all the factors underlying health and disease (Riese 1949). At the beginning of the 18th century, Friedrich Hoffmann, of Halle, influenced by the Newtonian mechanical cosmology and the corpuscular philosophy of Robert Boyle, became the greatest of iatromechanists and a forerunner of the neuropathological sect. According to Hoffmann, a subtle nervous fluid, ether, was carried from the ventricles of the brain through the nerves to the tissues of the body, controlling their tension. Cullen, whose medical thinking was influenced by the writings of Hoffmann, became the founder and spiritual leader of the sect of neuropathologists (Riese 1949). He regarded the nervous system as the most important part of the body, the carrier of life and the main seat of disease. Fever was considered to be an effect of diminished cerebral power resulting from local lesions caused by exogenous agents. Following the example of Boerhaave in Leyden, Cullen introduced bedside teaching in Edinburgh, which became one of the leading medical centres of Europe. The nomenclature of diseases applied by Cullen followed the standard forming principles in the botanical works of Linnaeus.

Two talented Swedes visited Cullen. In 1760, the astronomer Bengt Ferrner met Cullen, whom he described as "a voluble and funny man", curious to know about medicine in Sweden and particularly about Rosén and Linnaeus. In 1773, a disciple of Linnaeus, the physician Henric Gahn, attended Cullen's lectures. He received a signed copy of the latter's *Synopsis nosologiae medicae*, which he forwarded to Linnaeus (Selling

1968). Like the *Systema morborum* of Linnaeus, Cullen's nosology was based on symptoms. Linnaeus, however, was much less categorical than Cullen in his opinions on the role played by changes of the nervous system in various disease processes. Like Cullen, Linnaeus considered different types of fevers as consequences of cerebral reactions to local external lesions.

The most widespread and most comprehensive nosology of the 18th century, i.e. that of Sauvages, was strongly influenced by the botanical books and often to a lesser degree by the medical writings of Linnaeus. Whether the neurological views of Linnaeus exerted any influence on the neurological concepts of Sauvages remains to be investigated. However, when the posthumous French translation of *Nosologia methodica* by Sauvages appeared in 1772 it was published together with Linnaeus's *Genera morborum* in the original Latin and in a French version. Only a few years earlier Cullen included *Genera morborum* in his *Synopsis nosologia methodicae*. In the final chapter of *Genera morborum*, entitled "Theoria", Linnaeus briefly mentioned some of his neurological ideas. Probably they did not have any marked impact on the opinions of the contemporary European learned world. *Clavis medicinae duplex*, with its strange view of the maternal origin of the white matter of the nervous system, probably never became widely known. In the Swedish medical literature, comments on it have been published by Hjelt (1903) and by Müller (1903), who also presented an interpretation of its content.

Concluding remarks

According to a modern philosophical view (Popper 1963), the growth of scientific knowledge proceeds by conjectures (anticipations, guesses, tentative solutions) controlled by attempted refutations. Linnaeus in his *Diaeta naturalis* stated: "Medicine in the old days was an art of guessing and still is." Like many scientists today, Linnaeus was frequently occupied with making conjectures. In his bright hours, he made many brilliant conjectures also in the field of neurology, which posterity has proved adequate. In old age, worn out with hard work and sick, his power of judgement failed and he became a victim of uncontrolled, mystically coloured, archaic and wishful thinking.

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P. SMIT

The Zoological Dissertations of Linnaeus

"He (Linnaeus) discovered more animals than any of his predecessors, and he was the first to give them their *characteres genericos et specificos* according to the natural method. The knowledge of the *Insecta* must be attributed to him, not to speak of the method found by him for classifying the fishes according to their fins, *a cardina Conchylia* and *a scutis Serpentes. Cetos ad Mammalia, Nantes ad Amphibia reduxit, et Vermes ab Insectis removit*" (1).

Essentially there is a basic difference between Linnaeus's contribution to the system of botany and that of zoology in that in the field of zoology he made greater contributions to the *natural* system than in that of botany. Furthermore, the system of zoology remained less "open" and constantly admitted of improvement (2). The most important element contributed by Linnaeus is his method of comparison and description; he had a gift for discerning resemblances and correlations between different organisms and basing a system on them.

There exists of course a great deal of literature on this subject; in this context we would only state that in this respect the zoological literature has greatly lagged behind the botanical literature, both absolutely and relatively (3). A possible cause of this relative lag is that Linnaeus's contributions to zoology—more so than those to botany—are hidden away in his systematic works. One of the principal sources in this field is formed by the zoological dissertations.

Out of the 186 dissertations written during Linnaeus's professorship at Uppsala University (1741–1773) (4), about thirty were devoted to zoological problems. Linnaeus considered all the theses maintained by students under his guidance as his own work, and this is the reason why he published the collected dissertations under his own name in several volumes under the title of *Amoenitates academicae* (5).

In imitation of Linnaeus, most biographers and bibliographers assume that the master wrote the dissertations himself and is to be held responsible for the contents. This conclusion has an important practical consequence. Since the Linnaean names have been explicitly established by international rules, the works of Linnaeus, including these dissertations, are very important from the taxonomic point of view. In fact, it is precisely in these dissertations that a considerable number of the best-known animals as well as plants are described.

However, there is yet another complication. Linnaeus was so firmly convinced of his own copyright concerning these dissertations (6) that he would often highhandedly make alterations in the nomenclature when the dissertations were reprinted in the *Amoenitates*. This implies that from the taxonomic point of view one should consult both the version of the dissertation reprinted in the *Amoenitates* and the original version if one is to arrive at a correct nomenclature. In this context it is interesting to note that the Linnaean Society in London possesses those copies of the dissertations which were originally the personal property of Linnaeus. These copies were used by Linnaeus for the reprint in the *Amoenitates*, as appears from the alterations in the text made by his own hand.

Since the great majority of the original dissertations is difficult of access, Messrs Asher of Amsterdam have decided to publish a reprint, at least of those which are important for natural history in general and for taxonomy in particular. It is hoped that this reprint will appear this year, furnished with detailed indices (7).

Although there is already a good deal of literature on the systematic-taxonomic work of Linnaeus in the field of zoology (8)—in which data from several of these dissertations have also been incorporated directly or indirectly—it may be hoped that this publication will have a stimulating effect in this field. However, in this address I would try to describe the contents of these dissentations rather more from the point of view of a student of the history of science, by pointing to the richly varied contents of a number of them. This would appear to be all the more important because on the whole the zoological dissertations are much less well-known than the botanical dissertations. It is therefore to be hoped that this re-publication will stimulate further study of a number of general aspects of the work of Linnaeus, a subject to which some Dutch students have already devoted attention. One of the first themes which seems suitable for this is concerned with the sources used by Linnaeus in these dissertations; this study has meanwhile been embarked upon.

The eigtheenth century was a period in which our knowledge of the world—and especially of the animate world—was rapidly growing. It was the era of longer and shorter expeditions for the exploration of unknown regions so as to find things new to science and useful for economy.

In this connection Linnaeus was active in two ways: by exploring his own country and by sending his students abroad to often very remote regions. These activities are also reflected in a number of zoological dissertations.

Thus, the dissertation *Instructio Peregrinatoris* (9) was intended as a guide for the young traveller to foreign countries. It contains a great deal of practical information (10), and it is described there, *inter alia,* how such a traveller is to behave abroad and how the journal is to be kept. In particular it is indicated what is worth recording, and the following practical advice is given: "If the traveller would be successful in his undertakings, he must make a point of entering and arranging the remarks of each day, before the next arrives" (from Pulteney, p. 426) (11).

The dissertation *Instructio Musei Rerum Naturalium* (12) describes the technique of assembling a collection of natural curiosities and gives directions on what objects should be collected and how this should be done. Furthermore, information is given about the way in which the objects should be exposed and preserved. This dissertation is further interesting because it contains a list of the principal collections of natural curiosities in Sweden.

Some of the dissertations appeared in the form of a kind of travel record, summing up the organisms observed during the journey. An example is the dissertation *Rariora Norvegiae* (13). The text begins with a *Historia literaria,* in which a historical survey of the exploration of Norway is given; this is followed by a list of animals and plants (14) which do occur in Norway, but are scarcely known, if at all, in Sweden. This list includes animals from all the Linnaean classes (15). A very special theme is the subject of the dissertation *Natura Pelagi* (16), which gives a general description of animal life in the open sea. The mammals described include several cetaceans; among the *Amphibia* there are som turtles, but also the shark called *Voraces Squali;* among the fishes there are mentioned, *inter alia,* the flying fishes, tunny, pilot fish, sucking fish, but also the dolphin. However, the majority of the animals described belong to the Linnaean class of the *Vermes;* great attention is devoted especially to the *Corallia.* This dissertation is also of interest on account of the numerous reports from books of travel incorporated in it.

Anders Sparrman, one of Linnaeus's best-known "apostles", like all the other apostles, is indeed known as a botanist, but his dissertation is largely devoted to zoology. In 1765 Sparrman went to China for two years as a ship's surgeon; this was also the most successful voyage ever undertaken by any naturalist under the auspices of the Swedish East India Company (17). Under the title *Iter in Chinam* (18) Sparrman gives an enumeration of the animals observed by him during that voyage, an enumeration which, however, is quite unsystematic. The description of newly discovered species is given very summarily in the form of footnotes.

The zoological objects collected were as a rule accommodated in so-called collections of natural curiosities. As will be stated elsewhere, Linnaeus became acquainted with these collections during his stay in the Netherlands (19), and after his return to Sweden he popularized the keeping of such collections there as well (20). It is interesting to note that the specimens in these Swedish collections largely originate from Holland; some attempts are now being made to ascertain the origin of this material. Thanks to his study of the royal collections (21) in particular, Linnaeus was able to extend his knowledge of zoology tremendously, as may be inferred, *inter alia,* from a comparison of the different editions of the *Systema Naturae.*

Four of the oldest zoological dissertations are concerned with the description of curious specimens from collections of natural curiosities. They are devoted to collections donated to Uppsala University, and they give accurate descriptions of a number of frequently common, but noticeable animals. These collections were donated by King Adolph Fredrik (22); by Claudius Grill, a collection coming fron Surinam (23); by Magnus Lagerström, director of the Swedish East India Company and one of the greatest promoters of natural history in Sweden (24); and by August Carl Gyllenborg, Chancellor of Uppsala University (25). In this last-mentioned dissertation a first attempt is made to derive the specific character of the various serpents not from the highly variable colour-pattern, but from the different numbers of the *scuta* and *squama* of the body and the tail (26).

Linnaeus's journeys were made not only for a scientific purpose but they also, and equally emphatically, had economic importance. It is especially this latter importance which was set forth by Linnaeus in his 1741 address: *De Necessitate Peregrinationum Intra Patriam,* the importance of travelling through one's own country (27). The prospective traveller—

the speaker was thinking of young doctors—is recommended to pay attention especially to the exploration of the natural resources of Sweden for the benefit of the whole nation, in order to make the country independent of other countries. Thus, local diseases should be described, along with the medicines used against them; the uses of newly found plants, either as medicine or as food for men or domestic animals, should be stated; agricultural methods should be studied, etc.

The well-known dissertation *Pan Svecicus* (28) is designed entirely on these lines. Its object is to ascertain which meadows in Sweden yield good, bad, or even toxic food for the commonest domestic animals, such as cows, goats, sheep, horses, and pigs. In the dissertation *Esca Avium Domesticarum* (29) it is studied what animals and plants respectively are eaten by geese, ducks, and chickens; in particular it is ascertained what species of lower animals are eaten by chickens.

Interesting features are the reflections on the comparability of the data and the difficulties involved in the experimental circumstances; attention is drawn to matters such as seasonal circumstances, the fact that certain parts of plants are and others are not consumed, that the animals must not be too hungry, etc.

An economic background is also present in two dissertations which appeared in 1766. In the first, entitled *Usus Historiae Naturalis in Vita Communi* (30), attention is drawn to the need of a growing knowledge of natural history for the improvement of agriculture, horticulture, and cattle breeding; to the uses of some plants and animals for therapeutic purposes; to useful and noxious insects, their significance for the equilibrium in nature, and the means that can be used for combating noxious insects. In the second dissertation, entitled *Necessita Promovendae Historiae Naturalis in Rossia* (31), a Russian nobleman tries to stimulate his compatriots to study the natural history of their native country. This dissertation contains, *inter alia,* a list of zoological objects present in the Museum Petropolitanum and biographical information about a number of scholars who had contributed to the knowledge of the natural history of Russia.

A number of dissertations are devoted to the lower animals. Although Linnaeus recommended his students to use a microscope, he himself only seldom made use of this instrument. This has had its consequences for the classification of the lower animals, for his group of the lowest animals, the *Vermes,* represents a very heterogeneous collection of animals; the only thing that can be said of it is that they belong neither to the vertebrates nor to the arthropods.

In the dissertations on the *Vermes* Linnaeus frequently appears as a man who corrects, ridicules, or praises other authors. This group of animals forms the subject of a special study.

The minutest organisms—even smaller than the motes dancing in a beam of light—according to Linnaeus were responsible for the origin and the transmission of contagious diseases. In two dissertations (32) he further developed this theory about the importance of the *Animalcula viva* for the origin of diseases and reckoned diseases such as whooping cough, smallpox, dysentery, plague, and leprosy among the diseases caused in this way: typical infectious diseases, which we now know to be transmitted by bacteria or viruses. The dissertations contain much information on seventeenth-century notions concerning the posibility that tiny animals might be the transmitters of diseases. This discussion became of current interest in particular after Antoni van Leeuwenhoek had discovered that scabies was caused by a tiny animal, the itch-mite (33).

Another phenomenon in which tiny animals play a part is the phosphorescence of the sea, a phenomenon to which the dissertation *Noctiluca Marina* is devoted (34). A survey of other views of this phenomenon is given.

The group of the *Vermes* is classified by Linnaeus according to fairly broad morphological criteria (35). Probably he carried out very little research on living animals and based himself especially on material from collections or from illustrations, as he admits more or less in the dissertation *Fundamenta Testaceologiae* (36). The *Testacea* in Linnaeus are largely identical with those animals we now call the *Mollusca* (37). The dissertation contains an account of Linnaeus's views on the classification of these animals and accurate descriptions of the structure of the shell; a list of conchyliological terms is added.

A good deal of attention is paid in several dissertations to the corals, to which Linnaeus's first zoological dissertation, the *Corallia Baltica* (38), was already devoted. One of the interesting aspects of this dissertation is that it contains a historical survey of all the writings that had so far appeared about these organisms. The author discusses in detail the question of whether the corals must be considered to belong to the vegetable or the animal kingdom or to the mineral kingdom; however, he does not consider himself competent to answer this question and refers to future research.

The problem of the nature of the corals is one of the main themes of the dissertation *Animalia composita* (39), in which it is stated that it is very difficult to draw absolute lines of demarcation between the three kingdoms of nature when one descends to the lowest organisms (40). Linnaeus makes a distinction between the *Lithophyta* and the *Zoophyta,* the former of which, in view of their calcareous skeleton, show much affinity on the one hand with the mineral kingdom and on the other hand with the *Testacea.* The *Zoophyta* according to Linnaeus show great affinity with the vegetable kingdom (41). Then a number of broad analogies between plants and animals are described, composite plants being compared with composite animals, the medulla of the plant with the *medulla spinalis* of the animal, etc.

In the dissertation *Mundus invisibilis* (42) Linnaeus developed the following theory about the *Lithophyta* and the *Zoophyta:* the *Zoophyta* in combination with the *Fungi* are in the boundary area between the vegetable and the animal kingdom. As to the *Fungi,* the young leave the seed in the form of animalcules and are then transformed into vegetable *Fungi.* As to the *Zoophyta,* they arise from plants in the form of animalcules; the growing stem belongs to the vegetable kingdom, the flower-like animal to the animal kingdom. According to Linnaeus this metamorphosis can be compared to the way in which leaves are transformed into petals. The taxon of the *Lithophyta,* finally, according to Linnaeus consists of animalcules which build a house. When they live together as families, they form colonies of corals.

On two species of worms a monograph has been written as a dissertation. The first deals with the tapeworm (43), and four species of *Taenia* are described. Then the author discourses on whether the head of the tapeworm can or cannot be compared to that of other animals and whether each of the segments of a tapeworm consists of a complete animal (44). A survey of the theories concerning the reproduction of these worms is given. Finally the dissertation contains an attempt at subdividing the *Vermes* into the *Mollusca,* the *Testacea,* the *Lithophyta,* the *Zoophyta* (44), and the creeping worms. The second monograph is devoted to the leech (45). In addition to a discussion of its anatomy, its medicinal use, etc. a historical survey is given of the different views of this animal since Antiquity (46).

Until shortly before Linnaeus the study of the world of insects had been very unattractive, because scholars—in imitation of Aristotle—assumed that the lower animals arose as a result of spontaneous generation. It was assumed that they were generated in infinite numbers and that their outward form was not subject to any laws.

After Redi had shown that flies are only generated by flies, after

Antoni van Leeuwenhoek had shown that even the most inconsiderable insects have a highly complicated anatomical structure and that—just like the higher animals—they reproduce sexually, and after Jan Swammerdam had shown that different groups of insects can be distinguished on the basis of the progress of their metamorphosis, the road for further entomological research was open.

More than anyone else Linnaeus contributed to the development of entomology, and this is reflected very plainly in the dissertation *Fundamenta Entomologiae* (47).

In the dissertation it is stated that the seventeenth and eighteenth centuries saw an explosive increase of our entomological knowledge, in consequence of new geographical discoveries, of the assembling of collections of natural curiosities, and of the publication of pictures of insects (48). Although Linnaeus did not speak very highly of his predecessors, still he borrowed a good deal from other authors, and in this dissertation he gives a chronological list of the most important entomological literature published before his time. His predecessors, however, had not succeeded in giving a clear description of the outer structure of the body of insects, so that it was impossible to compare them with each other; moreover, there existed a complete chaos in the matter of nomenclature. Both these aspects were disposed of by Linnaeus in this dissertation, and this goes to show his importance for the development of entomology. Linnaeus gives a simple but at the same time plain and very logical terminology for the description of insects. Unfortunately he does not always mention the sources from which he has taken the terms used by him; it is, however, certain that he has introduced a number of terms, such as larva, pupa, etc., terms which are still in general use. A more detailed analysis of this terminology appears to be very interesting, especially from a historical point of view (49).

After the definition of the terms used by him, Linnaeus gives the classification of the class of the *Insecta* into the following orders: *Coleoptera* (50), *Hemiptera, Lepidoptera, Neuroptera, Hymenoptera, Diptera,* and *Aptera.* The order of the *Aptera* combined the most heterogeneous elements, such as spiders, myriapods, crustaceans, and wingless insects.

The rich contents of this dissertation is supplemented with a number of very interesting data and suggestions, *e.g.* on the combating of insects with the aid of their natural enemies; on the risk that, when a plant one wants to grow is imported, at the same time the noxious insect feeding on that plant may be imported; on the possible role of insects in the fertilization of plants; on the nidification of some tropical ants; and on the location, the structure, and the function of the sense-organs in insects.

Via his pupils Linnaeus received numerous insects from remote parts of the world. The dissertation *Centuria Insectorum Rariorum* (51) contains descriptions of one hundred insects which were largely unknown in those days and which had been sent from the New World. The last zoological dissertation written under Linnaeus's direction contains descriptions of two new genera, one belonging to the order of the *Diptera,* the other to that of the *Coleoptera* (52).

Linnaeus's contribution to entomology, however, did not remain confined to the systematic and taxonomic aspects (52). Already in his *Oratio de Memorabilibus in Insectis* (54) (On the Curiosities of Insects) of 1739 Linnaeus tried to rouse the interest of scholars in this group of animals by pointing out on the one hand the many useful things with which they provide mankind, while showing on the other hand what damage they can cause to property and to the economy. An investigation into the role which insects play according to Linnaeus in the equilibrium of nature would appear to be of interest. A part of this problem is formed by the question how far these dissertations shed new light on such problems and how far older sources have been borrowed from.

Three dissertations are concerned with the occurrence of insects on plants and the damage they cause by it (55). They contain on the one hand lists of plants and on the other hand lists of those insects which occur on those plants. One of these dissertations, the *Hospita Insectorum Flora,* contains a historical survey of the principal authors who have written on the metamorphosis of insects and on the role of insects in the economy of nature. Another dissertation, the *Pandora Insectorum,* gives many details on the progress of the metamorphosis of insects and on those parts of the plant which are visited by the various insects (56).

The dissertation *Noxa Insectorum* (57) goes further into the many possible forms of damage which insects may cause to man's body, his house, garden, fields, trees, cattle, poultry, etc. The forms of damage described are also elucidated from a historical point of view. The dissertation *Miracula Insectorum* (58) is concerned in more general terms with the role of insects in the economy of nature, special attention being paid to the gall-producing insects. The author discusses a number of plant genera which are extremely susceptible to gall production, and he states that most galls on plants have a characteristic form. The dissertation also contains a long discourse on *Furia infernalis,* the insect which was said to have caused the outbreak of the plague in Finland and Northern Sweden.

As to the uses of insects for mankind, Linnaeus refers to matters such as the production of honey (59) and the role of the insect in the fertilization of plants (60). On the importance of insects in medicine there exists a monograph, *De Meloë* (61), on the oil beetle as a supplier of cantharidin, which is used in the manufacture of blistering-plasters.

The silkworm is treated in a second monograph, *Phalaena Bombyx* (62) with detailed information on rearing and on the introduction of silk-farming into Sweden.

Not a single dissertation pays special attention to fishes; they are only referred to obliquely in dissertations devoted to one of the collections.

The same applies broadly also to the *Amphibia*, among which Linnaeus also reckoned the *Reptilia*, although he did lay the basis for the classification of this group of animals (63). A survey of the whole taxon is given in the dissertation *Morsura Serpentum* (64), a dissertation which is really devoted to snake-poison, its production, its secretion and effect, and to the measures that should be taken against snakebites.

One monograph was devoted to the neotenic *Siren lacertina* (65) from North Carolina, which lives in mud. Linnaeus was not sure whether he had to call this animal with its exterior gills a larval stage or an adult animal.

The basis of Linnaeus's ornithology was laid down in the dissertation *Fundamenta Ornithologica* (66). In this context it is worth noting that Linnaeus discovered that the feathers of birds are arranged in particular patterns (67). The dissertation opens with a *Historia literaria ornithologorum* with a good deal of historical information, and it also includes a chapter with biographical sketches of ornithologists. In addition information is given about matters such as the importance of birds in nutrition, in the economy of nature, as weather-prophets, and as objects of beauty and delight in the life of man.

Bird migration is the subject of another dissertation (68); in this case it is striking how much Linnaeus knew about the migration of indigenous Swedish birds. He considered lack of food in the breeding grounds to be the principal cause of migration. The return of the birds was more difficult to account for: Linnaeus assumed that the high temperatures in the hibernating areas, combined with a kind of love of the birthplace, were the main incentives. It is striking that this dissertation, in addition to the great amount of exact information, also shows traces of old popular beliefs. Thus Linnaeus still believed that swallows hibernate on the bottom of the Swedish lakes, a popular belief held since the days of Aristotle.

Linnaeus's monographs on a number of mammals excel in the accurate description of anatomical details and vivid characterizations, especially of behaviour. A good instance of this is the dissertation on the dog: *Cynographia* (69), in which Linnaeus succeeded in showing that all dog-breeds belong to one species, *Canis familiaris*. He was able to distinguish this species clearly from related animals, such as the wolf, the fox, the jackal, etc., on the basis of differences in behaviour and in hair implantation.

The remaining monographs also deal with domestic animals: the reindeer, *Cervus Rheno* (70), in which particularly the usefulness of the animal for man is expatiated upon; the sheep, *Oves Breviter Adnumbrans* (71), including many data on its food and its diseases, especially with reference to the liver-fluke; Guinea pig, *De Mure Indico* (72), including a historical survey of the order of the rodents; the pig, *De Pinguedine Animali* (73), including an account of its economic importance, its food, movements, behaviour, diseases, excrements, colour, etc.

In the days of Linnaeus the knowledge of the anatomy of mammals was still insufficiently developed for it to serve as a basis for the classification of this taxon. An attempt at classification of the highest representatives of this taxon is to be found in the dissertation *Anthropomorpha* (74), a study dealing with the position of man in the natural system. Linnaeus held that man is hardly to be distinguished from the apes on the basis of exterior features. The dissertation contains many examples of human beings and their properties, who grew up among animals. Linnaeus's conceptions of man recently formed the subject of a detailed study by Dr. Broberg, to which I am pleased to refer, although this work is difficult of access, because it is written in the Swedish language (75).

Since a number of the theoretical and speculative dissertations are to be included in the reprint among the zoological dissertations, I would devote a few words to this group.

As to the theoretical dissertations, in the *Metamorphosis Humana* (76) man's life is divided into 12 periods, on the analogy of the 12 hours of the day and the 12 months of the year. The properties characteristic of each period are described, along with the regimen appropriate to that period. The dissertation Generatio Ambigena (77) deals with the problem of spontaneous generation. It contains a discussion on the controversy between the ovulists and the animalculists; Linnaeus refers to

Leeuwenhoek and states that both the exterior form and the specific energy of the vital functions primarily originate from the male component. As Aurivillius states, Linnaeus also makes an attempt in this dissertation to show, on the basis of hybridization experiments between species of the same genus, that all species belonging to one natural genus originate from the same initial species. This may lead to the conclusion that the number of original species need not have been greater than the number of natural genera (78).

In the speculative dissertations it is set forth that, according to Linnaeus, the three kingdoms of nature have been created solely for the benefit of man, since it is given to him alone to use living nature for his benefit. Moreover, according to Linnaeus it was the duty of man to study the works of nature, to the greater glory of his Creator. This must also be regarded as accounting for the fact that man is gifted with reason; the variety of nature serves to stimulate his curiosity and incite him to study natural history.

There are four of these speculative dissertations. *Cui Bono* (79) (What is the good of it?) contains the familiar suggestion to use carnivorous insects to combat their noxious congeners (80). In *Curiositas Naturalis* (81) the central problem is man as a part of Creation; in this it is also stated in what way the Book of Creation should be read. According to Linnaeus the study of nature must lead automatically to knowledge of God, and the study of natural history should therefore be considered as one of the most important occupations of the human mind. In the *Politia Naturae* (82) the problems of equilibrium and struggle for life in nature are illustrated by means of examples taken from the interrelations between plants and insects. It is explained that in nature everything is connected with everything else, and that each organism has its own specific significance within the whole system. In the dissertation *Oeconomia Naturae* (83), finally, the cycles within the mineral, vegetable, and animal kingdoms are discussed, and general biological concepts such as design in nature, cycles, reproduction, adaptation, dispersion, struggle for existence, etc. are discussed.

Notes and references

1. Quoted by Goerke, p. 132, after Afzelius, A., 1826: Linnés eigenhändige Anzeichnungen über sich selbst mit Anmerkungen und Zusätzen (Berlin). (esp. p. 81). Goerke, H., 1966: *Carl von Linné.* (Grosse Naturforscher, Band

31) (Stuttgart). A very interesting Linnaeus biography, because it gives much information from Swedish sources.

2. The first edition of his Systema Naturae contains 549 species of animals, ed. 7: 1174; ed. 10 (1758): 4386; ed. 11 (1766): 5897. A great part of these animals was described by Linnaeus himself.
3. Cf. Soulsby, B. H., 1933: *A catalogue of the works of Linnaeus* ... preserved in the libraries of the British Museum and the British Museum (Natural History), ed. 2, 246 p. (London).
4. The dissertations appeared as independent pamphlets, bearing the name of the pupil as the respondent and the name of Linnaeus as the president.
5. The *Amoenitates academicae* appeared between 1749 and 1790 in 10 vols. During Linnaeus' lifetime already 7 vols. were published between 1749 and 1769 (Linnaeus-edition). After his death 3 more volumes were added, containing those dissertations which appeared after 1768 (Schreber edition).
6. Although Linnaeus must have had a great influence on the dissertations of his pupils, it remains impossible to trace exactly what has been the input of the defendant and what are Linnaeus's own words. On account of style and contents, it seems likely, that in the majority of the dissertations the student's share has been financial only, but sometimes the input of the student might have been somewhat greater and in some cases the student even may be considered as the author and the professor as the editor. Cf. Stearn, W. T., 1957: *An introduction to the Species Plantarum and cognate botanical works of Linnaeus,* 176 p. (London); and Ramsbottom, J., 1959: Caroli Linnaei Pan Suecicus (*Trans. Bot. Soc. Edinburgh* vol. 38: 151–167).
7. Of course, it is not always easy to decide whether dissertation has to be included in the zoological or in the botanical part. For practial reasons, all the entomological and the greater part of the contemplative dissertations have been included in the zoological series. The botanical volumes are to be edited by F. A. Stafleu, the zoological volumes by P. Smit.
8. For instance, publications on type-specimens of snakes, birds and reptiles; on Linnaean collections of shells, fishes, snakes, Amphibia, non-marine Mollusca, etc.; on the species of Lepidoptera, Echinoidea, etc. described by Linnaeus, etc. For a review, see, e.g. Soulsby, l.c. and some titles in the list of references of W. Blunt's *The compleat naturalist: a life of Linnaeus.* (London, 1971.)
9. Nordblad, Ericus And., 1759: *Instructio Peregrinatoris,* cf. Soulsby, 2022-2029.
10. In his public oration of 1741, dealing with the importance of travelling through one's own country (De necessitate peregrinationum intra patriam), Linnaeus gives a lot of practical information. So the traveller had to pay attention to such matters as: the exploration of the natural resources; local diseases and the remedies employed; agricultural implements, the way of manuring the fields, etc.
11. Pulteney, R., 1805: *A general view of the writings of Linnaeus,* 596 p. (London). Also in French: *Revue générale des Ecrits de Linné,* 2 vols. (Paris, 1789).

12. Hultman, David, 1753: *Instructio Musei Rerum Naturalium,* cf. Soulsby, 1770–1778. German translation: Murr, C. G. von, ed., 1771: *Abhandlung von Naturalien Cabinetten,* 72 p. (Leipzig). Pulteney, l.c., p. 392 writes: "This little tract has been published in Holland for the use of merchants dealing in subjects of natural history." Up to now it is not clear whether a Dutch translation exists.
13. Tonning, Henricus, 1768: *Rariora Norvegiae,* cf. Soulsby, 2381–2384.
14. The list of plants contains a number of alpine plants, not known of the Swedish flora. The dissertation also contains a section devoted to Lichen islandicus and its medical application; this is the subject of A. H. Berlin's dissertation: *Usus Muscorum* (1766).
15. According to Tönning, leprosy should be caused by the Hair worm (Gordus aquaticus); cf. I. Uddman's dissertation: *Lepra* (1763).
16. Hagen, Johannes Henricus, 1757: *Natura Pelagi,* cf. Soulsby, 1962–1965.
17. Cf. my address on Linnaeus and Holland (also delivered at the symposium).
18. Sparrman, Anders, 1968: *Iter in Chinam,* cf. Soulsby, 2393–2396.
19. The most important and most extensive cabinet visited by Linnaeus during his stay in Holland is that of Albert Seba. In my paper on Linnaeus and Holland more details have been given.
20. "Linnaeus (wrote Linnaeus) had brought natural history in Sweden from the lowest place to the very highest, because it was loved and cultivated by the great in the land, and even by royalty." (Quoted after Blunt, l.c., p. 205.)
21. Among the most famous and extensive Swedish collections were those of King Adolph Fredrik and of Queen Louisa Ulrike. The King's collection was described by Linnaeus in 1754: *Museum S. R. M. Adolphi Friderici;* it is the first work in which Linnaeus used the binominal nomenclature. The catalogue of the queen's collection appeared in 1764: *Museum S. R. M. Ludovicae Ulricae* a substantial catalogue of 720 pages, of which about two-thirds are devoted to the Insecta.
22. Balk, Laurentius, 1746: *Museum Adolpho Fridericianum,* cf. Soulsby, 1443–1446. The greater part of this dissertation is devoted to the Linnean class of the Amphibia and gives excellent descriptions of Chamaeleon, rattlesnake, and Amphisbaena. Some Rana-, Testudo-, Lacerta- and Coluber species have been described. Also descriptions of, e.g., the marsupial Didelphus, the armadillo, the squid Sepia officinalis and the nudibranch Aphrodita aculeata. Interesting are the references to Seba's Thesaurus.
23. Sundius, Petrus, 1748: *Surinamensis Grilliana,* cf. Soulsby, 1486–1489. Descriptions of 26 zoological specimens, collected at Surinam by M. Gerret—a Surinam missionary—and sent to Mr Clas Grill of Stockholm.
24. Odhelius, Johannes Laurentius, 1754: *Chinensia Lagerströmiana,* cf. Soulsby, 1844–1847. Magnus Lagerström fostered, that to each vessel of the Swedish East-India Company, a naturalist has been added for exploration purposes. He was an ardent collector of natural curiosities, particularly from China and the East Indies.
25. Hast, Barth. Rudolph, 1745: *Amphibia Gyllenborgiana,* cf. Soulsby, 1413–1416. This dissertation is the first specimen of Linnaeus's method of de-

scription. The collection consists of rare Amphibia, Insecta, corals and minerals.

26. Of these four dissertations, three were published before the *Museum Adolphi Friderici* (1754) and consequently do not adopt the Linnaean binomial nomenclature, but follow the traditional custom by giving a genus name followed by a short description of the main characteristics.
27. Linnaeus's second public oration, delivered at the occasion of his appointment to the post of professor in anatomy and medicine at Uppsala University on October 27, 1741. Cf. Soulsby, 1354–1368. English translation in: Stillingfleet, B., 1759: *Miscellaneous tracts relating to natural history, husbandry, and physick, with notes.* (London), p. 1–30.
28. Hesselgren, Nicolaus L., 1749: *Pan Svecicus*, cf. Soulsby 1565–1584[a]. English translation: The Swedish Pan, cf. Stillingfleet, l.c., p. 184–210; also: Ramsbottom, cf. note 6. Also in French: Buc'hoz, P. J., ed., 1801: Pan Suecus, in: *Traité, ou Manuel vétérinaire des plants, qui peuvent servir de nourriture et de médicamens aux animaux domestiques,* ed. 2, part 3, p. 311–345. German translation in Hoepfner, E. J. T., 1776–1778: *Des Ritters Carl von Linné auserlesene Abhandlungen aus der Naturgeschichte, Physik und Arzneywissenschaft,* 3 vols. (Leipzig), vol. III, p. 271–331.
29. Holmberger, Petrus, 1774: *Esca Avium Domesticarum,* cf. Soulsby, 2432–2433. Supplementary to these observations of Hesselgren and Holmberger is P. G. Tengmalm's study: *Pan Suecus emendatus et auctus,* published in the Amoenitates, vol. 10, no. 1, Appendix, p. 132–172.
30. Aphonin, Mattheus, 1766: *Usus Historiae Naturalis,* cf. Soulsby, 2329–2334. English translation in: Brand, F. J., 1781: *Select dissertations from the Amoenitates academicae:* a supplement to Mr Stillingfleet's tracts, relating to natural history (London), p. 1–70. German translation by I. K. H. Boerner, 1774, in *Sammlungen aus der Naturgeschichte,* vol. 1: 76–156. Aphonin's dissertation gives a review of a great number of earlier theses dealing with the same subjects.
31. Karamyschew, Alexander de, 1766 (1764): *Necessitas Historiae Naturalis Rossiae,* cf. Soulsby, 2259; 2323–2328. This dissertation also contains a list of Siberian plants, extracted from some manuscripts in the possession of Linnaeus.
32. Nyander Johannes C., 1757: Exanthemata viva, cf. Soulsby, 1970–1973. Roos, Johannes Carolus, 1767: *Mundus invisibilis,* cf. Soulsby, 2348–2352. Hult, O. T., 1934/'35: Om Linné och den osynliga världen. (*Svenska L. Årsskr.* 17: 118–128; 18: 16–22.) (Quoted after Goerke.) Cf. also the dissertation of Sidrén, Jonas, 1750: *Materia Medica in Regno Animali,* Cf. Soulsby, 1605–1611. The greater part of the dissertation Mundus invisibilis deals with the question, whether the dust of Fungi should be very small animals or not, for doubts had arisen whence Fungi should be arranged in the plant or in the animal kingdom.
33. The author is convinced that a species of the genus Acarus causes dysentery and in the Systema Naturae this species is described as Acarus Dysenteriae.
34. Adler, Carolus Frid., 1752: *Noctiluca marina,* cf. Soulsby, 1673–1677.

Pulteney summarizes Adler's conclusions as follows: "Then it was found to be owing to an inconceivable number of these minute 'insects'. One of these insects is here completely described, with a figure, augmented by the microscope. It stands in the Systema under the name of Nereis noctiluca."

35. In the Systema Naturae, ed. 10, the Vermes have been divided in the following taxa:
Intestina: solitary animals, nude, without extremities.
Mollusca: solitary animals, nude, with extremities.
Testacea: solitary molluscs with calcareous shell.
Lithophyta: compound (in colonies living) Mollusca, building up a hard construction.
Zoophyta: growing plants with animal flowers.
36. Murray, Adolphus, 1771: *Fundamenta Testaceologiae,* cf. Soulsby, 2405–2410. German translation: Schröter, J. S., 1782: *Des Ritters Karl von Linné Termini Conchyliologici* (Weimar).
37. With Linnaeus, the Mollusca comprise a variety of animals, such as: *Nereis* (Annelida); *Sepia* (Mollusca); *Medusa* (Coelenterata); *Asterias* (Echnodermata). For his definition of the Mollusca, cf. note 35.
38. Fougt, Henricus, 1745: *Corallia Baltica,* cf. Soulsby, 1401–1412. English translation, cf. Brand, l.c., p. 457–480. German translation, cf. Hoepfner, l.c., vol. III, p. 89–126. Fougt's dissertation is the first study on corals of the Northern waters and a first attempt to classify them.
39. Bäck, Albertus, 1759: *Animalia composita,* cf. Soulsby, 2036–2039. The compound animals are characterized by being connected together by one common base or support.
40. It must be noticed, that the sponges are wanting in *Systema Naturae,* ed. 10. In the 12th edition they are classed in the taxon of the *Zoophyta.* The *Zoophyta* are classified as compound animals, which reveal themselves like plants; they can be divided in moving and sedentary animals. To the moving specimens belong, e.g., *Taenia, Volvox, Hydra.*
41. Whereas the *Animalia composita* propagate, not only by eggs, but also by budding, progressive extension and ramification, they seem to unite—according to Linnaeus—both the powers of the animal and the plant kingdoms.
42. Cf. note 32.
43. Dubois, Godofredus, 1748: *De Taenia,* cf. Soulsby, 1507–1513. German translation, cf. Hoepfner, l.c., vol. II, p. 101–140. As to the systematic position of this animal, cf. note 40.
44. According to the author, each internode should have its own mouth; probably he is mistaken by the opening of the uterus, lying on the ventral side of each internode.
45. Weser, Daniel, 1764: *De Hirudine,* cf. Soulsby, 2281–2284.
46. In the last edition of the *Systema Naturae* prepared by Linnaeus, 14 species of leeches have been enumerated.
47. Bladh, Andreas Johann, 1767: *Fundamenta Entomologiae,* cf. Soulsby, 2367–2371. English translation: Curtis, W., 1772: *Fundamenta Entomologiae or, An*

Introduction to the Knowledge of Insects, etc. (London). For a critical examination of Linnaeus's contributions to entomology, cf. Aurivillius p. 24 ff.

48. Mentioned are Maria S. Merian and Jac. Hoefnagel.
49. The names of the various body parts have been used consequently in the *Systema Naturae.* In the descriptions on species level some more terms have been used, not mentioned in this dissertation. According to Aurivillius, p. 29–30 it is striking that in Linnaeus's entomological system "mised genera" hardly occur.
50. With Linnaeus the order of Coleoptera included the *Orthoptera,* which later on were considered as an independent order; they differ in their metamorphosis.
51. Johansson, B., 1763: *Centuria Insectorum Rariorum,* cf. Soulsby, 2251–2254.
52. Dahl, Andreas, 1775: *Bigae Insectorum,* cf. Soulsby 2455–2456. Cf. also: Shillito, J. F., 1974: "Paradoxum insectum"—Linnaeus in Diopsis (Insecta: Diptera). (*Biol. J. Linn. Soc.* 6: 277–278.)
53. Linnaeus describes his interest in insect life in the following words: "Insects have been the greatest of my pleasures ever since I lived in Upsala as a young man in the years 1728–1734 and I devoted all my free time to collecting, studying and describing them." (After Bryk, F. 1924: *Linné als praktischer Entomologe.*) (Stockholm), p. 21.
54. Linnaeus, C., 1739: *Tal om märkwärdigheter uti insecterna,* cf. Soulsby, 1341–1353. English translation in Brand, l.c., p. 309–343. German translation Von den Merwürdigkeiten an den Insekten (*Allgem. Magazin der Natur, Kunst und Wissenschaften,* vol. 2, p. 328–353, 1753). It was Linnaeus's first public oration.
55. Forsskåhl, Jonas Gustav, 1752: *Hospita Insectorum Flora,* cf. Soulsby, 1707–1715. English translation in Brand, l.c., p. 345–368. French translation by Buc'hoz, l.c., part 3, p. 346–380. This dissertation particularly deals with the problem that some insects have certain food plants and he made a study of the damage these plants undergo by the insects. Rydbeck, Ericus Ol., 1758: *Pandora Insectorum,* cf. Soulsby, 2008–2012. This dissertation gives more detailed information about the parts of the plant on which the insects live, and about larval and pupal stages. Söderberg, Daniel Henr. 1771: *Pandora et Flora Rybyensis,* cf. Soulsby, 2303–2304. Probably this is one of the scarce dissertations written by the respondent himself.
56. Both in the *Fauna Suecica* and in the *Systema Naturae* for each herbivorous insect the plant on which it feeds is also mentioned. Further, Linnaeus has pointed out by means of examples that many insects feed on only one plant species, whilst other insects, in the absence of a particular plant, feed on another, and that sometimes it is even possible to get a hint, through insects, of the close relationship between two species of plants, despite great morphological differences (*cf.* also Aurivillius, l.c.).
57. Baeckner, Michaël, A., 1752: *Noxa Insectorum,* cf. Soulsby, 1829–1738. English translation in Brand, l.c., p. 369–411. German translation in Bryk, F. ed., 1924: *Linné's gesammelte Schriften entomologischen Inhaltes,* p. 49–66. This dissertation has served as an example for forthcoming dissertations in the

field of applied entomology. It consists of eleven sections, each considering one of the ways in which insects cause damage to Man. It contains descriptions of the most common insects in house and garden. It gives for many animals the relevant passages in Linnaeus's own writings.

58. Avelin, Gabriel Emanuel, 1752: *Miracula Insectorum,* cf. Soulsby 1722–1728. English translation in Brand, l.c., p. 413–436. German translation in *Allgemeines Magazin der Natur, Kunst und Wissenschaften,* vol. 9., p. 321–350.
59. The production of honey has never been the central theme of one of the Linnean dissertations, but has been the subject of a prize-essay, entitled *Pan Apum,* written by J. O. Hagström, one of Linnaeus's pupils.
60. The problem of the fecundity of plants was discussed, for instance, in G. Hegard's dissertation *De Ficu,* 1744, cf. Soulsby 1389–1394; and in J. G. Wahlbom's dissertation *Sponsalia Plantarum,* 1746, cf. Soulsby, 1447–1460; and in B. M. Hall's dissertation *Nectaria Florum,* 1762, cf. Soulsby, 2206–2213. German translations of the relevant passages in Bryk, l.c., p. 34–37.
61. Lenaeus, Canutus Aug., 1762: *De Meloë vesicatorio,* cf. Soulsby 2219–2222. Many arguments have been summed up to prove that the Clinese species *Meloë Cichorii* is the true *Cantharis* of Dioscorides. Cantharidin is normally derived of the Spanish fly (*Cantharis vesicatoria*).
62. Lyman, Johannes, 1756: *De Phalaena Bombyce,* cf. Soulsby 1931–1935.
63. Linnaeus himself seems to have had little interest in this group, for in the tenth edition of his Systema Naturae he speaks of "These foul and loathsome animals, . . . abhorrent because of their odd body, their offensive smell, terrible venom, etc., so that their Creator has not extered his powers (to create) many of them". Cf. Porter, K. R., 1972: *Herpetology,* p. 1–4. (Philadelphia.)
64. Acrell, Joh. Gustavus, 1762: *Morsura Serpentum,* cf. Soulsby, 2169–2173. English translation by Brand, l.c., p. 265–308. Two more dissertations deal with the venomous bites of serpents, viz., those of J. A. Darelius and of J. Kiernander. Darelius, Johannes Andr., 1749: *Lignum colubrinum,* cf. Soulsby, 1531–1537. German translation: Hoepfner, vol. III, p. 216–240. Kiernander, Jonas, 1749: *Radix Senega,* cf. Soulsby, 1545–1554. German translation: Hoepfner, l.c., vol. III, p. 152–174. Full botanical and medical account of the plant *Polygala Senega,* or milk-wort.
65. Österdam, Abrahamus, 1766: *Siren lacertina,* cf. Soulsby, 2335–2338. Cf. also: Lönnberg, E., 1909: Carl von Linné und die Lehre von den Wirbeltieren esp. p. 39 (Jena).
66. Bäckman, Andreas Petrus, 1765: *Fundamenta Ornithologica,* cf. Soulsby, 2285–2288.
67. This discovery induced Linnaeus to constitute the science of pterography.
68. Ekmarck, Carolus Dan, 1757: *Migrationes Avium,* cf. Soulsby, 1936–1942. English translation: Brand, l.c., p. 215–263. German translation: Hoepfner, l.c., vol. II, p. 269–309. In this dissertation the author has brought together all the then known species of migratory birds, whether exotic or indigenous in Sweden. Much information on the time of migration, the places where food is to be found, etc. Linnaeus also explains that some birds can pass the

winter, because they can find their food even under the most severe circumstances, such as the woodpecker. The author is remarkably well informed in the migration routes for about 100 species of birds.

69. Lindecrantz, Ericus, 1753: *Cynographia,* cf. Soulsby, 1793–1798. Appeared in the Amoenitates under the title *Canis familiaris.*
70. Hoffberg, Carolus Frid., 1754: *Cervus Rheno,* cf. Soulsby, 1823–1827. Appeared in the Amoenitates under the title *Cervus tarandus.* English translation in Brand, l.c., p. 167–214.
71. Palmaerus, Isacus, 1754: *Oves breviter adnumbrans,* cf. Soulsby, 1828–1831. Appeared in the Amoenitates under the title *Ovis.* The dissertation contains a list of 140 plant species which sheep do not eat; some of the plants are highly noxious or even poisonous.
72. Nauman, Johan Justus, 1754: *De Mure Indico,* cf. Soulsby, 1833–1837. Appeared in the Amoenitates under the title *Mus porcellus.* German translation in Hoepfner l.c., vol. I, p. 135–154. As to the use of guinea pigs, we read, that they afford pleasure and that they are very delicious when prepared for dinner.
73. Lindh, Jacobus, 1759: *De Pinguedine Animali,* cf. Soulsby, 2100–2103. Appeared in the Amoenitates under the title Sus scrofa.
74. Hoppius, Christianus Emmanuel, 1760: *Anthropomorpha,* cf. Soulsby, 2124–2129. German translation in Hoepfner, vol. I, p. 57–70.
75. Broberg, G., 1975: *Homo sapiens L. Studier i Carl von Linnés naturuppfattning och människolära,* 320 p. (Lychnos-Bibliothek). English summary, 287–293, extensive bibliography, p. 294–314 and Index.
76. Wadström, J. A., 1767: *Metamorphosis Humana,* cf. Soulsby, 2372–2375.
77. Ramström, Christianus Lud., 1759: *Generatio Ambigena,* cf. Soulsby, 2082-2086.
78. Cf. Aurivillius, l.c., p. 41.
79. Gedner, Christophorus, 1752: *Questio historico naturalis: Cui Bono?*, Soulsby, 1691–1706. English translation in Stillingfleet, l.c., p. 128–162. German translation in Hoepfner, l.c., vol. I, p. 109–134.
80. German translation of the relevant passage in Bryk, l.c., p. 48.
81. Söderberg, Olaus, 1748: *Curiositas Naturalis,* cf. Soulsby, 1500–1506 a. This dissertation aroused a storm of criticism from the side of the theologians, cf. Hagberg, K., 1964: *Carl Linnaeus. De bloemenkoning,* p. 218–219. (Amsterdam.) French translation in Jasmin, B., ed., 1972: C. Linné. L'équilibre de la nature, p. 125–144. German translation in Hoepfner, l.c., vol. III, p. 127–151.
82. Wilcke, H. Christ. Daniel, 1760: *Politia Naturae,* cf. Soulsby, 2104–2110. English translation in Brand, l.c., p. 129–166. French translation in Jasmin, l.c., p. 103–122. German translation of the entomological passages in Bryk, F. 1924: *Linné's gesammelte Schriften entomologischen Inhaltes,* p. 71–76.
83. Biberg, Isaac J., 1749: *Oeconomia Naturae,* cf. Soulsby, 1514–1530. English translation in Stillingfleet, l.c., p. 31–108. French translation in Pulteney, l.c., vol. 2, p. 216–297, and in Jasmin, l.c., p. 57–102. German translation in Hoepfner, l.c. vol, II, p. 1–56, and for the entomological parts in Bryk, l.c., (note 82), p. 41–47.

JAMES F. SHILLITO

Linnaeus—Zoology in the last years

Introduction: The scientific climate circa 1770

The publication of the Twelfth Edition of Systema Naturae, completed by its third zoological addendum in 1768, was perhaps the climax of Linnaeus' career as a zoologist, at least as far as his publications indicate, but his unpublished notes, preserved in the Strong-Room Collection at Burlington House, tell a different story.

The last ten years of his life coincided with an era of World Exploration in which "Naturalists", many of them Linnaeus' "Apostles", played quite an important part, though all too often their Zoology has been over-shadowed by their Botany.

It was about this time that Lt. James Cook was setting out on his first circum-navigation in Endeavour, and with Banks and Solander to discover the "Kanguru". Peter Simon Pallas, with his companions, was likewise sent by Catherine the Great to explore Siberia and other parts of her Empire.

In Sweden, Carl Wilhelm Scheele was experimenting with "Fire Air" and Linnaeus' friend, the Baron Charles De Geer was compiling his volume of *Mémoires* ... on insects.

In England, Gilbert White in his earlier Selborne Letters, was discussing with Thomas Pennant the nicer points of *British Zoology* and sharing with Barrington—not very convincingly it seems—information on the migrations of birds, quoting observations made by his brother John, then Chaplain at Gibraltar. Some of these letters appeared in *Philosophical Transactions* (1774–75).

John Fothergill, supported by Peter Collinson, had become a leading figure in medico-scientific London, sending many plants and insects to Linnaeus from his collectors, sharing his shell collection with the Duchess of Portland, his insect cabinet with Dru Drury for the illustrations of his volumes of *Exotica* (1770–73/82).

In America, his opposite number Dr Alexander Garden—as a naturalist another protégé of Charles Alston and therefore in the

Boerhaave Succesion—was a prominent physician in Charles Town, South Carolina, at that time still a colony of George III and the habitat of many curious creatures, as Mark Catesby had shown earlier. After his American experiments on lightning, Benjamin Franklin in London succeeded in directing Joseph Priestley to the study of Science, and in this Fothergill too added his support.

So in the early seventies, we find on all sides a wealth of scientific activity, Cook departing in *Resolution* on his second great voyage, taking with him Reinhold Forster and his son Georg, to meet Linnaeus' Apostle: Anders Sparrman at the Cape of Good Hope. There too they probably met Carl Peter Thunberg, later to be the successor of the younger Linnaeus at Uppsala. The biological results of Cook's voyages have been analysed by Whitehead (1969) while his first voyage was recorded fully by Hawkesworth (1773).

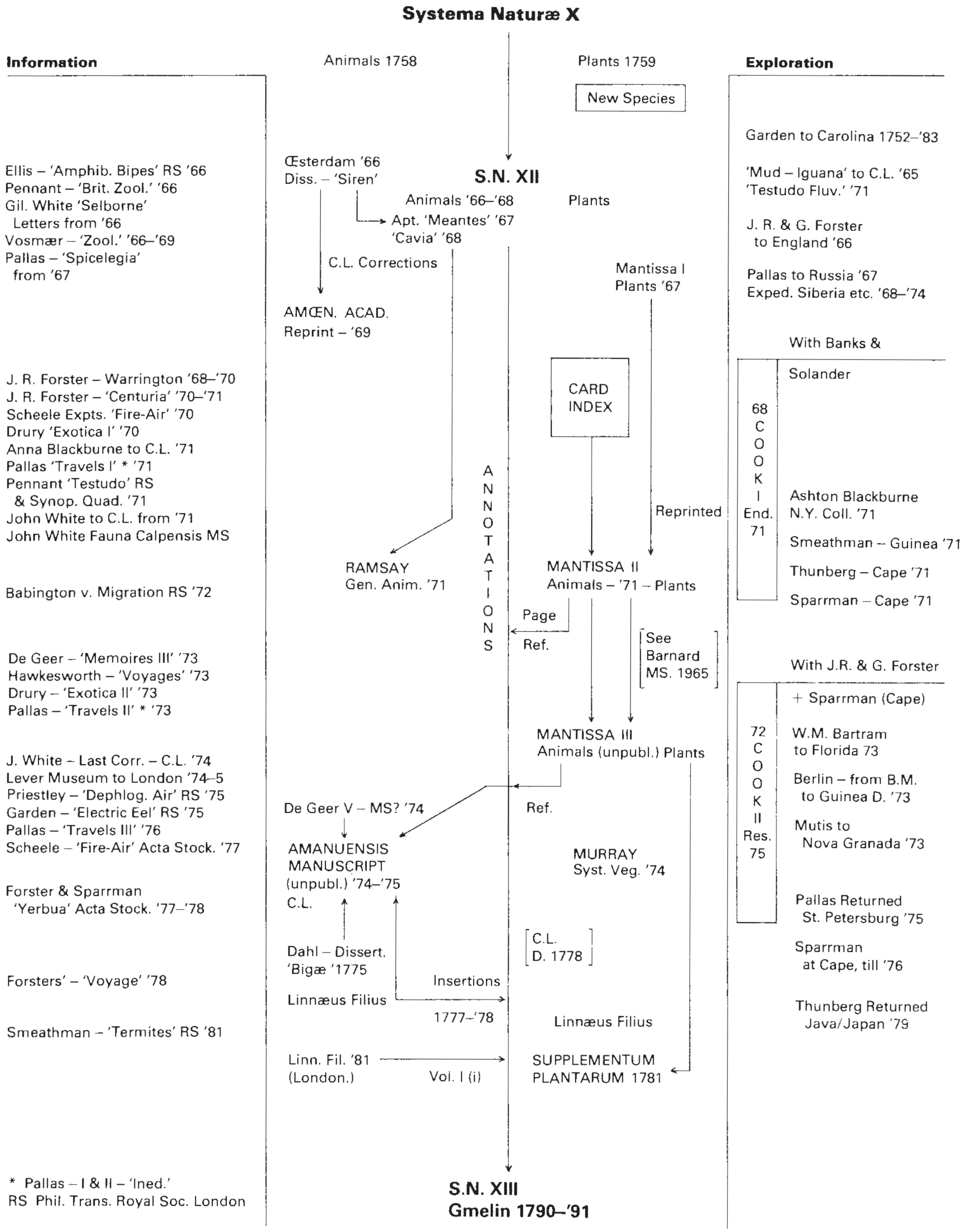
Priestley, who denied the post of Astronomer to Cook, stayed in Leeds to discover "Dephlogisticated Air"—or oxygen—independently but after Scheele in Stockholm, even if, thanks to "Phlogiston", they were both theoretically wrong. It seems that J. R. Forster borrowed their errors to explain how birds fly.

Fothergill, Banks and some others sponsored a voyage of Henry Smeathman on the Guinea Coast of Africa, so to lay the foundations of Sierra Leone as a Colony. There most unfortunately he was deprived of the well-qualified assistance of Andreas Berlin, who tragically died on the Isle of Delos on his voyage out from the British Museum in 1773; neither Linnaeus nor Fothergill lived to see the publication of Smeathman's classical paper on Termites in *Philosophical Transactions* (1781).

Another exploration supported by Fothergill was the famous pioneer journey of William Bartram, son of "Old John", who himself had been responsible for so many plant introductions to Europe through Peter Collinson and his Friends, and also of course to Linnaeus.

When, in due course, the Reverend John White returned from Gibraltar to become Vicar of Blackburn, he was encouraged by Gilbert to get his "Fauna Calpensis" printed by their youngest brother Benjamin. Of this project Linnaeus wrote: "*Fauna* tua *Calpensis* esset et mihi et omnibus exoptatissima". It is not very clear just why this "most desirable" book failed to get published and so a valuable contemporary manuscript was mysteriously lost, only the "Introduction" surviving to be reproduced by the Selborne Society in 1913.

Benjamin White might also have secured the publication rights of


Systema Naturæ X
Information
Animals 1758
Plants 1759
Exploration
New Species
Garden to Carolina 1752–'83
Ellis – 'Amphib. Bipes' RS '66
Pennant – 'Brit. Zool.' '66
Gil. White 'Selborne' Letters from '66
Vosmær – 'Zool.' '66–'69
Pallas – 'Spicelegia' from '67
Œsterdam '66
Diss. – 'Siren'
S.N. XII
Animals '66–'68
Plants
Apt. 'Meantes' '67
'Cavia' '68
C.L. Corrections
'Mud – Iguana' to C.L. '65
'Testudo Fluv.' '71
J. R. & G. Forster to England '66
Mantissa I
Plants '67
Pallas to Russia '67
Exped. Siberia etc. '68–'74
AMŒN. ACAD.
Reprint – '69
With Banks &
Solander
J. R. Forster – Warrington '68–'70
J. R. Forster – 'Centuria' '70–'71
Scheele Expts. 'Fire-Air' '70
Drury 'Exotica I' '70
Anna Blackburne to C.L. '71
Pallas 'Travels I' * '71
Pennant 'Testudo' RS & Synop. Quad. '71
John White to C.L. from '71
John White Fauna Calpensis MS
CARD INDEX
68 COOK I End. 71
ANNOTATIONS
Reprinted
Ashton Blackburne N.Y. Coll. '71
Smeathman – Guinea '71
Thunberg – Cape '71
Sparrman – Cape '71
RAMSAY
Gen. Anim. '71
MANTISSA II
Animals – '71 – Plants
Babington v. Migration RS '72
Page
Ref.
See Barnard MS. 1965
With J.R. & G. Forster
De Geer – 'Memoires III' '73
Hawkesworth – 'Voyages' '73
Drury – 'Exotica II' '73
Pallas – 'Travels II' * '73
+ Sparrman (Cape)
72 COOK II Res. 75
MANTISSA III
Animals (unpubl.) Plants
W.M. Bartram to Florida 73
J. White – Last Corr. – C.L. '74
Lever Museum to London '74–5
Priestley – 'Dephlog. Air' RS '75
Garden – 'Electric Eel' RS '75
Pallas – 'Travels III' '76
Scheele – 'Fire-Air' Acta Stock. '77
De Geer V – MS? '74
Ref.
Berlin – from B.M. to Guinea D. '73
Mutis to Nova Granada '73
AMANUENSIS MANUSCRIPT (unpubl.) '74–'75
C.L.
MURRAY
Syst. Veg. '74
Forster & Sparrman 'Yerbua' Acta Stock. '77–'78
Pallas Returned St. Petersburg '75
Dahl – Dissert. 'Bigæ '1775
C.L. D. 1778
Sparrman at Cape, till '76
Forsters' – 'Voyage' '78
Insertions
Linnæus Filius
1777–'78
Linnæus Filius
Thunberg Returned Java/Japan '79
Smeathman – 'Termites' RS '81
Linn. Fil. '81 (London.)
Vol. I (i)
SUPPLEMENTUM PLANTARUM 1781
* Pallas – I & II – 'Ined.'
RS Phil. Trans. Royal Soc. London
S.N. XIII
Gmelin 1790–'91

some of Linnaeus' later editions, including quite probably the document which is the main subject of this paper.

It is important too not to overlook the then current situation at Warrington in Cheshire, where the "Dissenters' Academy" provided a centre of culture with freedom in learning for those barred from the Universities of Oxford and Cambridge. Priestley and Reinhold Forster were successively on the staff, giving lectures on (*inter alia*) "Experimental Philosophy" and incidentally writing many interesting works. Pennant was a visitor, John Blackburne and his daughter Anna (a correspondent of Linnaeus, and later Pallas) (Wystrach 1977) lived nearby as did also several members of the Fothergill family.

Sir Ashton Lever, related to the Blackburnes by marriage, had established his original Museum—the Holophysicon—not far away before it became the Leverian Museum in London, about 1774, and to be inspected by Linnaeus filius in due course.

Linnaeus—later zoology

From all these many sources, specimens were sent to Linnaeus in Uppsala to be entered variously, perhaps erratically, as major or minor additions to his own writings, or as marginal notes in other books in his library. It was from these notes that Linnaeus, as he wrote to John White on 2nd January, 1774, was "about to edit" a manuscript in which he would not neglect to make due acknowledgements to his many contributors.

We have therefore to consider the sources from which he was to compile this volume, and for this, apart from a few Dissertations, we have to rely on three sets of his writings, now preserved in the Strong-Room Collection at Burlington House. But one must enter one caveat: the manuscript names used here have not, and cannot have any priority under the International Code of Zoological Nomenclature.

It was only on the title page of Part II of the Annotated Volume in the first series that Linnaeus deleted *duodecima* to substitute above: *decima tertia*, so making clear his plan. Seemingly these volumes were so used by Gmelin for his eventual Edition XIII (1790), though it appears that he did not have access to the Amanuensis Manuscript.

According to Blunt (1971:228) Murray borrowed the interleaved plant volume when preparing *Systema Vegetabilium* for publication in 1774, but the present whereabouts of the volume or volumes does not seem to be

Table II. *Documentation—Linnaeus, 1766–1775*

I. ANNOTATED PERSONAL COPIES of SYSTEMA NATURAE, ED. XII bound in green leather—Shelf marks: 21/22. Vols. I, II & III—marked on spine: "LINN. ANNOT." Vol. 1 (Animalia) only—marked: "ANNOT. LINN."

Interleaved and bound in three parts. [I–L] ("Vertebrates", Insects & Vermes etc. respect.)

II. A series of descriptions—*a* "CARD-INDEX"-preparing for "Mantissae". [C–I]
   a. Species included in Mantissa II
   b. Species prepared for MS. of Mantissa III
   c. Species remained unselected.

III. The partly edited MANUSCRIPT of MANTISSA, III: Animalia, The "Amanuensis Manuscript" fide Arvid Hj. Uggla. [AM. MS.]

[II & III filed in STRONG-ROOM Burlington House, London under "UN. PAT. Zool."]

on record. A somewhat speculative conjecture leads me to suggest that, as Murray had undertaken a botanical revision, Linnaeus himself at that time might have been encouraged to transfer more of his attentions to advances in Zoology, in that year which was to prove so critical for him.

It might also be noted that the first part of I-L XII was additionally annotated by Linnaeus filius, who took this volume with him to the British Museum in London in 1781.

Linnaean "Mantissae"

The Uppsala tradition of adding supplements, or "Mantissae" to volumes of the Systema seems to have started after the Tenth Edition; the first "Mantissa Plantarum" (1767) being restricted to plants but the second volume, or "Mantissa altera" (1771), had one section devoted to descriptions of new animals.

Dr T. T. Barnard (1972) has traced the compilation of the plant sections of these volumes to a series of slips, found boxed in the Linnaean Miscellany. These had been described by Savage (1938) as: "Linnaeus's later method of keeping records of new species of both plants and animals."

Fortunately for me, Dr Barnard sorted out the animal slips, though it is much to be regretted that neither Amphibia nor Pisces parts have been traced; Coleoptera and Hemiptera are also missing *en bloc*, but whether these slips were re-used, borrowed for study or "just lost" is not known. In total rather less than one-third of the final entries have been traced to these slips, many others may not have been "carded" but entered straight from books.

The surviving descriptive slips, comparable with a modern card-index system of recording, fall into four categories:—

i. Entries traced to S.N. XII or to Mantissa II, but perhaps revised. From a note in I-L XII:274 opp. it can be seen that the final Entry 50: *TETRAO scoticus* [the Red Grouse] can be traced via a slip to *T. senegalus* of Mantissa II:526.

ii. Early entries which have been deleted, presumably re-written elsewhere. *PAUSUS paradoxus* (the only beetle represented at all) was deleted; Entry 14 in AM. MS. was given its final name: *P. microcephalus* and a different description.

iii. Descriptions apparently drawn up from specimens to hand, in one case: *CAVIA fossoria* (Dassow – Cape) we find: "oculorum vestigia in exsiccata non vidi" (also copied up in AM. Entry). These form the majority so far found, several showing corrections to names.

iv. Species apparently not selected for the final manuscript, perhaps of dubious status or of later origin. From Pennant, five species of birds in G. *FALCO* and a species of *MUS* which proves to be the Brown Rat, or *MUS decumanus* Linn. MS.

One additional function of this Card-Index may well have been to serve as a reservoir of problems, which, when satisfactorily researched by Linnaeus with his students, would serve for Dissertations. This might well explain the partnership of *Diopsis* and *Paussus* in Dahl's *Bigae Insectorum* for *on the slips*, both descriptions include as a summing-up: "Paradoxum insectum". A pair of paradoxa in fact.

Mantissa tertia: Animalia

It is now possible to consider in greater detail the surviving zoological text, the so-called "Amanuensis Manuscript", edited from these sources but never published.

This must have been a folio volume of some 80 pages, now no longer bound together and missing any title pages that might have existed. This manuscript was—I think—written by one amanuensis who identified himself in Part II by his stylised continuation mark "β". I agree with Dr Barnard that the corresponding botanical manuscript (also preserved in

Table III. *Mantissa Tertia—provisional Counts*

	Card-index			Manuscript (Original)
	M II	In-cluded	Ex-cluded	Total
Quadrupedia	4	4	11	7
Aves	11	55	9	67 (+1 error)
Amphibia	1	–	1	7
Pisces	–	–	–	16 T: 98
PART II—"Insecta"				
Coleoptera	–	1 (δ)	–	86
Hemiptera	–	–	–	36
Lepidoptera	–	3	–	17
other Orders	–	13	–	24
Misc. Inverts.	1	20	–	32 T: 195
Totals	17	96	21	293

the Strong-Room Collection) was probably the work of a different amanuensis.

That the formal manuscript was largely composed from the Card-Index slips can hardly be doubted, but some entries indicate that the Interleaved volumes were also involved. One very clear example of copying from the C-I slip is the entry for *PIPRA cyanea* (AM. 76), one of Mutis' species and so after 1773. On the slip Linnaeus had deleted *FRINGILLA* (typically in capitals) and written in *Pipra* (lower case) to be exactly copied up by the amanuensis and corrected later by Linnaeus himself.

The sequence of Classes and Genera is essentially of the 12th Edition S.N. and Linnaeus' correspondence with John White (discussed later, p. 147) suggests that these slips were kept up to date to April 1774 as new species were recognised. By having them in their correct order, as some pencilled numbers indicate, the amanuensis would have been able to continue with but minimal supervision during Linnaeus' intervals of reduced activity after the stroke of May in that year.

It is interesting to note that some species were cross-referenced in I-L XII; species marked "Mant." with page number refer to *Mantissa* II, while others marked "Mant. 3" or just "Mant." can be traced to this manuscript.

Table IV. *Amanuensis manuscript—summary of important sources*

Collectors	Pt. I	Pt. II	Authors	
Sparrman	5	39	Pennant	28
Fothergill	–	30	Catesby (fish)?	4
J. R. Forster	?	30	De Geer (III & V)	27
J. White	7	16	Drury (I & II)	12
A. Blackburne	6	8	Forster (Centuria)	26
Dassow	8	3		
Garden	9	1	(These totals must be regarded as *minima*, owing to incompleteness of many entries.)	
Mutis	7	–		

Form & content of the Amanuensis Manuscript

For convenience the manuscript can be divided into two parts, using common terminology anachronistically: Vertebrates and Invertebrates, retaining the general sequences of Classes and Genera of S.N. XII. In the first part sub-headings were inserted by Linnaeus in his "spidery-capitals", using a fine pen, somewhat as an editorial procedure. In the second part, INSECTA and COLEOPTRA (*sic*) were added immediately after the last of the fishes (P. 30) and HEMIPTERA and LEPIDOPTERA similarly in their correct places (PP. 53 & 60). Spaces left for HYMENOPTERA and DIPTERA were left unfilled and after this no spacing was allowed for sub-dividing the rather miscellaneous remaninder.

Though several corrections, some major ones, were made in this last quarter of the text, some inconsistencies in generic sequence were overlooked and it seems that the whole process of editing tapered off, especially so on the last page of all (P. 80) dealing with a revision of Bivalve Mollusca from S.N. XII.

As Linnaeus did not re-number his species here as in his other annotations, I have given here page and entry numbers as they have been allocated in my personal Xerox copy, which will eventually be deposited in the Linnean Society Library.

It is possible then to distinguish five classes of entry:—

i. ADDITIONS of new species, actually copied from his own sources, e.g. *DIOPSIS*—first placed in G. *MUSCA* on the slip, this changed to its new name and so copied up as AM. 71.
Several others were not copied exactly, word-order often being changed, suggesting perhaps partial dictation.

Table V. *Summary of contents*

Ref. 01 QUADRUPEDIA		PP. 1–3	Entries	7 (1 in error +4 Linn. fil.)
02 AVES		4–21		67 (+1 C.L.)
03 AMPHIBIA		22–24		7
04 PISCES		25–30		16
			TOTAL	102
05 INSECTA (& etc.)		PP. 30–80	Entries	1 to 196
Coleoptra (*sic*)		30–53		86 (incl. 1 C.L.)
Hemiptera		53–60		36
Lepidoptera		60–65		17
Groups not sub-headed [appendix]	Other Insects	66–72		24
	Crustacea, Mollusca etc.	72–79		28
	Bivalve Mollusca genera	79–80		4 (lists only)
			TOTAL	196

ii. QUOTATIONS from other sources—drawings, letters etc. In these actual quotations were underlined, usually by a rather wavy line as in the notes on John White's species (see p. 147).

iii. ABSTRACTS—often very short—from published sources: many from Pennant's books and also a block of entries of *CIMEX* spp. (P. 56) rearranged from de Geer's Volume III (1773).

iv. CORRECTIONS, mainly to names (genus/species) from S.N. XII, as in the somewhat muddled addendum setting out to revise certain Bivalve Mollusca (P. 80).

v. INSERTIONS made by Linnaeus himself, especially the corrections to *SAGITTARIUS*—the Secretary Bird—to be discussed later (p. 150).
Under this heading might also be added the loosely-inserted page (P. 3 A) written by the younger Linnaeus, quoting from papers dated 1777–78, and very similar to his own additions to the first volume of I-L XII.

Individual entries were made in standard format; each species had a typically short diagnosis, some of these being added by Linnaeus personally, along with changes in names. Book references were generally correct in detail though his coded abbreviations are not always easy to solve. Habitat was left blank and collectors' names omitted all too often, some of these could have been remedied from I-L XII.

Other important additions are in the form of footnotes to the descrip-

Table VI. Summary: John White's correspondence with Linnaeus
(Letter numbering and page references: BELL's Nat. Hist. SELBORNE, II (1877))

J.W.to C.L.	C.L. to J.W.
I, p. 67 30:vi:71 (Gibraltar) Notes on Fauna: Coll. I	
	II, p. 70 20:i:72 Identifications
—, p. 72 13 or 17:v:72 (Gibraltar) Collection II	
	III, p. 72 7:viii:72 More identifications
IV, p. 74 1:i:73 (London) Answers Letter III	
	? *not* received by C.L. ?? letter of C.L. missing
V, p. 78 26:xi:73 (Blackburn) Holding back specimens	
	VI, p. 80 2:i:74 more identifications with requests for information "editurus"
VII, p. 81 1:iii:74 covering letter Coll.III—17 or 19:iii:74	
	ENTRIES IN MANTISSA III: Animalia Quotations from L.VII & L.VIII
VIII, p. 85 22:iii:74 "Catalogus" Answers to letter VI	
	IX, p. 88 3:vii:74 Report on Coll.III— "Dona vere aurea"
X, p. 90 8:x:74 Discussion, mostly on letter IX	
	Not answered—?? Not read

tions, in some cases, posing queries on relationships. It is clear that Linnaeus must have returned many times to the task of editing as variations in his script seem to correspond to progressive deterioration—a task for a calligrapher to solve.

On the dating of the Amanuensis Manuscript

The full argument on the dating of this zoological text is derived from Bell's Edition of the *Natural History of Selborne*, Volume II (1877), and summarised here in this table (Table VI). Note especially that the *final* set of specimens was sent by John White to Linnaeus in March 1774, together with its "Catalogus", to be acknowledged as "Dona vere aurea"—a truly golden gift—by Linnaeus in his last letter, July of that year.

(Note: The "Catalogus" is not correctly transcribed in Bell—l.c. p. 88—as some of Linnaeus' marginal comments have been misinterpreted.)

Observations from this last collection appear in their correct sequence in the Manuscript and some points undecided there correspond to undecided points in Linnaeus' last letter, which leads me to believe that the *detailed* planning of *Mantissa* III: Animalia started late in 1773 or early in 1774, and that, thanks to his Card-Index, specimens received up to April could therefore be included correctly in sequence. As these particular slips were written in much the same script as others known to be earlier, it can be assumed that they preceded Linnaeus' stroke of May in that year and that the weaker script corrections can be ascribed to the post-stroke period.

Quotations from John White's letters appear in some of the AM. MS. entries in Aves, and were underlined by Linnaeus to show this, e.g.:—

i. J. W. in his letter VII, on *COTURNIX tridactylus* and its migrations is quoted in exactly the same words, in (I suggest) a somewhat distinctive phraseology in AM. Entry 51: *TETRAO tridactylus*:

"Ad Europam Africamque quotannis reditque cum *T. coturnide*".

ii. *MOTACILLA vernalis*—a C.L. MS name in AM.72—has a less direct quotation:—

"venit tempore vernae. J. Withe"—this name left uncorrected.

iii. *MOTACILLA gibraltarica*—also a C.L. MS. name in AM. 73—was given this specific name by Linnaeus himself and also written up personally. In his last letter he had written: "non antea vidi", but he sent no name for this species to White, though this choice of name would have pleased him.

Further supporting this dating, we find that Blunt (1971) commented that some activity on the part of Linnaeus continued until 1775, after that he could hardly write in 1776. That is why I have supposed that the very weak script additions referring to Dahl's Dissertation of December 1775 were among the last Linnaeus made, very much as Adam Afzelius explained to this Society here in London in 1798, explaining the derivation of "*Pausus*", and its spelling. Also the major event of 1775—the return of COOK-II and Forster's later letpers about the voyage—failed to find a place. (c.f. Time-chart-Tab I)

The major contradiction to this dating at first appeared to be the inclusion of three species from De Geer's Fifth Volume, formally dated 1775. From internal evidence (certain errors) these references seemed suspect but any doubts were then dispelled when Mr. Gavin Bridson showed me a De Geer manuscript from the Linnaean Miscellany (in Strong-Room Collection) which proved to be an advance copy of species, with latin diagnoses, illustrated in that volume. On the cover of this, Linnaeus had written on the loose cover, in what I have called his "pre-stroke script":—"Car. de Geer—Tomi 5^{ti} non dum editi Tabulae—cum nominibus manu auctoris".

It seems that De Geer and Linnaeus must have discussed this book, but strangely, though I-L XII has several species from the corresponding Volume IV, none of these appear in AM. MS.

So the dating from the letters is consistent with other evidence and it shows that Linnaeus, despite his handicaps, was—as he wrote to John White in the letter dated July 1774—continuing daily to correct his manuscript:— "Scripsi multa addenda Vol. I Syst. nat. idq. quotidie; absolvi dimidium tomum ... " and again: "Si vixero absolvam opus in autumnum."

It might well be taken that Linnaeus would have liked Benjamin White to publish this work in London, along with revision of some of his other works, when he wrote: "Quid mihi offerat in sostrum? An poterit habere optimum correctorem typi?"

Selected examples from the manuscripts

Here some examples are presented which may help to counter criticisms levelled at Linnaeus because of his obstinacy to accepting changes in his *Systema*, and in this I support Pennant's contemporary views, expressed in his "*Synopsis of Quadrupeds*" (1771:p.v.).

Remembering the *uncompleted* nature of the Mantissa III MS, we can see how much the stroke of May 1774 interrupted progress, Linnaeus found himself unable to finish this work *in the autumn* as he had hoped.

(i). The "Kanguru" and other quadrupeds

It is clear from many annotations that, along with Pallas and Pennant, but disagreeing with Buffon, Linnaeus was carefully considering the re-classification of Mammals, including especially the sub-divisions of his Order Glires, by that time proving inadequate for so many newly discovered species and genera.

One segregate from his Genus *MUS*—Klein's Genus *CAVIA*—must have reached Linnaeus via Pallas' "Spicelegia" (1767) along with *APER* [later *SUS* in the Addendum] *aethiopicus* [the "Wart-Hog"] from the same fascicule, just in time for a final Addendum to the Mineral Volume of S.N. XII (1768).

In the Card-Index several species of *MUS* remain in the unselected section, these were mainly from Pennant, including the Brown Rat already mentioned, and two from Pallas (1769) and so before his Russian Expedition.

Also in the Card-Index (a typical economy) is a list on the reverse of the slip for *MUS fossor* which correlates with Pennant's revision of the genus in *Synopsis of Quadrupeds* (1771), but this is not without anomalies; similar notes from Pennant also appear in the Annotated Vol. I.

In the I-L XII, the Genus *MUS* has been marked off into four "starred" groups based on tail-length, but this is a contribution from Linnaeus filius, copying Pallas' revision of 1778.

Pennant (loc. cit) had incorporated the Klein–Pallas Genus *CAVIA*, but, as he admired Buffon's use of vernacular names (even if disapproving of his lack of "System"), he proceeded to use anglicised names for his new segregates. How far Linnaeus intended to apply his own interpretations of these revisions, we cannot tell, it was left to Pallas (1778) formally to revise *Glires* in his own fashion, so only to be quoted by Linnaeus filius in I-L XII.

The greatest interest must still centre on these first records of the "Kanguru" of Banks, & Solander: *MUS Jerboa* originally, as described and illustrated in Hawkesworth (1773) Vol. III. Linnaeus gives this reference as "iter. austral. p.560.t.20" [pagination of the 1st Edition], but Linnaeus must have had some information from Pennant who used *Jerboa* in a generic sense for the Gerbils—hence the reference on slip 5 A: "*jerboa* Penn. synop.", but this was deleted before the amanuensis came to copying up the entry.

A second slip (C-I:5 B) refers to Forster's *YERBA*; the description here seems to correspond with one that Forster *repeated* in his letter after the return of COOK-II, stating that he had previously sent it four years before. This then must have been part of the missing pages of his letter from the Cape dated Nov. 19 1773 (Linn. Corr. IV:277 etc.) for Forster's phraseology agrees in places, especially in the correction of size: originally "canis major" [or Banks' greyhound], this was changed to "ovis" from Forster, on slip 5 B.

This second slip, remaining in the unselected section of C-I, was awaiting a new name to fill up a dotted line, Linnaeus not being prepared it seems to accept "*Yerba maxima Forst. MS*" from slip 5 B.

On the return of COOK-II, Forster's manuscript descriptions of new genera and species, "List 23" in the J. E. Smith Miscellany, gave a full account of his new Genus *YERBUA* but this did not get recorded by Linnaeus. The Forster–Sparrman papers in *Acta* Stockholm 1778 incorporating much of this revision were only noted in I-L XII by Linnaeus filius, along with similarly dated references to Erxleben and Zimmerman.

So here again we see additions and corrections to additions by Linnaeus up to 1774, perhaps extended to 1775, but then only to be continued by his son.

(ii). The secretary bird of Africa

Another example on which Linnaeus spent some time was *SAGITTARIUS*; "*secretarius*" it has been alleged is but a corruption of this, so the specific name has been given as *serpenterius*. Early records of this bird seem obscure, almost legendary, but Linnaeus seems to have acquired reliable information first from Vosmaer (1769), as note on the C-I slip, with a reference to Edwards (1772) obviously added later, with the phrase "victitat serpentibus et India".

Boddaert, Vosmaer's colleague in Amsterdam, sent Linnaeus a coloured tracing of the Vosmaer plate (now in Boddaert–Zoology: S R. ref.: BL770F); in the letter which accompanied this, it is made plain that comparison with the long-legged Herons had led to placing this bird in *Grallae*, but both Vosmaer and Boddaert considered it as a bird of prey and more likely to belong to Accipitres—this point here seems to have been overlooked by Linnaeus.

On transfer to AM. MS., the C-I slip was incorrectly copied as Entry 38 with *SAGITTARIUS* as the generic name, and the amanuensis must have been stopped before halfway. This entry was deleted, and Entry 39 started more correctly, the generic name left blank with a footnote added by Linnaeus: "genus nondum rite determinatum". Later he restored

SAGITTARIUS only to delete it and replace it by "*OPHIAS*" (he also deleted "et India" recognising an error in Edwards (l.c.))

Presumably on receiving a letter from Forster—probably the one now with pages missing (see p. 149) the entry had to be completely revised, placed where *Accipitres* should be: P.3 at the head of Aves (Entry 13)—in a very weak script. One can only assume that *ANGUICIDA* was Forster's erudite name, not acceptable to Linnaeus, who substituted his own *OPHIAS*, indicating one supposes: snake-eater.

It must then have been on one of his better days that Linnaeus re-wrote the whole description on a loose sheet, as Entry 40: *OPHIAS Sagittarius*, retaining the note: "D. Forster ad Accipitres primus retulit."

On the return of COOK-II when both Forster and Sparrman brought back living pairs of these birds, the situation became finalised, and it was left to Linnaeus filius to enter this species in I-L XII as *FALCO serpenterius* Forster MS", as given in that "List 23" (but with a different description). This was the name later adopted by Gmelin in S.N. XIII.

(iii). Garden's "Mud-Iguana" of Carolina

Manuscript additions referring to the amphibians and fish Garden sent to Linnaeus show his continued interest in zoological thinking to best advantage, especially perhaps his various comments on that most mysterious of his acquisitions, the "Mud-Iguana" from S. Carolina. However, he seems to have failed to connect with one Surinam frog his own earlier "*Rana paradoxa*", despite Garden's note: "... a fish which turns into a frog, or rather the tadpole of a frog."

Some account of these species appears in J. E. Smith's edited *Correspondence of Linnaeus with Others* and is well documented in the Berkeleys' *Life of Alexander Garden* (1969).

In S.N. XII, Amphibia constituted a Class of three Orders: *Reptilia* (with legs); *Serpentes* (without legs); *Nantes* (swimmers). When Garden insisted that his Mud-Iguana was a "New Creature", Linnaeus having first placed it in Nantes, invented a new Order: *Meantes*, for this meandering crawler.

Garden's first specimens were sent to Ellis in London in 1765, to be shared with Linnaeus, it seems he only received the smallest one, to which he gave the classical name "*SIREN*". In June of the following year, Ellis read a paper to the Royal Society (5:vi:66) on *An Amphibious Bipes*, with a plate sub-titled: "*Siren* of Linnaeus". At the same time Hunter, who had earlier obtained some specimens (source not recorded) described the dissection of this species. Some examples of dissections are preserved in the Hunterian Museum (Royal College of Surgeons, London) but it is not certain which of these are Hunter's—one of his was said to have been destroyed in the incident of 1941.

Garden's specimen, excellently preserved in the National Collection, (B.M.N.H.) is probably one of the second or third series which included "some pretty large ones".

Later in that same month (21:vi:66) Abraham Österdam described Linnaeus' specimen in a Dissertation at Uppsala: *Siren Lacertina*, with a plate including a mermaid: "*Siren Bartholini*", though this is elsewhere noted as *forte fictu*.

I am indebted to Dr Cunnar Broberg for drawing my attention to his references to Bartholin in his recent book *Homo sapiens L.* (1975), and to his reproduction of the original figure (as fig. 12, p. 185) from *Historiarum anatomicarum centuria secunda*, 1664. (24:v:78)

Discussion about the Sirens continued for some time as new and better specimens became available, but Linnaeus, who had at first regarded it as definitely a larval form, as indeed he seemed to think all Salamanders might be [see footnote on p. 371 in S.N. XII on *Lacerta salamandra*—corrected in the annotated volumes—] allowed himself to be persuaded otherwise by Garden (if only temporarily). So in the Addendum to Part I of S.N. XII (1767) he created a new Order: *Meantes* (literally; crawlers) for *SIREN lacertina*. It is bordering on the impossible to sort chronologically the many scattered corrections in the various annotations—including those on the printed version of the Dissertation which Linnaeus prepared for reprinting in *Amoenitates Academicae* Vol. VII (1769).

Very unfortunately too, the Card-Index slips (if they ever existed) are missing—they might have given us further clues.

With hindsight, and knowing about neoteny in Salamanders we can perhaps say that both Linnaeus and Garden were equally right, but neoteny it seems remained undefined for the next hundred years. However, when not entirely dissimilar specimens were collected, including the American version of the so-called African "Congo-Eel"—later to be called "*Amphiuma means*" by Garden, Linnaeus reverted to his old opinion, so we find AM. Entry 85: *SIREN tetrapoda*—changed by Linnaeus to *anguina*—with a reference to the Amoenitates reprint with its redrawn plate and adding: "*Siren lacertina* ... larva hujus", but this is not a view that can find any acceptance today.

It now seems probable that in these early collections, Garden sent examples of at least two species of *biped* Sirens, some large *c*. 75 cm, others much smaller 20–30 cm, but all caught by bait-fishing. A current Handbook of Salamanders (Bishop 1962) distinguishes several species and varieties, the later four-footed one being placed in a different family from the original *Siren*, but still regarded as neotenous, and not as yet, having suffered induced metamorphosis.

Conclusion

In attempting to be fair to critics, even if their criticisms have been embellished by hindsight, one must point out that it has been their misfortune to have been left so long in ignorance of these last writings of Linnaeus; at some future date it may be possible to provide microfiche copies of some of these documents.

The examples here selected from so many more also worth discussing of the 300 or so in the Mantissa MS., in turn *selected* from the large number available at that time to Linnaeus, show that to the end of his working days and despite his disadvantages, he was quite prepared and even willing to accept progressive changes in his Systema, but perhaps only with a proper sense of caution under the circumstances.

This can perhaps be best summed up in the contemporary phraseology of Thomas Pennant's eulogy in "Synopsis of Quadrupeds" (1771):

"His country may triumph in producing so vast a Genius whose spirit invigorates science in all that chilly region, and diffuses it from thence to climates more favourable, which gratefully acknowledge the advantage of its influence."

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ALWYNE WHEELER

The sources of Linnaeus's knowledge of fishes

Introduction

"He [Linnaeus] possessed the smallest collection in the class of fishes, but the illustrious Dr. Garden, who lives in the American South Carolina, has greatly enriched and deserved an immortal name for sending to our Dr President all the fish of Southern America to be made known to the public. The same man, at the request of our President, dissected the Branchiostegos fish to determine whether they are furnished with lungs in addition to gills ..." (quoted from the translation in Berkeley & Berkeley, 1969).

This statement from the dissertation on *Siren lacertina* defended by Abraham Österdam (Linneaus, 1766*a*) although, perhaps unintentionally apparently belittling to Linnaeus's collection of fishes, and intentionally flattering to Alexander Garden, the physician and naturalist of colonial Charles Town, nevertheless casts considerable light on Linnaeus and his involvement with the study of fishes.

His personal collection of fishes was small. Even after his death when all of Garden's donations had been included it contained only 158 specimens "siccati et chartis glutinati" plus some others in spirits of wine according to Acrel's list of 1784, compared with 3198 Insecta, 1564 Conchylia, and 2424 mineral specimens (Smith, 1832). This was possibly a reflection of Linnaeus's early resignation from the field of ichthyology in favour of Petrus Artedi (1705–1735), when he wrote, "... in the department of Ichthyology, I was finally fain to admit my inferiority to my rival [Artedi], and thenceforth I left that subject entirely in his hands, as also the study of Amphibia", (quotation from the English translation of Lönnberg (1905)). It is certainly true that in the earliest of Linnaeus's published works he relied very heavily on Artedi's *Ichthylogia* ..., but as more material became available for study Linnaeus increasingly showed a critical faculty towards the classificantion of fishes and the precise designation of species. The emphasis during his lifetime shifted most markedly from a virtual reliance on the earlier literature, chiefly the Renaissance encyclopaedists and the classical authors, with the notable additions of Belon (1553), Ray (1686), and Willughby, to a classification which was firmly based on specimens available in collections. Although Linnaeus's personal collection was small, by the end of his life the rich collections of the Swedish royal family had become the property of the state and had begun their progress towards the Naturhistoriska Riksmuseet where they found safe keeping, the collections of the University of Uppsala had increased, as material flowed in from his disciples or was the subject of dissertations by his students. Other collections, such as those of Gronovius and Seba, were then in existence and have survived at least in part. Such collections were the foundation of Linnaeus's later knowledge of fishes; their preservation and continued existence provide a basic source of information for the taxonomist in unravelling the later complexities of nomenclature that have surrounded some Linnaean species.

The purpose of the present note is to trace the sources available to Linnaeus from which his knowledge of fishes was derived. In addition, the trends in the evolution of his classification of fishes are discussed, and the general advance in knowledge of fishes which occurred between 1735, the date of publication of the first edition of the *Systema naturae* (Linnaeus, 1735), and 1766, the year of publication of the zoological part of the twelfth edition are noted. Linnaeus published little on fishes between 1766 and his death, possibly the most significant item being the three new species described in Linnaeus (1771). The identification of Linnaeus's literary sources brings their relative importance into prominence, and will, it is hoped, help authors to elucidate his rather cryptic references a little more easily.

Linnaeus's important ichthyological publications

Besides the *Systema naturae* Linnaeus published several works which contained information on fishes together with other animals but only one, his *Museum .. Adolphi Friderici* (1754 and 1764) was of major importance. However, a substantial body of his work was published as theses in the *Amoenitates Academicae,* defended by various students but written by Linnaeus; works which present certain bibliographical problems and which are difficult to cite correctly. A third, but minor, body of information on fishes is found on his Swedish travels and his general fauna of Sweden *Fauna Svecica* (1746*b*). Finally, Linnaeus's knowledge of fishes was influenced greatly by his editing Artedi's *Ichthyologia* (1738), and to a lesser extent the travel journals of his students Fredrik Hasselquist and Pehr Löfling. The publications of lesser importance are discussed later but it is appropriate here to comment upon the two important texts, Artedi's *Ichthyologia* and Linnaeus's account of the royal museum published in *Museum ... Adolphi Friderici*.

Soon after Artedi's untimely death by drowning in an Amsterdam canal in the early hours of 28 September 1735 Linnaeus attempted to obtain his manuscripts from his lodgings. According to the account Linnaeus later published in the biographical note "Vita Petri Artedi" with which he introduced the *Ichthyologia* (1738), he later obtained copies of the manuscripts which Artedi's landlord had impounded after negotiation over the unpaid account for lodgings and the burial expenses. The details of the struggle to find sufficient funds for this have been discussed by Engel (1951) and Wheeler (1961), and there are many inconsistences between Linnaeus's account in his "Vita Petri Artedi", other sources, and even other accounts by Linnaeus (Engel, 1951), sufficient at least to suspect the true roles played by Seba, Clifford, and Linnaeus in the negotiations were obscured by Linnaeus certainly to the detriment of Seba who had died eighteen months before Linnaeus wrote Artedi's biography.

The *Ichthyologia* comprises five parts (in addition to the introduction provided by Linnaeus), each with a separate, dated title page, wrappers, and pagination. The parts are *Bibliotheca ichthyologica* (pp. [iv]+1–66+[ii]), *Philosophia ichthyologica* (pp.[iv]+1–92), *Genera piscium* (pp. [iv]+1–84+[iv]), *Synonymia nominum piscium* (pp. [iv]+1–118+[xxii]), and *Descriptiones specierum piscium* (pp. [ii]+1–112+[ii]). All appear to have been published in 1738. These sections correspond to the manuscripts enumerated in the inventory prepared by the public notary after Artedi's death and published by Engel (1951). Although Engel had some difficulty in identifying them I recognise them as follows: "Petri Artedi Synonymologia manuscript" is clearly the *Synonymia nominum piscium*, the "Prolegomena Institutionum manuscript" is the *Philosophia ichthyologica*, the "Historia Literariae Ichthiologiae" is the *Bibliotheca ichthyologica*, the "Historia piscium universalis" is the *Genera piscium*, and the *Descriptiones specierum piscium* must be identitied with the "rough manuscript" described in the inventory as "Een boekje Ichthyologia in ruw manuscript".

Engel tentatively suggested that the "Historia piscium universalis" of the inventory might have been the part finally published as *Descriptiones specierum piscium* but I regard this as unlikely on two counts. Firstly, the *Descriptiones specierum piscium* is confined to species recognised by Artedi from specimens examined (as its title implies) and numerous measurements are given for specimens under most of the species described. It is therefore inherently unlikely that Artedi would have chosen a title such as "Historia piscium universalis" to describe such a limited selection of the world's fishes, nor if the title was descriptive and coined by the public notary would such a specific title be employed. Secondly, the coverage of the *Genera piscium* as published was clearly an attempt to provide generic nomenclature of the fishes of the world as recognised by Artedi from the literature and his own observations. Although most of the species Artedi recognised as congeneric were European, this was a bias imposed by the limits of the literature of the early eighteenth century, but some exotic genera were introduced, for example, *Anableps*, *Gymnotus*, *Chaetodon*, and *Ostracion*. This seems to me to be more worthy of the descriptive title used by the public notary.

It is difficult to assess the contribution made by Linnaeus to the Artedi work as published. Certainly he changed the titles which Artedi had used in manuscript although it is, of course, by no means certain that Artedi might not have changed his provisional titles before publication had he lived. In making these changes Linnaeus was clearly influenced by the titles he had employed or was to employ in his botanical writings. *Bibliotheca ichthyologica* clearly equates with his own *Bibliotheca botanica* (1736), which Stearn (1957) shows was begun in 1730, the year after Linnaeus and Artedi first met. *Philosophia ichthyologica* corresponds with Linnaeus's *Fundamenta botanica* (1736), although later he used the title *Philosophia botanica* (1751). *Genera piscium* is directly associated with the *Genera Plantarum* (1737) and *Descriptiones specierum piscium* is a modest equivalent to *Species Plantarum* (1753) which Linnaeus published after some sixteen years of active botanical work (Artedi's tragically short working life was at most of six years' duration). The parallels between the published writings of the two was more than coincidence and probably stemmed from the early informal division of the plant and animal kingdoms that Linnaeus is describing in his autobiographic notes (Linnaeus, 1823).

Beyond altering the titles of the parts of the *Ichthyologia,* there is no intrinsic evidence that Linnaeus contributed anything material to Artedi's work apart from the mechanical editorial process of adding page numbers within the text and seeing it through the press. That three of the parts (*Genera piscium, Synonymia nominum piscium,* and *Descriptiones specierum piscium*) all terminate with an Appendix in which various genera, references, and species descriptions are placed, suggest that this is how the manuscript stood at Artedi's death. Clearly all the species listed in these appendices could have been placed within their respective orders, and the fact that Linnaeus chose not to do this suggests that his editing of the manuscript was limited to the basic editorial processes.

Despite this, Artedi's work contributed fundamentally to Linnaeus's later work on fishes. By the excellence of its analysis of the earlier literature it stood as the basic key to previous descriptions of fishes in Europe and overseas. In addition, Artedi's methods used in the description of fishes set the study of fishes on a firm footing, and emphasising the importance of features such as the numbers and placement of fins, and numbers of rays or spines in the fins, laid the basis for the present-day use of meristic features in ichthyology. Equally as important, Artedi's classification of Pisces into five orders (Malacopterygii, Acanthopterygii, Branchiostegi, Chondropterygii, and Plagiuri) served as a convenient working classification for Linnaeus in the *Systema naturae* (1735) and later. These orders, using the term in the contemporary concept, were used (although in the reverse order) for subsequent editions of the *Systema* through to the ninth edition (1756) which was edited by J. F. Gronovius. In the tenth edition, however, the Artedian classification was abandoned; the cetaceans were removed from Pisces–Plagiuri to form the order Cete within Mammalia, while the fishes were categorised according to the presence or absence of a freely opening gill cover, and then the absence or presence and position of the pelvic fins in relation to the pectoral fins. Five classes of fishes were recognised (Apodes, Jugulares, Thoracici, Abdominales, and Branchiostegi) while a sixth class, containing an unnatural assemblage of sharks, rays, sturgeons, and the angler fish, was erected as Amphibia Nantes.

Possibly more important to the development of ichthyology than the classification adopted or the analyses of method or literature was the careful description of specimens that Artedi produced. In the *Descriptiones specierum piscium* are some of the most precise descriptions of fishes that were published in the eighteenth century, in most cases terminating in a list of measurements made on the specimen examined. In the precision of the descriptions there lay considerable importance for most of them were cited by Linnaeus in 1758 as the bases for species' names.

There are few cases of ambiguity of application when Artedi's descriptions were the sole source for the binomen (as they were for 71 species in the *Systema naturae* of 1758). The greatest significance, however, lay in the shift from literary sources, which Artedi presumably considered had been adequately summarised in his *Bibliotheca ichthyologiae* and *Synonymia nominum piscium*, to examination and exact description of specimens. This was a trend which continued (and in a sense was repeated in Linnaeus's ichthyological studies) and ultimately led to the type concept in systematic zoology.

Linnaeus's own essay into descriptive ichthyology was best exemplified by his studies of the collections of Adolf Fredrik, first in 1746 while he was Crown Prince, and later in the *Museum S:ae R:ae M:tis Adolphi Friderici:* the first volume in folio published in 1754, the second more modest volume containing also the Queen's collection was published in octavo in 1764. The earlier of these two collections was presented to the University Museum of Uppsala by the Crown Prince and was studied by Linnaeus and an account published in a dissertation defended by Laurent Balk on 31 May 1746. In the tenth edition of the *Systema naturae* Linnaeus cited this publication as *Amoen. acad.* 1 followed by a page number, elsewhere (as in Linnaeus, 1748) he cited it as *Museum Principis*, which is given as a running title throughout the work in the reprinted edition of *Amoenitates Academicae* (Linnaeus, 1749). This edition was the one cited by Linnaeus, as the Pagination in his references proves, for the original printed dissertation is paged separately from 1–48 (for bibliographic citation see references under Linnaeus, 1746*a*).

The dissertation comprised descriptions of several animal groups represented in the collection given to the university museum. Descriptions are arranged by numbered 'Classis', Quadrupedia, Aves, Amphibia, Pisces, Insecta, and Vermes, all are numbered in a single series. Twenty-one species of fish are described, but only a few are given localities. However, the collection contains a small element of the Neotropical freshwater fish fauna including numbers 42 *Aspredo*, 50 *Callichthys*, 51 *Gymnotus*, while other specimens, such as 40 *Ostracion* are associated with references to Marcgrave's *Historiae rerum naturalium Brasiliae* ... (1648) and may thus have originated in the New World. Other species included in the collection are of Indo-Pacific origin with a few possibly of European origin; only one can be given a locality, and that by inference and possibly only of ancestry, namely the species described as '56 *Cyprinus* pinna ani duplici, cauda bifurca. Chinesiska Gull-Fisken'. The five specimens in alcohol of *Cyprinus auratus* L., 1758 (now *Carassius auratus*) described on this occasion are still preserved in the Zoological Museum, Uppsala (Holm, 1957).

It is necessary here to point out that the *Catalogue of the works of Linnaeus* compiled by Soulsby (1933) is in error in claiming (:87) that the University of Uppsala was presented with the specimens described in the *Museum ... Adolphi Friderici* (1754); only the specimens described by Linnaeus in Balk's dissertation became the property of the University later royal collections eventually passed to the Naturhistoriska Riksmuseet, Stockholm.

In 1754 Linnaeus published the sumptuously produced *Museum S:ae R:ae M:tis Adolphi Friderici Regis*, a folio volume printed in Latin and Swedish and lavishly illustrated. This work was based on the later collection made by Adolf Fredrik (who had succeeded to the throne in 1751). Compared with the collection described by Linnaeus for Balk in 1746, this royal collection was very rich and extensive, especially in the classes Amphibia and Pisces. Described here were thirty-nine Quadrupedia, twenty-three Aves, ninety Amphibia, one hundred and two Pisces, forty-one Insecta, and twenty-three Vermes. Linnaeus's Class Pisces was divided into the five major orders proposed by Artedi which were adopted by Linnaeus in his system (although in a reverse order to Artedi's) until 1758. Plagiuri contained descriptions of two whales; Chondropterygii contained accounts of nine species of cartilaginous fishes, while Branchiostegi, Acanthopterygii, and Malacopterygii contained sixteen, forty-one and twenty-four species respectively. In addition, the hagfish *Myxine glutinosa*, was included (as *Myxina glutinosa*) amongst the Vermes.

Again much of this collection represented European species. Localities are given in many cases, mostly in general terms although some are specific. The most strictly localised is the specimen of the small sturgeon, *Acipenser ruthenicus*, for which it is written. 'Hab. Lacu ad arcem Regiam Ulricsdal ex Russia oriundus'. The specimen of the loach *Misgurnus fossilis*, described as *Cobitis fossilis*, also came from the lake at the royal palace of Ulriksdal, as also had the specimen described in 1754 "Habitat ad arcem Regiam Ulricsdal, in piscinis". Other specimens which came from Swedish localities include *Cyclopterus heptagonus* (now *C. lumpus*, the lumpsucker) and the sandeel *Ammodytes tobianus*, two of seven or more fish from 'Mari Balthico' (the Baltic Sea), the sturgeon *Acipenser europaeus* (now *A. sturio*) and the viviparous blenny *Blennius viviparus* (now *Zoarces* *viviparus*) both from 'Mari Bothnico' (gulf of Bothnia), while from the deeper waters of the Skagerrak coast came a specimen of the ratfish, *Chimaera monstrosa* ('Mari Bahusian') as did the specimen of hooknose, *Cottus cataphractus* (now *Agonus cataphractus*). More general regions of origin for the specimen described were, however, more usual, for example 'Atlantico', 'Europae Maribus', 'Anglia' 'mari et fluviis Sveciae', and 'Oceano Norvegico', virtually the only non-Swedish exception to this being 'Habitat Venetiis' for the specimen of *Blennius gattorugine* (now *Parablennius gattorugine*), the tompot blenny.

Outside Europe the "localities" become, if anything, even more generlised. "India" appears as the habitat at least ten times, probably erroneously on occasions, for *Acipenser indicus* is a loricariid catfish, a family confined to the New World. A similar confusion has apparently occurred with *Albula maculata* from 'Amboina' which is clearly a characoid fish. The neotropical fauna is represented by at least five species from "Brasilia", three from "America meridonali", and one from "Suriname". Many, if not most, of the exotic species are quite without locality or habitat information, and few of the species of *Sciaena* (a composite genus which contained several unrelated fishes now placed in the Cichlidae and Labridae), *Chaetodon* or *Ostracion* bear any indication of their provenance.

This descriptive catalogue was critically compiled. Species which had already been adequately described mainly by Linnaeus in his Swedish journeys or in the *Amoenitates Academicae* (principally in Balk's dissertation), or by Artedi (1738) were merely listed with the normal brief diagnosis and a reference to the previous publication. Previously undescribed species, however, were described in some detail. The description was objective, consisting of a phrase or two describing the salient features of head, body and fins separately. It was also systematic in that each description was first of the body form of the fish, then of the head, and finally of the fins, the number of spines or rays in each fin being given. The descriptions were good of their period, although lacking the detail of those of Artedi in his *Descriptiones specierum piscium* or of Gronovius in his contemporary *Museum Ichthyologicum,* but they were perfectly adequate to allow the recognition of the species in the context of the four hundred or so species known at the time. The illustrations, however, more than compensated for any deficiency in description. The nine plates of fishes contained illustrations of thirty-five species (some of them illustrated in two or more views), and most are clearly recognisable to species level. These excellent figures make it all the more surprising that succeeding generations of ichthyologists failed to recognise the true identity of Linnaean species, such as *Labrus punctatus*, *Cyprinus cylindricus*, and *Cyclopterus nudus*, all of which received binominal names from later authors, the junior synonym gaining wide acceptance.

It is appropriate here to draw attention to the use in the *Museum ... Adolphi Friderici Regis* (1754) of binominal nomenclature for the numerous animals described. Although the tenth edition of the *Systema naturae*, with the arbitrarily decided publication date of 1 January 1758, is officially the starting point for zoological nomenclature, it is not the first work to show 'the consistent general application of binominal nomenclature in zoology' as is stated in Article 3 of the International Code of Zoological Nomenclature. (The first volume of the tenth edition was, in fact, published some time before 8 February 1758—Linnaeus letter to Ellis (Smith, 1821).) Binominal nomenclature was used consistently in the *Museum ... Adolphi Friderici Regis* (Linnaeus, 1754*a*). This work, however, was essentially a descriptive catalogue of the royal collection and not a complete account of the recognised species in zoology as was the *Systema* ... It is important to recognise that Linnaeus's nomenclature was a process of evolution from the occasional use of biverbal names as in the *Öländska och Gothländska Resa* (1745) to their consistent application in the *Species Plantarum* (1753), from which botanical nomenclature commences (Stearn, 1957). It is therefore not surprising that in publishing an account of the collection of King Adolf Fredrik, in the following year, Linnaeus should have employed his biverbal nomenclature consistently, although the first opportunity for him to apply the system to all known animals was in the tenth edition of the *Systema naturae* which was published four years later. The point is important as some authors have claimed that 'the tenth edition of the *Systema naturae* introduced them [binominal names] for animals' (Allen, 1978), whereas they were used in the description of the royal collection of animals as early as 1754.

Compared with the impressive appearance of the first volume of the *Museum ... Adolphi Friderici*, the second volume, published in 1764, was very modest. This was printed in octavo, written entirely in Latin and is unillustrated. It extended only to 112 pages. Its full title *Museum S:ae R:ae M:tis Adolphi Friderici Regis Svecorum, Gothorum, Vandalorumque ... In quo Animalia Rariora imprimis & exotica: Aves, Amphibia, Pisces Describuntur* shows that it was intended only as an account of the novelties in the collection, including the famous elephant embryo which Seba had illustrated in his *Thesaurus* and which had been purchased in 1753 (Blunt, 1971). Again, there are the four major systematic divisions, Mammalia (eight species), Aves (thirty-four species), Amphibia (nineteen named species, excluding the Amphibia Nantia which numbered thirteen species), and Pisces (eighty species). The use of the term Mammalia as a class in place of Quadrupedia in 1754, should be noted; this was an innovation of the tenth edition of the *Systema naturae*.

Fishes were thus split between the two classes Amphibia and Pisces. The Amphibia Nantia comprised sharks and rays (eight species), trigger-fishes and puffer-fishes (four species), and a single species of *Pegasus*. All the sharks and rays were of Mediterranean origin; both the rays, the eagle ray *Raja aquila* (now *Myliobatis aquila*) and the sting-ray *R. pastinaca* (now *Dasyatis pastinaca*) have vernacular names allocated 'obispo' and 'chucho') which are names used for these species in Spain (Palombi & Santarelli, 1961). A more precise locality of the Spanish coast of the Mediterranean is therefore indicated.

The class Pisces followed the tenth edition of the *Systema* ... in arrangement, viz. Apodes (one species), Jugulares (nine species), Thoracici (forty-seven species), and Abdominales (twenty-three species). The great majority of the species are given general localities, such as 'Habitat in Nilo' or ' ... Mari Mediterraneo', but few have more than this. One exception, however, in which an observation of a biological nature is given appears under *Sparus salpa* (now *Sarpa salpa*), 'Habitat in Mari Mediterraneo, victitans Alga.', an early description of the food preference of this Mediterranean sea bream which browses on algae, a diet for which its broad incisiform teeth are well adapted. A number of the fishes which came from the Mediterranean also have vernacular names allocated; some are not now identifiable with modern vernacular names but a few can be recognised. Thus 'faneca' against *Gadus luscus* is used in Spain for the related gadid fish *Phycis phycis*, 'rubio' is in current Spanish usage for *Trigla cuculus* (now *Aspitrigla cuculus*), and 'cabrilla' also used in Spain for *Perca cabrilla* (now *Serranus cabrilla*), although it is used in conjunction with other names in southern France, and Italy. An exception to this prevailing suggestion of Spanish origin for many of these fish is the 'cappa' of *Sciaena cappa;* Palombi & Santarelli (1961) give cappa nigra as the vernacular name in use on the Ligurian coast of Italy for *Sciaena umbra* L., 1758. There seems to be a strong suggestion derived from study of these vernacular names that part of the collection at least was made on the Spanish Mediterranean coast. In all forty-two species described in this work are indicated to have come from the Mediterranean.

A smaller number (fourteen in total) are more strictly localised as coming from the Nile. These were certainly specimens collected by Fredrik Hasselquist during his expedition to the eastern Mediterranean coastline and the Nile in 1749–1752. Hasselquist's itinerary did not apparently take him to the Spanish coast of the Mediterranean, although presumably he could have obtained specimens of fishes with their Spanish names at Gibraltar from local fishermen although there is nothing to indicate in his journal (Hasselquist, 1766) that any contact was made. His Nile specimens are clearly recognisable by the locality given by Linnaeus, 'Habitat in Nilo', with occasionally, as in the cases of *Silurus mystus, Salmo niloticus,* and others, of Hasselquist's name.

Other regions represented by fish specimens in the *Museum ... Adolphi Friderici* (1764) comprised Surinam (four species), America (thirteen species), India (six species), Amboina (one species), Asia (one species), and Europe (two species). The European species were more precisely localised as 'Germania' for *Cobitis barbatulus* and 'Hispania' for *Cyprinus barbus,* but none of the other general regions are so localised.

The quality of the descriptions in the second volume of the catalogue of the royal collection varied, but in most cases was perfectly adequate in relation to the standards of the period. Again, they follow the standard method employed in the first volume with a brief account of the shape and characters of the head (frequently including references to the appearance of the nostrils, mouth, teeth, and, when present, barbels), then the body is described, and finally the fins are enumerated with their position on the body detailed and the number of bony elements expressed numerically. The descriptive text varied in length, that of *Salmo niloticus* (= *Alestes* sp.) comprised only eight lines, mostly concerned with meristic features of the fins, besides the introductory descriptive phrase from the *Systema naturae,* and the locality and collector's name. In contrast, the account of *Esox sphyraena* (now *Sphyraena sphyraena*, the Mediterranean barracuda) extends to sixteen lines (and many more words) in addition to the introductory matter. It is noteworthy that both descriptions are prefaced by a comparison with some similar but well-known fish, in the case of *Salmo niloticus,* 'Corpus faci Cyprini Alburni' recalling the slender build and silvery appearance of the European bleak, *Alburnus alburnus,* while the account of *Esox sphyraena* contains the phrase 'Corporis facies E. Lucii' thus inviting comparison with the European pike, *Esox lucius,* a common fish in Sweden. This comparison with a well-known fish saved much descriptive text, although it failed to compensate for the lack of illustrations which had been such a conspicuous feature of the first volume of the work.

The omission of plates from the second volume has been said to be due to financial difficulties connected with the outbreak of the seven years war in 1756 which rendered necessary the publication to be in the cheapest form consistent with propriety. Certainly there was considerable delay in publishing the work. In the tenth edition of the *Systema naturae* (Linnaeus, 1758) there are numerous references to the second volume of the *Museum Adolphi Friderici* with the page number omitted; thus, *Silurus anguillaris* is referred to as '5. S[ilurus] pinna dorsali unica radiis 70, cirris 8. Mus. Ad. Fr. 2. p . . .'. This shows that some of the text of the second volume was complete earlier than late 1757 (when the tenth edition was being printed), although as late as 1763 additions were still being made, because under *Silurus anguillaris* there is a reference to Gronovius's *Zoophylacium* which was published that year. The date of publication of the second volume of the *Museum Adolphi Friderici* must have been late in 1763 to allow for the reference to Gronovius's work and later printing of Linaeus's work.

These four works (Balk's dissertation, the two volumes of the *Museum . . . Adolphi Friderici*, and Artedi's *Ichthyologia*) provided the base of Linnaeus's knowledge of fishes. In editing Artedi's manuscript Linnaeus was instrumental in making available a single work which at a stroke cleared away the great mass of confusion in nomenclature in pre-eighteenth century literature, and provided a working summary of it for later workers. Artedi had also a keen sense of method and proposed, and on a small scale practised, the methods of description of specimens of fish (as opposed to the compilations of earlier authors) which were to remain the ideal method, an ideal that was rarely attained until the present century. In particular, his introduction of the study of meristic features paved the way for one of the vital modern methods in species description. Artedi's *Ichthyologia* was the framework within which Linnaeus built his later systematic arrangement of fishes.

The major contributions to ichthyology that Linnaeus made himself were in the descriptions of the royal collections. Of these, the first volume of the *Museum . . .Adolphi Friderici* was most important, both in the number of species described and in their illustration. The actual description of the specimens was terse and fell short of the standards of Artedi, but was adequate within the demands of the period. In the second volume, without the illustrations which had redeemed the earlier publication, a number of the species have not been recognised by later workers. Nevertheless the two volumes are cited no fewer than one hundred and fifty-four times and thirty-one Linnaean names are based on these descriptions only. The specimens described in the earlier *Museum Adolpho-Fridericianum* (Linnaeus, 1746*a*) reprinted in *Amoenitates Academicae* (1749) account of the Crown Prince's donation to the museum of Uppsala University increased this total by twenty-three citations in the *Systema naturae* of which three were the sole authority. Linnaeus's own descriptions of fishes were thus a major source for the species named in the *Systema naturae.* In fact, the three works describing the royal collections discussed here were in total the second most important source for citation (177 total citations) in the tenth and twelfth editions, thirty-four of which were the sole authority for the name. The only source of greater importance was Artedi's *Ichthyologia* which was cited two hundred and forty-five times and was sole source for seventy-four Linnaean names. No other work or group of cognate publications approached these two sources, with the exception of L. T. Gronovius's two publications which will be discussed in greater detail later.

Fishes in the Systema naturae *1735–1756*

In the nineteenth century the adoption of the Stricklandian code of zoological nomenclature, which resulted in the twelfth edition of the *Systema naturae* being accepted as the official starting date (1766) for biverbal names for animals, caused the tenth edition of the work to be largely overlooked by taxonomists. In a similar way the present-day acceptance of the tenth edition of the *Systema naturae* as the starting place has cast into shadow the previous nine editions. Nomenclaturally, there is no reason why a taxonomist should consult any of these earlier publications, but historically they are important for the light they shed on the development of zoological knowledge during the middle decades of the eighteenth century. At the least their study sheds a little light on the increase in numbers of recognised taxa within each animal group between 1735 and 1758 (and 1766), for they serve as an index to the animals of the period recognised by Linnaeus and his editors. The opportunity is therefore taken here to compare each of the editions of the *Systema naturae* in which significant changes were made in the section devoted to fishes and to comment on these changes. A simple numerical summary is given to show the increase in the total number of named forms (Table I).

Not all the editions of the *Systema* ... showed significant changes. In his introduction to the tenth edition Linnaeus gave a list (page 1 unnumbered, but with signature A) of the editions of the *Systema naturae* which he recognised. These are also described by Sherborn (1899) who added some explanatory comments. Those editions which have significance in the present context were the first edition, Lugduni Batavorum, 1735 (numbered 1 on Linnaeus's list), the second edition, Stockholmiae, 1740 (2), the fourth edition, Parisiis, 1744 (4), the sixth edition, Stockholmiae, 1748 (6), and the ninth edition, Lugduni Batavorum, 1756 (9). The remaining editions were of less importance so far as the animals listed are concerned but may be briefly mentioned here; third edition, Halle, 1740, was a new printing of the first edition with German names added and a new preface; fifth edition, Halae Magdeburgicae, 1747, was a new printing of the second edition again with German names added; seventh edition, Lipsiae, 1748, was a copy of the sixth edition with German instead of Swedish vernacular names; the eighth edition, Holmiae, 1753, did not apparently differ from the sixth edition so far as animals were concerned and also gave Swedish names.

In the first edition of the *Systema naturae,* published in Leiden in 1735, in folio, the text of the body of the work is arranged in tabular form. Each major group bears the appropriate heading, with orders set vertically up the page in the left hand column. Pisces is divided into the five orders which were introduced by Artedi (1738) and were used in successive editions until the tenth edition of the *Systema* ... in 1758. The second column carries the generic names, the third contains brief diagnoses of the genera, in which much reliance is placed upon the number of branchiostegal rays ('Membr. branch. ossic') with reference to additional characters to support this feature and to further subdivide. The fourth column contains trivial names, many of them single words and thus biverbal at that early date. Some others are polyverbal, and the definition of species is not precise in all cases, for example, in *Gadus* we read 'Asellus diversar. specier'. However, some species names are used which were to be given permanence in the tenth edition, as, for example, in *Coryphaena* which contained the two species, *Hippurus* and *Pompilus,* then as now.

The indefinite number of species included within the genera *Gadus* (see above), *Pleuronectes*, and others, makes a count of the number of species uncertain. Other sources of error exist in the manner in which certain species, or groups of species, are included in *Raja*, *Cyclopterus*, *Cottus*, and other genera (in *cyclopterus* for example, the species *Lumpus* is clear, but *Lepus mar.* may have been intended to be a second species). The total of species listed in Table I (p. 177) is, however, conservative, and doubtful names, such as this, have been omitted. Excluding the order Plagiuri (which were all cetaceans in modern terms), one hundred and fifty-six species in thirty-six genera were accepted by Linnaeus in 1735. Of the genera all except for one are western Palaearctic in distribution; the exception being *Gymnotus*. Most of the species recognised are also western Palaearctic in their distribution although here exceptions are more numerous. *Ostracion*, which in the Linnaean (1735) sense included elements of the modern families Ostraciontidae, Tetraodontidae, and Diodontidae, contained six species several of which must have been of extra-European origin as there are only three European species in these families. Similarly, *Balistes* contained exotic species, as was suggested by the "species name" *Guaperua*, which originated from Marcgrave's (1648) account of the fishes of Brazil, although not necessarily directly as many of Marcgrave's Brazilian names were cited by Ray (1686). The genus *Lophius* also included the *Guacucuja* which also originated from Marcgrave; this name was also used by Ray.

The second edition of the *Systema naturae* (1740) was typographically very different from the first edition. Instead of the tabular form of the first edition the format is in octavo, page size 120×197 mm, each class with a separate heading and the five named orders within Pisces. Subordinate to the orders are the genera, each being numbered and with a short diagnosis and preceding a list of species. With only slight elaboration, where literary references and in some cases fin-ray counts were added, this arrangement was continued through to and including the ninth edition (1756).

Textually there are few important differences from the first edition, but these are nevertheless significant. The genus *Chaetodon* was admitted to the system with three recognised species (*Paru*, *Guarerua*, and *Acarauna*). All three originated from Marcgrave (1648) and Ray (1686) in the latter of which the last is well illustrated (plate 3), being clearly recognisable as a *Holacanthus* sp. *Chaetodon Paru* is likewise recognisable from its description as the French angelfish, *Pomacanthus paru* (Bloch, 1787), although for some reason the name was not continued through to Linnaeus's tenth edition. The genus *Sciaena*, with two species (*Umbra* and

Umbrino), was also introduced at this time, although as with *Chaetodon* neither name was new, both having been used by Artedi (1738) and the former by earlier and classical authors. Both the species included within *Sciaena* had been listed by Artedi and derived from Ray's *Historia Piscium* (1686) but the names were used by other authors.

Other new genera introduced in 1740 were *Anableps, Ophidion, Anarhichas, Stromateus, Exocoetus,* and *Argentina*. Again none were truly novel, all had been employed as genera by Artedi (1738) and all but one had been in use by some if not all the seventeenth century encyclopaedists. Thus *Stromateus* was used by Rondelet (1554–5), Gessner (1558), Aldrovandi (1613), and Ray (1686), and of the two species Linnaeus included (*Callichthys* and *Fiatola*) both names had been used by Bellon (1553) and Gessner. The single exception, *Anableps*, had been an innovation of Artedi, who had recognised that this fish seen in Seba's museum was nondescript; he wrote in Genera Piscium (1738: 25) 'Novus piscis, quem in Sebae thesauro descripsi'. Parenthetically it is worthy of note that the figure of this fish in Seba's *Thesaurus* (1758: 108*a* tab. 34) is one of the finest in existence today while the fascinating adaptation of the eye-lens of this fish to life at the surface of the water is faithfully illustrated. In adapting Artedi's genus name into his system Linnaeus had no existing trivial or phrase name to add so *Anableps* began its nomenclatural career simply as *Anableps Anonymus*.

Like most of the novel genera which were introduced in 1740 many of the new species which appeared in this edition were culled from the literature or were clarifications of the listing in the first edition. Thus in *Ostracion* two new species were listed, *Holosteus* and *Mola*, but the phrase 'Orbis div. sp.' was omitted resulting in clarification. Changes within other genera, such as *Perca*, where *Lupus* and *Asper Pisciculus* were novel, and *Cottus* increased by three species (*Scorpaena, Dracunculus,* and *C. tuberibus 4 capitis*) while *C. gobio fl. capit* was omitted, were relatively minor, although this resulted in an extension of the coverage of the genus *Cottus* to include forms which are in present-day terms included in *Scorpaena* and *Callionymus*, while the previously included species were members of the present families Cottidae and Agonidae. Some trivial names included within the new genera such as *Argentina Sphyraena* and *Anarhichas Lupus*, have been retained through the later editions of the *Systema* . . . and are in use today, but as has already been pointed out these names date from wider use by the seventeenth century encyclopaedists.

Changes in the second edition therefore were relatively minor with the exception of the establishment of the name *Anableps* from Artedi's original proposal. Most of the additions and changes can be seen as a "tidying up" of the system based on Artedi's *Ichthyologia,* and as a result most of the novelties are from the European fauna of species previously overlooked or confused with others. Extra-European forms were introduced from the earlier literature (mainly from Marcgrave through Ray) most notably in the three species of *Chaetodon,* and only *Anableps Anonymus* stood as a genuine innovation. It is significant that these extra-European species all originated in north-eastern South America and came to be known through the contacts of the Dutch with that part of the world.

The fourth edition of the *Systema* ... (Linnaeus, 1744), edited by Bernard de Jussieu, was published in Paris. It closely followed the second edition of 1740 but French vernacular names were given in place of the Swedish names, and many more species were given vernacular names. The format closely follows that of the second edition being octavo, with a page size of 125×194 mm, and the arrangement of the text on the pages is similar. There are, however, numerous textual changes and additions. One innovation of significance is the listing for many of the species of fishes of the number of fin rays, in column form under the headings 'Pinnae dorsi. Pector. Ventr. Ani. Caudae. Ossiculorum', this was the first systematic use of meristic features to characterise species in the *Systema* ... and continued through later editions. In view of the importance of meristic data in modern systematic ichthyology this development has considerable significance.

Changes in the number of species included were few. There was no increase in the Chondropterygii (rays, sharks, sturgeons and lampreys), but in Branchiostegi there were numerous addition in *Ostracion,* to bring the total to twenty-two species from the eight of the second edition. The genus *Balistes* was increased by two species. Within Acanthopterygii there were additions to the genera *Chaetodon* and *Trigla* both with ten species, *Labrus* with three additions, and *Scomber* with two additions. The additions in *Chaetodon* were mostly polynomial (e.g. 'Chaetodon cauda bifurca') although one exception which persisted in binominal form to validity in tenth edition was *Chaetodon canescens* (now *Zanclus canescens* (L., 1758)). *Trigla,* with its additions, included five of the European species which were aligned in this genus until the twentieth century, and *Trigla Coccyx* "Le Malarmat" which is *Peristedion cataphractum* (L., 1758), and *Trigla Milvus* which later became known as *Dactylopterus volitans* (L., 1758). Surprisingly, this genus still contained the red mullets as *Trigla Mullus, T.*

Surmulet., and *T. Rex Mullorum,* for there is little they have in common with the gurnards (now Triglidae) except a tendency to a red coloration. The additions in the genus *Scomber* (*Glaucus* and *Sphyraena*) are of some interest in that this appears to have been the first recognition of the barracuda in the system although by the tenth edition it had been re-aligned as *Esox sphyraena* L., 1758. The most significant addition in the de Jussieu edition was the introduction of the genus *Scorpaena* into Linnaean nomenclature (it had earlier been accepted as a genus by Artedi (1738)); the two included species *Scorpaena* and *Scorpius* being removed from *Cottus*.

In the order Malacopterygii there were several additions to the genera *Muraena* (two additional species), *Gadus* (six), *Pleuronectes* (three), *Salmo* (six), *Coregonus* (one), *Cyprinus* (four), and *Syngnatus* (one). Of these, some such as those in *Muraena* (*Myrus* and *Serpens maculatus*) and *Pleuronectes* (*Flesus, Linguatula,* and *Pleuron. Amboin.*) were well found, but confusion had crept into *Gadus* where the earlier *Morhua* was omitted and *Gadus Molva* was given the French name La Morue. The apparently striking increase in the number of species of *Salmo* was due to the proliferation of names such as *Salmo griseus, S. Trutta salmonat.*, and *S. Trutta* lacustris, thus anticipating the confusion in nomenclature of European salmonids that was to continue until the early twentieth century. Equally, the large number of cyprinid fishes accepted (twenty-six species in this edition) was due to a certain degree of failure to recognise as identical the same species in different parts of Europe; thus, *Leuciscus Rutilus* was accepted from Artedi and Linnaeus in Sweden, and *L. Gardon* from France (both are names for the roach, *Rutilus rutilus*(L., 1758)).

The fourth edition of the *Systema* thus made a small contribution to the clarification of generic concepts, but if anything tended to confuse by the introduction of new species many of which were not well found. Many of the innovations clearly originated from re-examination of Artedi's (1738) work. Most were additions from the western Palaearctic region, and although some exotic forms were included they were of limited significance. The proliferation of species in the genera, as then accepted, of *Ostracion* and *Chaetodon* (and to lesser extent *Balistes*) were of forms which were notable by shape or coloration and may well have originated from casual dried specimens brought home from the Caribbean and the Indo-West Pacific by sailors. Such curiosities were to be found in respectable museum collections such as the Royal Socitey's Museum from whence Grew (1681) figured (tab. 7) a 'little Sea-Unicorn, a Square Fish, a Long

File Fish and a Hare Globe Fish', and in hostelries, such as the Nagg's Head, the White Bear, and the Green Dragon at Stepney where Artedi saw specimens of *Ostracion* in 1734–5 (Wheeler, 1961). Although the total number of species recognised in the system increased by the edition of de Jussieu the increase was not especially meaningful. The great majority of fishes recognised were still from the faunas of northern Europe and the Mediterranean.

The sixth edition of the *Systema naturae* (1748) published in octavo (page size 120×196 mm), at Stockholm, had several important general changes. For the first time the animal kingdom was placed first (followed by plants and minerals); the earlier editions had begun with minerals and continued with plants and animals. In addition, there were eight plates which illustrated the orders withtin each class; in Aves showing the method of counting the primary and secondary wing feathers and in Amphibia (within which the snakes were classed) the method of counting scales. For Pisces the plate (Tab. IV) included a cetacean (apparently spouting a fountain of water) to represent the order Plagiuri, a monkfish (*Squatina*), which from its distorted appearance was evidently drawn from a dried specimen, representing the order Chondropterygii. The Branchiostegi is illustrated with a most decorous boxfish, *Ostracion* sp. (possibly *O. tuberculatus* L., 1758), the Acanthopterygii by the four-horned sculpin, now *Myoxocephalus quadricornis* (L., 1758), and the Malacopterygii by a quite indeterminate cyprinid fish.

A fundamentally important innovation of this edition was the inclusion of literary references for most of the species included. For the first time in the *Systema* ... the reader can refer back to the source of Linnaeus's knowledge of the species concerned. This development continued through future editions and is the beginning of reference citation and thus synonymy which permits the typification of Linnaean species formally named in the tenth edition.

Another novelty in this edition was the numbering of the species. Genera had previously been numbered in series throughout the Regnum Animale but in the sixth edition the species were numbered within each genus. This continued through the later editions of the *Systema naturae*, although in the tenth edition the specific epithet took priority over the number by being placed before it.

Within the class Pisces there were numerous additions at species level and a few new genera were recognised. The sequence of the two major orders (Acanthopterygii and Malacopterygii) was totally altered. In Plagiuri the genus *Physeter* was introduced with two species, both defined in sentence form from Artedi, and one of them formerly in *Balaena*, while two additions were made, one in *Balaena*, the other in *Physeter*. In Chondropterygii, there were species additions in the genera *Raja*, *Squalus*, and *Acipenser*. The names *Raja Clavata*, *R. Fullonica*, *R. Miraletus*, and *R. Oxyrinchus*, which continued into current usage through to the tenth edition, were all introduced here, while two trivial names of the earlier edition, *Raja Bos* and *R. Raja*, disappeared. Similar changes took place amongst the sharks including the introduction of *Squalus Stellaris* in addition to *S. Catulus* which was continued from early editions, two names which continued in Linnaean nomenclature for the same species which were later stabilized as *Scyliorhinus stellaris* (L., 1758) after many years of confusion.

In the order Branchiostegi innovations were few. A second species of *Lophius* (*Lophius Guajacuja*) was included in the genus, as it had been in the second edition although omitted from de Jussieu's fourth edition. In *Ostracion*, although the total number of species was the same as in the fourth edition, names had changed and new forms had been substituted. More importantly, the twenty-two species contained in the genus had been divided into four groups (Polyodontes quadranguli, Polyodontes trianguli, Tetraodontes, and Edentuli); the third of these was later (1758) to form the basis of the genus *Tetraodon*.

The order Acanthopterygii contained additions in five genera (*Sparus*, *Labrus*, *Blennius*, *Chaetodon*, and *Trachinus*) but these were of little significance. One addition, *Trachinus Lyra*, however, continued to cause confusion for some years, as this was the first recognition of the male of the dragonet *Callionymus lyra* L., 1758, the female of which had been for long known as *Cottus Dracunculus*, a name which featured in the tenth edition of the *Systema naturae* as *Callionymus dracunculus*. The striking sexual dimorphism of the dragonets was not reduced to nomenclatural unity until the nineteenth century. More importantly, within the Acanthopterygii was the introduction of the two new genera *Callicthys* and *Aspredo*. *Callicthys Tamoata* was not supported by a literary reference although meristic counts were given but it was originally introduced in Linnaeus (1746*a*) and this, no doubt, was the origin of the use of the name here. It reappeared in the ninth edition with a reference to Gronovius's *Museum Ichthyologium*, but in the order Malacopterygii, and subsequently became aligned with the other catfishes as *Silurus callichthys* in the tenth edition. *Aspredo Bague*, the sole species within the genus, was based on the descriptions in Linnaeus (1746*a* and 1749), this also was cited within Malacopterygii in the ninth edition, and likewise ended as *Silurus aspredo* in the tenth edition of the *Systema*.

Finally, the order Malacopterygii contained no new genera but additions to the total number of species were made to *Cyprinus*, *Gadus*, *Pleuronectes*, *Coregonus* and *Argentina*. In the second of these genera *Morrhua* was re-established as a trivial name and the confusion caused by de Jussieu's failure to recognise the cod and the ling as separate species was resolved. The complexity of the genus *Cyprinus* in the sixth edition, where it comprised thirty-eight species as opposed to twenty-six in the fourth edition, was a mute commentary on the difficulty Linnaeus, and other eighteenth and nineteenth century naturalists, found in defining the limits of species in this rather variable but speciose group.

Because in the sixth edition Linnaeus referred to his literary sources for authority in recognising species it is possible to assess the contributions each made to the total number of fish species he recognised. By far the most important, as has already been indicated, was the work of Artedi. References usually as *Art. syn.*, *Art. gen.*, sometimes as *A. g.*, and *Art. sp.* with a numeral, refer to Artedi's *Synonymia nominum piscium*, *Genera piscium*, and *Descriptiones specierum piscium*, respectively. The numeral usually refers to the numbered species account in the respective part, but sometimes when prefaced with p. is a page number reference. Artedi's work is referred to on one hundred and eighty-seven occasions. The second most important source is to the first edition (Linnaeus, 1746*b*) of the *Fauna Suecica*, Linnaeus's list of the animals of Sweden; references to this occur sixty-seven times, usually being cited merely as *Fn.* with the numeral following being the species number in the work. Sources of less frequent citation are *M. princ.*, *M. pr.*, or *M. Pr.*, again with numeral indicating the number of the species in the *Museum Principis* or *Amoenitates Academicae* (Linnaeus, 1749), the new edition of Balk's doctoral dissertation (see p. 168). Eight references are made to this publication. Four references (all within *Cyprinus*) are made to *Gron.* without title citation or page number cited. These refer to J. F. Gronovius (1741) who produced a list of fishes from the Netherlands (Pisces Beigii) which included fifty-eight fishes and two cetaceans. This paper must also have been the source of *Cyprinus Hamburgerus* although it is not cited as such, for Gronovius used this name for the crucian carp (now *Carassius carassius* (L., 1758). Three references were made to Linnaeus's (1747) account of his travels in West Gothland (*Wästgöta-Resa* . . .) as *It. W-goth.* (followed

Table I. *Analysis of species in Pisces described in the Systema naturae 1735–1756*

Order	1735	1740	1744	1748	1756
Plagiuri					
genera	5	5	5	6	6
species	10	8	8	12	13
Chondropterygii					
genera	4	4	4	4	5
species	22	22	22	30	31
Branchiostegi					
genera	4	4	4	4	4
species	14	15	30	31	31
Acanthopterygii					
genera	12	15	17	19	20
species	54	71	89	105	104
Malacopterygii					
genera	16	21	20	20	29
species	66	76	97	112	120
Total genera	41	49	50	53	64
Total species	166	192	246	290	299
Increase genera	–	8	1	3	11
Increase species	–	26	54	44	9

by a page number). A single reference to *Act. Stockh.* (under *Cyprinus Deaurata*) is a citation of Linnaeus's paper in *Swenska Vetenskaps Academiens Handlingar* volume 1 in which he described and illustrated the specimens of goldfish which had recently arrived in Sweden (Linnaeus, 1740*b*).

Nine of the species listed in this edition have no authority cited against them. Certainly, in two (*Callicthys Tamoata* and *Cyprinus Hamburgerus*) this seems to be due to the accidental omission of a reference, as both are traceable amongst Linnaeus's sources. Possibly this applies to the remaining seven also.

The sixth edition of the *Systema naturae*, like its predecessors was mainly a tabulation of the western Palaearctic fish fauna. Few exotic species were included and those, mainly in the genera *Ostracion*, *Balistes* and *Chaetodon* had been included from Artedi's careful synthesis of earlier workers' publications. It was, however, exceptional in that for the first time exotic species, mainly examples of the Neotropical fauna, were included, based on specimens in the collection of the University of Uppsala (these originated from the Crown Prince's donation of 1746). Some of these specimens are still extant and are the earliest Linnaean type material in existence.

Turning now to an examination of the ninth edition of the *Systema naturae*, we have to consider one of the most radical revisions of the work which exercised influence on Linnaeus's later editions but which, at the same time, showed how tenuous was his grasp of ichthyological concepts. The ninth edition was edited by Johan Frederic Gronovius (1686–1762), thus completing an involvement with Linnaeus's *Systema* ... which had begun in 1735 when, with Isaac Lawson, Gronovius had published the first edition. This edition was published in 1756 in Lugduni Batavorum (Leiden) in octavo, page size 120×203 mm. Sherborn (1899) claimed that this edition was substantially the same as the sixth edition but with some entomological additions by L. T. Gronovius from Réaumur and De Geer. He gives no authority for this claim, and although I have not made an exhaustive comparison I can find no references to Réaumur, and only two to De Geer in the Class Insecta. On the other hand Sherborn omitted to mention the numerous additions in the Class Pisces which stemmed from Laurens Theodore Gronovius's publication the *Museum Ichthyologicum* (1754). Soulsby (1933) credited J. F. Gronovius with being the editor of this edition, which seems more probable, and also refers to the use made of the works of Réaumur and De Geer, but claims that the additions to the fishes were made by the editor. This seems unlikely in view of the younger Gronovius's proficiency in the study of fishes. Certainly the general format followed that of the sixth edition and much of it appears to be reprinted word for word except that the Swedish names of the earlier edition have been replaced by French vernacular names (mostly identical with de Jussieu's fourth edition of 1744). However, in the Class Pisces there was major revision in the definition of the genera. For example, *Blennius*, which was characterised in three short phrases (eleven words) in the sixth edition, was now defined by five much longer phrases and a total of thirty-five words. This indicates that the revision of the fish section was carried out by the younger Gronovius who was distinguished by his interest in fishes and in his later years by an unrivalled collection both of fishes, other animals, plants, and minerals (Wheeler, 1958).

As in earlier editions the higher categories used were those originating from Artedi. Only minor changes occurred in the order Plagiuri and also in Chondropterygii with the exception of the addition of the genus *Callorynchus* which derived from Gronovius's description in the *Museum Ichthyologicum.* The species described reappeared in the tenth edition as *Chimaera callorynchus.* The order Branchiostegi was likewise unchanged from the previous edition. In the Acanthopterygii, however, there were major changes, chiefly additions, although two acanthopterygian genera of the sixth edition (*Callicthys* and *Aspredo*) were properly transferred to the Malacopterygii. More importantly, three new genera, *Polynemus, Mystus,* and *Holocentrus* were introduced from Gronovius's previous usage in the *Museum Ichthyologicum.* There were other, mostly minor, re-alignments, such as the removal of the dragonet, *Cottus dracunculus* to the new malacopterygian genus *Uranoscopus,* where it joined *Uranoscopus Lyra Harvicensis,* the polyverbal name for the male dragonet, now *Callionymus lyra* (see also above, p. 175) although *Trachinus Lyra* was allowed to stand. The genus *Scorpaena* was also added to by a third species *Scorpaena capite cavernoso* ... a reference which persisted under *Scorpaena scrofa* in the tenth edition.

In the order Malacopterygii not only was the sequence of genera altered but there were other substantial changes, both of omission and addition. Within *Cyprinus* six dubious species which had been admitted to the system in the sixth edition were omitted in the ninth, thereby bringing a little clarity into the complexity of the genus. Another deletion from the genus *Gadus of Gadus Silurus* (the Swedish Mahl of the sixth edition) led to the recognition of this European catfish (now *Silurus glanis* L., 1758) as a monotypic genus, *Silurus Silurus* in the ninth edition, although this was a name Gronovius had earlier used in the *Museum Ichthyologicum.* Additions to the system, in addition to *Silurus,* were a second species of *Gymnotus,* and of *Callichthys* (with the changed spelling of the name), which last, with *Aspredo,* was correctly removed from Acanthopterygii by Gronovius. Finally, there remains the series of new genera which were added to the system in this edition; *Plecostomus* (three species), *Atherina* (one species), *Uranoscopus* (three species—two of which belonged to the genus *Callionymus* in later usage), *Charax* (two species), *Gymnogaster* (one species), *Solenostomus* (one species), and *Silurus* (one species, which has already been discussed).

The innovations introduced by Gronovius, with one exception (*Gymnogaster Lepturus* which was cited from Artedi), all stemmed from his *Museum Ichthyologicum,* a work in which this twenty-four year old Dutch lawyer displayed his undoubted genius for the study of fishes. Three of the novel genera employed here, *Atherina, Uranoscopus,* and *Silurus,* referred to fishes from the western Palaearctic fauna, and it is noteworthy that all three were demonstratedly well founded being incorporated into the Linnaean system and in use today. What had greater significance, however, were the exotic genera introduced here. *Plecostomus, Charax,* and *Mystus* were Neotropical genera (all based on species found in the Dutch possession of Surinam), *Callorynchus* was representative of the fauna of the southern tip of Africa, again an area of Dutch influence. *Solenostomus* (*sensu* Gronovius, 1754) was a synonym of *Fistularia* Linnaeus 1754, a name which came to later validity in the tenth edition of the *Systema*. Gronovius's genus was used for a fish which originated on the Guinea coast of West Africa. *Polynemus* and *Holocentrus* were both genera which could have originated in the tropical Atlantic or Indo-Pacific. Apart from the few well-localised species and genera which had been introduced earlier, from Balk's dissertation, *Museum Principis* (Linnaeus, 1749), this was the first major injection of exotic forms made to the Class Pisces.

For reasons which are not clear the majority of these genera were rejected by Linnaeus in the later editions of the *Systema naturae,* although most of the species were accepted within earlier established genera. In this, Linnaeus showed an over-cautious attitude to the establishment of new genera and as a result extended generic limits beyond acceptable bounds. As the works of Laurens Gronovius published in his lifetime were mostly non-binominal his genera are not acceptable as of the date of their publication (his earliest works antedated 1758), and because of the failure of Linnaeus in the tenth edition of the *Systema* ... to adopt Gronovius's innovations in the earlier edition, names such as *Callorynchus, Mystus, Holocentrus, Callichthys, Plecostomus, Charax* (which are all in valid use today) had to be validated by later authors. It is interesting, however, to point out that both *Holocentrus* and *Polynemus* were names which Gronovius had employed from an Artedi manuscript which was (or had been) in the possession of Seba; his reference under *Holocentrus* attributes the name to Artedi 'Mss ad Sebam'.

To summarise this discussion of the sources used and development of the first nine editions of the *Systema naturae* certain trends must be pointed out. In the higher classification the names of the orders were those which Artedi had advocated in his manuscripts which survived his death in 1735. That they were given in the opposite sequence by Linnaeus does no appear to be especially significant although the logic of the change was probably to bring the Plagiuri (cetaceans) to the front of the class Pisces and thus into juxtaposition with the Amphibia. It is, incidentally, quite apparent that both Linnaeus and Artedi recognised that the Plagiuri were not fishes in the strict sense. The composition of the species included was predominantly that of the faunas of northern Europe and the Mediterranean with a very few exotic forms included and these mostly representing the more striking and noticeable elements of the tropical faunas. By 1748, however, there had been a substantial influx of representatives of the Neotropical freshwater fish fauna, and some from tropical West Africa and the Indo-Pacific. This change was an enrichment resulting from the collection of specimens for private museums (and not just the acquisition of casually collected curios) and set the pattern that was to be followed increasingly during the second half of the eighteenth century and later, leading eventually to large national museum collections. Later editions of the *Systema* ... were to list this increasing flow of new material, culminating in the large collections brought back to Europe by Linnaeus's students, or sent by his correspondents, during his last years and immediatley after his death.

Fishes in the Systema naturae 1758–1766

The significance of the tenth edition of the *Systema naturae* was both that it represented the first occasion in which binominal nomenclature had been applied to all groups of animals known, that its classification of fishes was radically revised, and that the addition of exotic forms increased dramatically. In place of the five Artedian orders Plagiuri, Chondropterygii, Branchiostegi, Acanthopterygii, and Malacopterygii, Linnaeus (1758) proposed five orders within the class Pisces (Apodes, Jugulares, Thoracici, Abdominales, and Branchiostegi) and Amphibia Nantes for the remaining fish-like vertebrates. The Amphibia Nantes comprised the former Chondropterygii plus *Lophius,* formerly in Branchiostegi. The Apodes, characterised by the lack of pelvic fins, comprised genera which had been previously assigned to Malacopterygii, with *Xiphias* being the sole Acanthopterygian included. Jugulares, characterised by the placement of the pelvic fins in front of the level of the pectorals, was a small order containing mostly Malacopterygii, although the acanthopterygian genera *Ophidion* and *Blennius* were also included (and the limits of the pre-1758 genus *Uranoscopus* had been redefined with *Callionymus* split off from it). The Thoracici, which had the pelvic fins placed beneath the pectoral fins was chiefly concerned with genera hitherto placed in Acanthopterygii, although several had been in Malacopterygii, and one (*Cyclopterus*) had previously been in Branchiostegi. The order Abdominales, members of which had pelvic fins placed behind the level of the pectoral fins, was likewise a mixture of genera placed previously in Malacopterygii and Acanthopterygii, although most were in the former category. The order Branchiostegi comprised fishes which appeared to lack a gill cover ('Apertura Destituta operculis pinnisve branchialibus') and included the former members of this order with the addition of *Syngnathus* which was removed from the Malacopterygii.

Although the Linnaean arrangement of 1758 was novel it was hardly an improvement on the earlier higher classification that Artedi had proposed. In fact, it proved short-lived in the sense that major alteration was required in the twelfth edition (1766) of the *Systema naturae*, and the only group name which acquired a significant length of life was Apodes, which in the greatly modified sense to include only eels, was in use until the mid-twentieth century. As a hierarchical classification it was of no validity but as a means of providing convenient "pigeon holes" into which all the known fish genera could be fitted it was valuable as it depended simply on the form of the gill covers and absence or presence and position of the pelvic fins in relation to the pectoral fins. As a convenient means of breaking down the mass of known fishes into five easily recognisable fractions it was outstanding, and this was the strength of Linnaeus's genius in this group as it was in the whole realm of natural creation.

In the twelfth edition of the *Systema* ... (Linnaeus, 1766*b*) the four major classes of bony fishes were retained, Apodes (with the addition of *Ophidium* from the Jugulares), Jugulares otherwise unchanged, Thoracici with one new genus but otherwise unaltered, and Abdominales with *Mormyrus* added (formerly a branchiostegan fish) and three new genera. There was, however, a major change in that the Branchiostegi of 1758 were now classed within Amphibia Nantes with the cartilaginous fishes, and *Cyclopterus* (formerly in Thoracici and earlier in Branchiostegi) joined them. This radical reorganisation, which brought the sharks, rays, puffer-fishes, angler fish, and lumpsucker together, seems incongruous to modern eyes, but was nevertheless founded on the apparently logical assumption that as the component parts had restricted gill openings with either no, or poorly developed gill covers, and had either cartilaginous or lightly calcified skeletons (which looked similar to cartilage), they should be grouped together. While this twelfth edition classification was in no sense an improvement in the systematic sense it continued to enjoy the advantage that it was a logical classification which permitted all fishes known to be categorised.

Several novel genera were introduced into taxonomy in these two editions. In the tenth edition the new genus *Trichiurus* was employed in Apodes as a substitute for *Gymnogaster* used by Gronovius in the ninth edition. In Jugulares Linnaeus erected the genus *Callionymus*, finally disentangling it from *Uranoscopus*, which was here (1758) used in the restricted modern sense with the stargazer, *Uranoscopus scaber*, as its type species. Unfortunately, Linnaeus's clarification did not extend to uniting the male and female European dragonet (now *C. lyra*) into the same species! No additions were made to this order in the twelfth edition. In Thoracici the most significant innovation of the tenth edition was the creation of the genus *Mullus* for the red mullets which had hitherto been bracketed with the gurnards in the genus *Trigla*. The name *Mullus* was not, of itself new, having been used in the work of Ray (1686) and others for the red mullets, although Artedi had united the two groups under the name *Trigla*. In the twelfth edition the novel genus *Cepola* appeared in the system, having been first used in the second volume of the *Museum Adolphi Friderici Regis* (Linnaeus, 1764), but the species it represented had earlier been included in the tenth edition as *Ophidion macrophthalmum*.

The class Abdominales in the tenth edition contained thirteen genera of which two, *Loricaria* and *Fistularia* were new. The former was derived from the first volume of the *Museum Adolphi Friderici Regis* where this armoured catfish is described and figured (Linnaeus, 1754*a*). *Fistularia* was also based on the same work and, as already shown, replaced *Solenostomus* of Gronovius (1754); Gronovius was also cited under *Loricaria* but here he had used the genus name *Plecostomus*. The twelfth edition of the *Systema* contained three novel genera, *Amia, Teuthis*, and *Elops*. Both *Amia* and *Elops* were genera proposed here to contain species from eastern North America sent to Linnaeus by Alexander Garden (see p. 184). *Teuthis* originated in Patrick Browne's (1756) use of the name in *The Civil and Natural History of Jamaica . . .*; there was no doubt as to the correctness of both authors in recognising it as a distinct genus, although the name has subsequently been rejected in favour of *Siganus* (Forsskål, 1775).

Some of the most radical changes in the tenth edition were to be found in the order Branchiostegi, hitherto one of the smallest but most speciose groups in Linnaeus's classification. The most important of these innovations was in splitting the genus *Ostracion* of the ninth, and earlier editions, into three genera, *Ostracion, Tetraodon,* and *Diodon,* a move commenced in the sixth edition of 1748 (see p. 176). Apart from the inclusion of the ocean sunfish (now *Mola mola*) within *Tetraodon* (which was logical in that they have four teeth in the jaws), this division into genera foreshadowed the later recognition of the three main families (*Ostraciontidae, Tetraodontidae,* and *Diodontidae*) within the modern order Tetraodontiformes. That Linnaeus's three 1758 genera had been elevated to family status two centuries later shows both the increase in the number of species recognised later and also his perspicacity in the differentiation of the groups. Other new genera in this order were *Mormyrus,* introduced in the *Museum Adolphi Friderici Regis* (Linnaeus, 1764) on the basis of Hasselquist's specimens collected in the Nile, and *Pegasus* which also had been first used in this work although the first description of the genus had been by Gronovius (1754) as 'Pisciculus Amboinensis volans ...'. With the exception of *Mormyrus* all the Branchiostegi were transferred to Amphibia Nantes in the twelfth edition, joining the genera already included in that order in the tenth edition.

To summarise, there was some extension of Linnaeus's knowledge of fishes shown in the tenth edition of the *Systema naturae,* mainly stemming from his own studies of the royal collections in Sweden (which included Hasselquist's specimens from North Africa and the eastern Mediterranean). Discoveries published by Gronovius (1754 and 1756) and by Linnaeus in his study of Lagerström's Chinese collections (Linnaeus, 1754*b*) had increased the number of exotic fishes recognised. In addition, there had been considerable clarification of several European genera and generic features. The twelfth edition carried these extensions still further, principally from the *Museum Adolphi Friderici Regis* (Linnaeus, 1764), Gronovius's *Zoophylacium* ... (1763), and from the large collections of Alexander Garden in South Carolina. The increase in the number of exotic genera and species was significant, and this was to continue after Linnaeus's death as the collections made by his students, correspondents, and others influenced by him were described and assimilated into ichthyological knowledge. More importantly, there was a change of emphasis from the largely literary compilation of Artedi which

Table II. *Analysis of species and genera in the* Systema naturae *1758 and 1766*

Order	1758	1766
Amphibia Nantes		
genera	6	14
species	36	76
Apodes		
genera	7	8
species	15	20
Jugulares		
genera	6	5
species	35	35
Thoracici		
genera	17	17
species	187	219
Abdominales		
genera	13	17
species	100	127
Branchiostegi		
genera	8	–
species	41	–
Total genera	57	61
	413	477
Decrease in genera (from ed. IX)	7	3
Increase in species (from ed. IX)	114	178

had been the framework for the earliest editions of *Systema naturae* to descriptions of specimens in collections on which many of the additions were based. These collections, now mainly in museums in Uppsala, Stockholm, and London, form the foundation collections of present-day systematic ichthyology.

It is instructive to make a brief numerical comparison of the fishes in these two editions of the *Systema* ... Clearly the numbers of species and genera within each order are not directly comparable because of the changes within and between them as discussed earlier, but the total number of taxa are comparable (as they are with those presented in table

I for earlier editions of the *Systema naturae*). The two outstanding differences shown by this comparison are the striking increase in the number of species between 1758 and 1766, and the fewer genera recognised in 1758 compared with Gronovius's ninth edition of 1756. The first is a convenient indicator of the increase in knowledge of fishes due mainly to the existence of museum collections and active collectors. The second is an indication of Linnaeus's uncertainty of the limits of fish genera and perhaps an innate conservatism which caused him to either ignore or occasionally to substitute names for some of the new genera proposed by the Dutch zoologist Laurens Gronovius.

The sources used for fish taxa in the tenth and twelfth editions of the Systema naturae

Because of the importance of the tenth edition of the *Systema naturae* to zoological nomenclature study of the sources used by Linnaeus is of considerable consequence in modern taxonomy. Very few of the species names that Linnaeus used in 1758 were directly referred to a single specimen which could in modern terms be regarded as a holotype. Most of his species names are followed by references to earlier descriptions, a few only being based on a single reference, and it is to these descriptions which one has to turn to establish the taxonomic limits or validity of Linnaeus's binominal species. In some cases the original specimens on which these earlier descriptions were based are still in existence and have a certain standing as type specimens. In citing these references Linnaeus abbreviated the title of the work concerned or gave a reference of another kind; most of these abbreviations are cryptic and because of changes in journal titles or the use of a special abbreviation, are difficult to identify today. For this reason a complete listing is given of the sources cited by Linnaeus for fishes. It also casts an interesting light on the contribution made to taxonomic ichthyology by various authors or collectors, information which may be of use to biographers or historians of natural history.

As a large number of new taxa were introduced in the twelfth edition of the *Systema* ... the sources in this edition have also been included.

The list is arranged in alphabetical order of the abbreviation used by Linnaeus. References from both editions are incorporated into the single list. The full title of published works, or an explanation of the abbreviation is given, together with any variation in the citation within or between the two editions. The total number of citations of the source is given for the tenth edition, and the number of additions to this total in the twelfth edition; also the number of occasions in which the reference is the sole source cited is given. In the case of serial publications the abbreviated title of the journal is given in World List style.

Sources which are not literary in nature, i.e. citations of specimens in museum collections, are included in the list in alphabetical order as cited by Linnaeus.

Act. angl.

Ed. X: 249, *Callionymus lyra.* Edward Tyson 1704 Cuculus Laevis caeruleo flavescens, cui in sypremo Capite Bronchiarum Opercula. Or, The Yellow Gurnard. *Philosophical Transactions* [of the Royal Society] Sept.–Oct. 1704, no. 293: 1749–1753, tab. 5. [*Phil. Trans. R. Soc.*]

Ed. XII: 462, *Chaetodon rostratus.* John Albert Schlosser 1765 An Account of a Fish from Batavia, called Jaculator: In a Letter to Mr. Peter Collinson, F.R. S. from John Albert Schlosser, M.D., F.R.S. *Philosophical Transactions LIV* (1764): 89–91, tab. IX.

[Figure of *Chaetodon rostratus,* later *Chelmon* rostratus, with an account of the behaviour of Toxotes sp. based on the observations of Mr Hommel, governor of the hospital at Batavia; the confusion between these species persisted for many years after the publication of this note.]

Act. bonon.

Ed. X: 334, *Tetraodon mola* [Janus Planchus = pseudonym Simon Giovanni Bianchi] Jani Planci Ariminensis (ad Josephum Montium) 1746 De Mola Pisce. *Reale Academia della Scienza dell'Instututo,* Bologna *2,* (2): 297–303 [pl. p. 304]. [*Comment. bonon. scient. Inst. Acad.*]

[The figure suggests that the fish described was *Ranzania laevis* (Pennant, 1776), not *Mola mola* (L., 1758).]

Act. harl.

Ed. XII: 427, *Gymnotus electricus.* J.N.S. Allamand 1758 Kort verhaal van de uitwerkzelen, welke een Americaanse vis veroorsaakt op de geenen die hem aanraaken. *Verhandelingen ... Hollandse Maatschappy der Wetenschappen te Haarlem 2:* 372–379. [*Verh. holland. Maatsch. Wet.*]

[See also *Baster act. harlem.*]

Act. helv.

Ed. XII: 427, *Gymnotus electricus.* Laur. Theodori Gronovii 1760 Gymnoti tremuli descriptio, atque experimenta cum eo instituta. *Acta Helvetica Physico-Mathematico-Anatomico-Botanico-Medica.* Basileae *4:* 26–35, tab. III, figs. 1–3. [*Acta helv.*]

Ed. XII: 434, *Callionymus dracunculus.* Laurentii Theodori Gronovii 1760 Animalium in Belgio Habitantium (centuria prima). *Tom. cit.*: 243–270.

[The description cited is No. 125 of Gronovius's account.]

Act. nidros.

Ed. XII: 452, *Cottus scorpius.* Henrich Tonnings 1765 Beschreibung des Fisches Sympen (Ulk). *Drontheimischen Gesellschaft Schriften aus dem Dänischen übersetzt.* Kopenhagen. *2:* 312–316, tab. XIII. [Dronth. Ges. Schr.]

[Linnaeus cited this pagination as 345. See also *Gunn*[erus] *act. nidros.*]

Act. petr.

Ed. XII: 511, *Salmo argentinus;* 524, *Clupea sima.* J. T. Koelreuter 1763 Piscium rariorum e Museo Petropolitano exceptorum descriptiones. *Novi Commentarii Academiae Scientiarum Imperialis Petropolitanae. 8* (1760–1761): 404–430, tab. XIV [figs. 1–3 *Clupea sima,* fig. 4. *Salmo argentinus*]. [*Novi Comment. Acad. Sci. Imp. Petropol.*]

[*Salmo argentinus* was cited by Linnaeus with the page reference 404 which is the first page of Koelreuter's paper; Koelreuter's description occupies pp. 413–421. The specimen described was preserved in spirits of wine.

Clupea sima was described on pp. 405–412, following citations of Gronovius's (1756) *Museum Ichthyologicum 2,* no. 155, tab. 7, fig. 5 account of *Gasteropelecus,* and Linnaeus's (1758) binomen *Clupea sternicla.* Despite the locality given for the specimen, 'ex Insula Zeylan ...', and the fact that the adipose fin is omitted from the illustration, the fish appears to be a gasteropelecid characin, and for this reason must have originated in the New World. Koelreuter's description and a specimen in the collection of the Royal Academy of Science, Stockholm (*Mus. acad. holmens.*) were the sources for this species in Linnaeus (1766*b*).]

Act. Stockh.

Ed. X: 258, *Blennius viviparus.* Nils Gissler 1748 Beskrifning På Tånglaken. *Kongliga Swenska Vetenskapsakademien. Handlingar 9* (Jan.–Mart. 1748): 37–43, tab. II. [*K. svenska Vetensk. Akad. Handl.*]

[Pagination (p. 32) given by Linnaeus (1758) is incorrect.]

: 261, *Coryphaena pentadactyla.* T. Ankarcrona 1740 Beskrifning öfver Femfingers Fisken ingifven af Vice-Ammiralen Ankarcrona. *loc. cit. 1* (Oct.–Dec. 1740): 457–461, tab. III, fig. 2.

[Ankarcrona is also spelled Ankarkrona. Fish illustrated is a *Novacula* (Labridae) from China.]

: 295, *Gasterosteus ductor.* Pehr Osbeck 1755 Beskrifning om en Fisk, som kallas Lods. *loc. cit. 16* (Jan.–Mar. 1755): 71–74

[Osbeck's description of the fish *Naucrates ductor* (L.) was made from specimens obtained in 1751 during his voyage to China.]

: 304, *Silurus glanis.* Pehr Osbeck 1756 Beskrifning öfver Fisken Mal. *loc. cit. 17* (Jan.–Mar. 1756): 34–39, tab. III [2 figs].

: 310, *Salmo lavaretus.* Nils Gissler 1753 Anmärkningar om sik-fisket uti Norrländska Älfver och Skärgårdar. *loc. cit. 14* (Jul.–Sept. 1753): 195–209.

: 322, *Cyprinus auratus*. Carl Linnaei 1740 Bescrifning om Guld-Fisken och Silfver-Fisken. *loc. cit. 1:* 403–410, tab. I, figs. 3–8.

Act. Ups.

Ed. X: 321, *Cyprinus carassius;* : 324, *C. rutilus;* : 325, *C. alburnus*. J. F. Gronovius 1741 Pisces Belgii seu Piscium in Belgio natantium, et a se observatorum catalogus. *Acta Societas Regiae Scientiarum Upsaliensis* (1746): 67–76. [*Acta Soc. R. Scient. upsal.*]

Ed. XII: 529, *Cyprinus grislagine*. Carolo Linnaeo 1744 Cyprinus pinnae ani radiis XI, pinnis albescentibus. *Faun. Svec.* 325. Staem Svecis. Descriptus a Carolo Linnaeo. *loc. cit.* (1751): 35–36, tab III.

[Se also entries under *Gron. Act. Ups.*]

Amoen. acad.

Ed. X, 18 references; two of which, under *Labrus linearis* (: 287) and *Perca radula* (: 294), are the sole basis of the binomen. All 1758 references are to the Museum Adolpho-Friedericianum sub praesidio D.D. Car. Linnaei propositum a Laurent Balk, (May 31, 1746). *Amoenitates Academicae 1,* Holmiae et Lipsiae 1749: 277–327, tabs. XIII–XIV.

[Linnaeus cited the "Linnaeus edition" of the *Amoenitates Academicae,* not the original printings of the dissertations. This dissertation is also referred to as *M. Pr.,* or *M. princ.* in the ninth edition of the *Systema naturae* (1756), an abbreviation of the running title of the Linnaeus reprint, Museum Princeps. Fishes in this edition occupy pages 307–322 and tab. XIV. The pagination of the Balk (1746) thesis in its original printing was 1–48, tab. I–II; fishes occupy pages 29–43.]

Ed. XII. 5 additional references. All the 1766 references are to the dissertation, LXI Chinensia Lagerstromiana, praeside D.D. Car. Linnaeo proposita a Johann Laur. Odhelio, (December 23, 1754). *Amoenitates Academicae … 4,* Holmiae 1759: 230–260 (1 pl.).

[Fishes occupy pages 246–252 in the 1759, Linnaeus edition. Odhelius's original dissertation title was Specimen Academicum sistens Chinensia Lagerströmiana …, Holmiae, 1754: 1–36 (1 pl.); fishes occupy pp. 20–27.

References under *Clupea thrissa* and *C. mystus* (: 524) to *Amoen. acad.* 5 were in error.

In Ed. X the Odhelius dissertation was referred to as *Chin. Lagerstr.* (*q.v.*).]

Art. gen., Art. syn. or *Art. spec.*

Ed. X. 241 references; 71 of which were the sole source for the species name.

Ed. XII. 4 additional references, 3 of which were in new taxa, 1 being the sole source of the name. Petri Artedi 1738 *Ichthyologia sive opera omnia de Piscibus …* Eddit Carolus Linnaeus. Conradum Wishoff, Lugduni Batavorum. In five parts separately paged.

[*Art. gen.* refers to the *Genera Piscium …,* the third part of the book.

Art. syn., or *syn.* when preceded by a reference to *Art. gen.* refers to the *Synonymia nominum piscium …,* the fourth part of the book.

Art. spec., or *spec.* when preceded by other references to Artedi's work refers to the *Descriptiones specierum piscium* ..., the fifth section of the *Ichthyologia*.

Numerals following these abbreviated references refer to the pagination of the individual section.]

Barrer. aequin.

Ed. X: 307, *Silurus callichthys*. Pierre Barrère 1741 Essai sur l'histoire naturelle de la France equinoxiale ... Chez la Veuve Piget, Paris pp. xiv+1–315+[viii].

[The single reference to Barrère is to p. 175 and the whole of his description follows; 'Mullus palustris, minor, loricatus. Tamoata Marcg. Gorret.' Barrère's account was based on observations made during a visit of three years' duration to Cayenne from 1722.]

Baster act. harlem.

Ed. XII: 425, *Cyprinus auratus*. Job Baster 1763 Natuurkundige beschrijving van den Kiu-yu of Goud-vis. *Verhandelingen ... Hollandse Maatschappye der Wetenschappen te Haarlem* 7: 215–246, [folding pl.] figs. I–IX. [*Verh. holland. Maatsch. Wet.*]

Bell. pisc. or *Bellon pisc.*

Ed. X, 9 references.

Ed. XII, 1 additional reference.

Petri Bellonii [Pierre Belon] 1553 *De aquatilibus, libri duo ... Carolum Stephanum, Parisiis, pp.* [xxxii]+448.

[All the references to Belon's work were made by Linnaeus in the first order Amphibia Nantes; it is curious that he made no references to Belon in the class Pisces. In contrast, Belon's work was cited by Artedi for all groups.]

Bont. jav.

ED. X: 331, *Ostracion cornutus*. Jacobi Bontii [Bontius] 1658 *Historiae naturalis & medicae Indiae orientalis libri sex* ... pp. 1–160. *In* Gulielmi Pisonis 1658 *De Indiae utriusque re naturali et Medica*. Amstelodami, apud Ludovicum et Danielem Elzevirios. [3 parts separately paged.]

[Bontius's title in the contents list is *Bataviae in majore Java novae medici ordinarii* ... The single reference made by Linnaeus is to page 79 'Caput XXVI De Pisciculo Cornuto, seu Ican Setang'; there is an unnumbered figure.]

Borlac cornub.

Ed. XII: 402 *Lophius piscatorius*. William Borlase 1758 *The natural history of Cornwall* ... Oxford, printed for the Author, pp. xix+326+[ii].

[Chapter XXIII, pp. 261–282 is concerned with fishes and includes many invertebrates. Many of the observations on fishes originated in the manuscripts of the Rev. George Jago. Linnaeus cited page 265, tab XXVII, fig. III, the Frog-fish.]

Bradl. natur.

Ed. X: 338, *Syngnathus hippocampus*. Richard Bradley 1721 *A philosophical account of the works of nature* ... London, W. Mears, pp. [xx]+194.

[Linnaeus refers to t.4. f.3. (Plate IV, Fig. III); the explanation of the figures for this number reads 'Fig. III The Shell-fish call'd the Sea-Horse, found upon the Coast of Italy; taken from the Royal Society'. Other fishes are described in this work but the descriptions were not cited by Linnaeus.]

Brander, E.

Ed. X: 245, *Muraena caeca;* :259, *Ophidion macrophtalmum.* [Specimens originating from Erik Brander (1722–1814), ennobled as Skjölderbrand in 1767. Swedish consul at Algiers from 1753–65 obtained much natural history material (insects, molluscs, amphibians, and fishes from the vicinity of Algiers and the western Mediterranean. His fishes were preserved in 'brännvin' (brandy) according to Löwegren (1952); neither is now identifiable in the extant Linnaean collections. See also Dance (1967).]

Brown. jam.

Ed. X. 10 references.

Ed. XII. 10 additional references of which 7 were to previously undescribed taxa. Patrick Brown 1756 *The civil and natural history of Jamaica.* London, for the author, pp. viii+503.

[References by Linnaeus are to page numbers in Browne, and in some cases to plates. Fishes occur on Tabs. 45–48, nine species being illustrated.]

Brun. it. or *Brunn. it.*

Ed. XII: 404, *Acipenser rutheneus,* and :490 *Gasterosteus ductor.*

[Probably a citation of an edition of Cornelius Bruyn (1698) *Reizen door de vermaardste deelen van Klein Asia, de eylandan Scio, Rhodus, Cyprus enz. mitsg. de voornaamste steden van Aegypten, Syrien, en Palastina et.,* Delft. Dean (1923) lists several English and French translations and made the comment "This author was a painter, not a naturalist, and his drawings and descriptions of fishes are more interesting than reliable". The citation by Linnaeus of *Gasterosteus ductor* (ed. XII: 490) as 'p. 325, t. 190 Loots mannekens' suggests that he was quoting a Dutch edition. I have not been able to examine a copy of this work.]

Brunnich, M. T.

Ed. XII: 464, *Chaetodon argus.*

[Citation of an unpublished communication from M. T. Brunnich. 'Habitat in India; e Mus. Schlosseri.' This was the same specimen that was described and illustrated from J. A. Schlosser's collection by Petri Boddaert 1770 *Epistola ad virum celeberrimum Johannem Burmannum ... de Chaetodonte Argo ... ex Museo ... Johannis Alberti Schlosseri ...* Amstelodami, apud Cornelium van Tongerlo, pp. [iv]+44+[1 col. pl.]. This specimen was presented to L. T. Gronovius by Boddaert and is still preserved in the Gronovius collection (Wheeler, 1958).]

Catesb. car. or *Catesb. carol.*

Ed. X. 24 references, 11 of which were the sole source for the name.

Ed. XII. 14 additional references of which 12 were to taxa introduced in

1766. Mark Catesby 1731–43 *The natural history of Carolina, Florida, and the Bahama Islands:* ... London, Benjamin White, vol. I, xiv+1–100; vol. II, [ii]+1–100+[vi]+Appendix 1–20+[ii].

[The fishes appear in volume II pp. 1–31 and the Appendix p. 19, plate 20 (*sic*).]

Charl. onom.

Ed. X: 236, *Lophius piscatorius.* Gualtero Charletono [Walter Charlton] 1668 *Onomasticon zoicon, plerorumque animalium differentias & nomina propria pluribus linguis exponens* ... Londino, apud Jacobum Allestry, pp. [xx]+1–[310]+[xxxiv].

[The description of the angler fish and its anatomy is on pp. 199–207, 'Ranae piscatricis anatome' Fig. 1. Another edition is dated 1671 with unchanged pagination.]

Chin. Lagerstr.

Ed. X. 10 references, one of which (*Chaetodon argenteus:* 272) was the sole source for the binomen. [C. Linnaeus] 1754 *S.N.A. Specimen Academicum, sistens Chinensia Lagerströmiana ... Johann Laur. Odhelio* (December 23, 1754), Holmiae, Jacob Merckell, pp. 1–36+[1 unnumbered plate].

[Tenth edition references are all to the original printing of Odhelius's dissertation in this form. In the twelfth edition references for four species, none novelties (*Labrus opercularis, Scomber trachurus, Clupea thrissa, Clupea mystus*) were to the reprinted dissertation in *Amoenitates Academicae 4* (1759), (see *Amoen. acad.*). In the original printing fishes occupy pp. 20–27.]

Clus. exot.

Ed. X: 236, *Squalus pristis, Chimaera monstrosa;* :328, *Balistes tomentosus.* Carolus Clusius [Charles de Lécluse] 1605 *Exoticorum libri decem: quibus animalium, plantarum, aromatum, aliorumque peregrinorum fructuum historiae describuntur* ... [Leiden], pp. [xiv]+1–378+[x].

[The pages cited by Linnaeus are: 136 Figure of *Pristis,* the description 'Pristis sive Serra. Cap XIX' being on p. 135; :136 'Galei genus Cap. XX' (=*Chimaera*), figure on p. 137; :143 'Monoceros pisciculus Cap. XXVIII', figure on the same page.]

Columm. ecphr. or *Columm. aquat.*

Ed. X: 232, *Raja aquilla,* : 232, *Raja altavela.*

Ed. XII: 397, *Raja pastinaca β* as *Columm. aquat.*

Fabio Columna [Colonna] 1606 *Minus cognitarum stirpium aliquot ... De aquatilis libellus, eodem auctore.* Romae, Apud Guilielmum Facciottum. pp. [viii]+1–340+i–lxxiii+[vii].

[The section *Aquatilium et terrestrium aliquot animalium* occupies pp. i–lxxiii. Linnaeus (1758: 232) referred to p. 3 t. 2. and the, very brief, account of 'Pastinaca marina laevis altera aquilone dicta' occurs on p. iii, the figure on p. ii. The account of 'Pastinaca marina altera Atlavela' is on p. iv and the figure on p. ii. Neither amounts to a significant description.]

E. Brander see *Brander, E.*

Edw. av.

Ed. X: 277, *Chaetodon lanceolatus;* : 317, *Polynemus paradiseus* (sole source for this binomen); : 322, *Cyprinus auratus.* George Edwards 1751 *A natural history of birds* ... pt. IV. London, for the author, pp. 236.

Ed. XII. 6 references none of which were in new taxa. George Edwards 1760 *Gleanings of natural history* ... Pt. II. London, for the author, pp. xxxv+220.

Fn. svec. or *Faun. svec.*

Ed. X. 65 references. Caroli Linnaei 1746 *Fauna Svecica sistens animalia Sveciae Regni: Quadrupedia, Aves, Amphibia, Pisces, Insecta, Vermes,* ... Stockholmiae, Laurentii Salvii. pp. [xxviii]+1–411+tabs. I–II. [Also published with imprint Lugduni Batavorum, Conradum Wishoff & Georg. Jac. Wishoff.]

[All Ed. X references are to this first edition of the *Fauna Svecica* ... in which the fishes occupy pp. 100–127, and tab. II (one figure of a goldfish). Cited with a numeral which is the species number in *Fauna Svecica* not the page number. Five species (: 258 *Blennius raninus,* : 287 *Labrus exoletus,* : 320 *Cyprinus carpio,* : 321 *Cyprinus carassius* and *C. tinca*) for which no source was given in 1758 are attributed to *Fn. svec.* in the twelfth edition.

Ed. XII. 23 references. Caroli Linnaei 1761 *Fauna Svecica sistens animalia Sveciae Regni: Mammalia, Aves, Amphibia, Pisces, Insecta, Vermes* ... Editio Altera. Stockholmia, Laurentii Salvii, pp. [xlviii]+579.

[References to *Fn. svec.* in the twelfth edition of the *Systema* ... are to this second edition. The numeral given in the reference refers to the number of the species not the pagination.]

Fresier. itin.

Ed. X: 236, *Chimaera callorynchus.* Amédée François Frezier 1717 *A voyage to the South-Sea, and along the coasts of Chili and Peru, in* ... *1712–14* ... *Describing* ... *their natural history, mines etc.* London, Jonah Bowyer, pp. [x]+1–335+[ix].

[This English edition has the description of *Callorynchus* on p. 121, pl. XVII; 'Elefant Pejegallo ou Poisson Coq' are given as names on the plate, 'Pezegallo' on text margin p. 121. Linnaeus (1758) referred to Prezier's work as 'vol. 1, p. 211, t. 17, f. 4. Pejegallo' which suggests that he was not citing the English edition of the work, which is in a single volume. The coincidence of plate number is explained by the plates in the English edition being a faithful copy of those of an earlier edition even down to the mis-spelled English name. Earlier editions in French are dated 1716 and 1732, but I have not seen a copy.

As a taxonomic aside it is worth noting that *Chimaera callorynchus* L., 1758 is based on Gronovius's description of a southern African specimen and Frezier's account of a Chilean specimen; taxa which are currently considered to be distinct.]

Garden

Ed. XII. 41 references, 37 of which were for new taxa, and 20 were the sole source for the name.

[These references are to specimens sent to Linnaeus by Alexander Garden of Charles Town, South Carolina between 1760 and 1766 (continuing to 1771). Most of these speciemens came from South Carolina but some were collected in the Bahamas. Eighty-four skins of fishes collected by Garden are preserved in the Linnaeus collection of the Linnean Society of London (Günther, 1899).]

Gesn. pisc.

Ed. X. 20 references, all in the order Amphibia Nantes. Conr. Gesneri [Conrad Gessner] 1620 *Historiae animalium Liber IV. Qui est de piscium & aquatilium animantium natura* ... Editio secundus novis iconibus ... Francofurti, Henrici Laurentii, pp. [xxxviii]+1–1052+30.

[The pagination given by Linnaeus against references to Gessner's work agree with this edition, not the first edition of 1558].

Gouan.

Ed. XII: 442, *Blennius phycis.*

[Citation of the letter of 8 January 1760 (Limm. Corresp. 5 folio 144) from Antoine Gouan (1733–1821) of Montpellier. Gouan later (1770) published *Historia Piscium* ... Argentorati [Strasbourg], Amandi König, pp. xviii+252.]

Grew. mus.

Ed. XII: 517, *Esox brasiliensis.* Nehemiah Grew 1681 *Museum Regalis Societatis or a catalogue & description of the natural and artificial rarities belonging to the Royal Society* ... London, for the author, pp. [x]+1–386+[ii].

[Fishes occupy 'Sect. V of Fishes', pp. 81–119, tabs. 7–8. Linnaeus's citation was to p. 87, tab. 7 the 'Under Swordfisk'.]

Gron. Act. Ups

Ed. X: 249, *Callionymus lyra.* J. F. Gronovius 1740 Cottus ossiculo pinnae dorsalis primo longitudinae corporis. Descriptus a Jo. Fr. Gronovio. *Acta Soc. R. Scient. upsal.* (1744): 121–123, tab. VIII.

: 251, *Trachinus draco;* :253, *Gadus virens;* : 255, *Gadus mustela;* : 258, *Blennius viviparus;* : 303, *Cobitis fossilis.* J. F. Gronovius 1742 Pisces Belgii. Descripti a Joanne Frid. Gronovio. *loc. cit.* (1748): 79–107, tab. III.

: 290, *Perca labrax;* : 298, *Scomber cordyla.* J. F. Gronovius 1750 Pisces duo. Descripti a Jo. Fr. Gronovio. *loc. cit.* (1751): 36–42, tab. IV.

[See also entry under Act. Ups.]

Gron. mus.

Ed. X. 109 references, eight of which were the sole source for the species name.

Ed. XII. 8 additional references, two of which were undescribed species and for one the sole source of the name. Laurentii Theodor Gronovii [Laurens Theodore Gronovius] 1754 *Museum ichthyologicum, sistens piscium* ... Lugduni Batavorum, apud Theodorum Haak, pp. [viii]+1–70, tabs I–IV.

1756 *Museum ichthyologici tomus secundus* ... Lugduni Batavorum, apud Theodorum Haak, pp. [vi]+1–88, tabs. V–VII.

[References to *Gron. mus.* are ususally followed by the volume number as the numeral 1 or 2, and by the number of the species description in the work (preceded by the letter *n*). In the twelfth edition such references also occasionally bear the page number.]

Gron. zooph.

Ed. XII. 57 references, thirteen of which were to previously unnamed species and two of which were the sole source for the species name. Laur. Theod. Gronovius 1763 *Zoophylacii Gronovianum fasciculus primus exhibens animalia quadrupeda, amphibia atque pisces* ... Lugduni Batavorum sumptibus auctoris, pp. ii+136+2+tabs. I–VIII, VIII*a*, IX–XIII.

[Title page for the whole work, issued with the third fascicule is entitled *Zogphylacium Gronovianum* and dated 1781. In citations of this work by Linnaeus the number given is the species number not the page number.]

Gunn. act. nidros. or *Gunner. Act. nidros.*

Ed. XII: 398, *Squalus spinax.* J. E. Gunnerus 1766 (Vom schwarzen Hayfische (sorthaae). *Dronthemischen (Der) Gesellschaft Schriften aus dem Danischen ubersetzt. Kopenhagen* [*Dronth. Ges. Schr.*] *2:* 284–290, tabs. VII–VIII.

: 400, *Squalus catulus.* J. E. Gunnerus 1766 Vom gelben Hayfisch. *tom. cit.:* 216–229, tabs. I–II.

: 400, *Squalus maximus.* J. E. Gunnerus 1767 Brugden (Squalus maximus) beschrieben. *loc. cit. 3:* 28–43, tab. II.

: 400, *Squalus carcharias.* J. E. Gunnerus 1766 Vom Haa-skierding. *loc. cit. 2:* 299–307.

: 401, *Chimaera monstrosa.* J. E. Gunnerus 1766 Von der Seekatze. *tom. cit.:* 248–283, tabs V–VI.

Gumill. orenogu.

Ed. XII: 428, *Gymnotus electricus.* Joseph Gumilla [José Gumilla] 1758 *Histoire naturelle, civile et géographique de l'Orenogue* ... Avignon & Marseille, Jean Mossy, volume 3 pp. 1–332+[iv].

Linnaeus's citation of volume 3, p. 136 shows that he employed this French edition of Gumilla's work. There were earlier Spanish editions in 1741 and 1745 but neither extended to three volumes. The fishes described by Gumilla occupied Chapter XLII and pages 123–139 of this (1758) edition.]

Hasselqv. itin

Ed. X. 23 references, 3 of which are the sole source for the species name. Fredrik Hasselquist 1757 *Iter Palaestinum eller Resa till Heliga Landet förrättad ifrån år 1749 til 1752* ... Stockholm, Lars Salvii, pp. 1–619.

[This work by Linnaeus's pupil was edited by Linnaeus after Hasselquist's death. The descriptions of fishes occupies pp. 323–407 and are meticulous in their accuracy and detail. These Hasselquist specimens were described again more briefly in the second volume of the *Museum Adolphi Friderici* (1764); several are still extant in the Naturhistoriska Riksmuseet, Stockholm.

The English edition of Hasselquist's work, *Voyages and travels in the Levant in the years 1749, 50, 51, 52* ... (1766) contains greatly abbreviated and uninformative descriptions of fishes between pages 223–227.]

It. Gottl.

Ed. X: 271, *Pleuronectes maximus*. Carl Linnaei 1745 *Öländska och Gothländska Resa på Riksens högloflige ständers befallning förrättad åhr 1741* ... Stockholm & Upsala, Gottfried Kiesewetter, pp. [xii]+1–344+[30].

[The page number given by Linnaeus (178) is an error. In *Fauna Svecica* (1761) he cited page 208 of *It. gotl.* as containing the description of the 'Butta', and here there is a cross-reference to p. 186 of this travel journal which appears to correspond to the meristic figures given by Linnaeus (1758). *Gothlandska Resa, förrättad åhr 1741* appears as a half-title on page 161 of this work, dividing the journey into its two parts of descriptions of the Baltic islands of Öland and Gotland.]

[Se also *It. oel.*]

It. oel.

Ed. X: 247–8, *Ammodytes tobianus;* : 252, *Gadus callarias*. Carl Linnaei [Carl Linnaeus] 1745 *Öländska och Gothländska Resa på Riksens högloflige ständers befallning förrättad åhr 1741* ... Stockholm & Uppsala, Gottfried Kiesewetter, pp. [xii]+1–344+[30].

Both references are to page 87 where Linnaeus describes specimens of sandeel and Baltic cod seen on 8 June at Ottenby, Öland (see Åsberg & Stearn, 1973: 68 for an English translation of these notes).]

It scan.

Ed. X. 17 references, 1 of which was the sole source for the species name. Carl Linnaei [Carl Linnaeus] 1751 *Skånska Resa, på höga öfwerhetens befallning förrättad år 1749* ... Stockholm, Lars Salvii, pp. [x]+xiv+1–434.

[*Cyprinus cultratus* (= *Pelecus cultratus*) was the single species based on the specimen collected during the journey through Skåne; this specimen is still preserved in the Zoological Museum, Upsala (Holm, 1957: 47).]

It. Wgot.

Ed. X. 20 references, 2 of which were the sole source for the species name. Carl Linnaei [Carl Linnaeus] 1747 *Wästgöta-Resa, på Riksens högloflige Ständers befallning förrättad år 1746* ... Stockholm, Lars Salvii, pp. [xi]+1–284+[xx].

[Several of the species described by Linnaeus in this work were exotic specimens preserved in collections at Götheborg or Gothenburg (pp. 137–139) seen during the journey through West Gothland. These included *Balistes aculeatus* which was based on a specimen seeen at Gothenburg.]

Jonst. pisc.

Ed. X: 230, *Petromyzon fluviatilis;* :231, *Raja batis;* :231, *Raja miraletus.* Johannes Jonstonus 1650–53 *Historiae naturalis de quadrupedibus ... de piscibus et cetis ...* 6 pts in 1 volume, Francofurti & Moenum.

[Several later editions of this book were published, e.g. Amstelodam, J. J. Schipper (1657), Amsterdam, J. J. Schipper (1660) but all had the plates with identical numbering, although in the 1657 edition the plates were reversed; it is thus not possible to be sure which edition Linnaeus cited.]

Kaemph. exot.

Ed. X: 231, *Raja torpedo.* Engelbert Kaempfer 1712 *Amoenitatum exoticarum politico-physico-medicarum fasciuli V, quibus continentur variae relationes, observationes, & descriptiones Rerum Persicarum & Ulterioris Asiae ...* Lemgovia, Henrici Wilhelmi Meyeri, pp. [xvi]+1–912+[xxxii].

[The passage cited by Linnaeus 'Observatio II. Torpedo Sinus Persici' is on pp. 509–515; the figure is on p. 510.]

Kaemph. jap.

Ed. XII: 494, *Scomber trachurus.* Engelbertus Kaempfer 1727 *The history of Japan* ...(halftitle), *Historia Imperii Japonici* ... (ed. Johannes Casparus Scheuchzer). Londoni, impensis editoris. Vol. 1, pp. [viii]+lii+iv+1–392+[iv]+XX pls.

[I have failed to find the illustration cited by Linnaeus, '1., tab. 11, fig. 5' in other editions; this English edition had a delicate drawing of *Trachurus* sp. on plate 11, fig. 5]

Klein. miss.

Ed. X: 305, *Silurus aspredo.* Jacobi Theodori Klein 1749 *Historiae piscium Naturalis ... missus quintus ...* Gedani, Schreiberianis, pp. [ii]+1–102+tabs. I–XX.

[Klein's description of this catfish is on page 86 amongst his 'Additiones', the plate is cited correctly by Linnaeus as Tab. IV, but he explicity includes only Figure 8, whereas Klein had indicated that his Figures 7 and 8 referred to his description. It is interesting that this is the only reference made by Linnaeus to Klein's work which was well illustrated and detailed, if highly idiosyncratic.]

Kölpin. mss.

Ed. XII: 432, *Xiphias gladius.*

[Presumably a manuscript of Kölpin's made available to Linnaeus for citation. Kölpin later published his account, see Alexander Bernh. Kölpin 1770 Anmärkningar vid Svärd-fiskens, Xiphiae, anatomie och natural-historia. *Kongliga Swenska Vetenskapsakademien, Handlingar* (*K. svenska Vetensk. Akad. Handl.*), 1770 *31:* 5–16, tab. II, fig. i–iv, and Kölpin 1771. Ytterligare anmärkningar vid Svärds-fiskens natural-historia. *loc. cit.* 1771 *32:* 115–119, tab. IV, fig. 1–2.]

Kram. austr.

Ed. XII. 5 references of which one (: 482, *Perca zingel*) was one of three sources for the new name. Guilielmi Henrici Kramer [Wilhelm Heinrich Kramer] 1756 *Elenchus vegetabilium et animalium per Austriam inferiorem observatorum* ... Vienna, Pragae, et Tergesti, Joannis Thomae Trattner, pp. [ix]+ 1–400+ [xxii]+pl. 1.

[Several endemic Danubian species were well described in this book which followed the classification proposed by Artedi.]

Loefl. epist. or *Loefl. msc.*

Ed. X. 9 references, two of which (: 284, *Labrus marginalis,* and : 285, *Labrus guaza*) were the sole source for these taxa.

[This citation must refer to the letters written to Linnaeus and the manuscript written by Pehr Löfling (1729–1756) who spent two years exploring the fauna and flora of Spain before sailing on a Spanish scientific expedition to Venezuela in 1754. He died of a 'tertian ague' in February 1756 in Guyana. His manuscript account of his Iberian explorations was later published by Linnaeus. See below.]

Loefl. it.

Ed. XII. Most of the references to the nine taxa named from Löfling's manuscripts in 1758 are cited in this form in 1766. One addition (: 103, *Gasterosteus ductor*) has been made. Petri Loefling 1758 *Iter Hispanicum, eller resa til Spanska länderna uti Europa och America ... år 1751 til år 1756 utgifven ... af Carl Linnaeus.* Stockholm, Lars Salvii, pp. [xviii]+ 1–316.

[This is the published text of Löfling's notes (see above); fishes are described on pages 102–104.]

Marcgr. bras.

Ed. X 13 references of which one (: 271, *Pleuronectes papillosus*) seems to have been based solely on this source.

Ed. XII. 6 additional references, three of which were to previously unrecognised species. Georgi Marcgravi [Georgius Marcgravius] 1658 *Historiae rerum naturalium Brasiliae* ... in *Historia naturalis Brasiliae* ... Lugduni Batavorum apud Franciscum Hackium et Amstelodami apud Lud. Elzevirium, separately paged, pp. [vi]+ 1–293:[vii].

[See also *Pis. bras.* below.]

Mars. dan.

Ed. XII: 530, *Cyprinus nasus.* Aloysio Ferd. com. Marsili [Luigi Ferdinando Marsigli, Count] 1726 *Canubius Pannonico-Mysicus, observationibus geographicis, astronomicis, hydrographicis* ... Hagae comitum, P. Gosse, R. C. Alberts & P. de Hondt; Amstelodami, N. Uytwerf & F. Changuion. Tom. 4, pp. [ii]+ 1–92+ [ii]+ tabs. 33.

Meyer. thier.

Ed. X: 324, *Cyprinus orfus.* Johann Daniel Meyer 1752 *Angenehmer und nützlicher Zeit-Vertreib mit Betrachtung curioser Vorstellungen allerhand kriechender, fliegender und schwimmender, auf dem Land und im Wasser sich befindender und nahrender Thiere* ... Nürnberg, Andreas Bieling, pp. [i]+1–28+[i]+100 col. pl.

[Citations to the collection in the Academy museum in Uppsala. Of the two

Mus. acad. or *Mus. Acad.*

Ed. X: 291, *Perca polymna;* : 293, *Perca stigma.*

[Citations to the collection in the Academy museum in Uppsala. Of the two cited specimens, *Perca polymna* (= *Amphiprion polymna*) was listed in Thunberg's manuscript catalogue of the collection in 1828, and is still preserved in the Zoological Museum of the University, Uppsala.]

Mus. Acad. Holmens. or *Holmensis.*

Ed. X: 250, *Callionymus indicus;* : 273, *Chaetodon punctatus;* : 304, *Silurus asotus;* : 305, *Silurus militaris;* : 319, *Clupea sima.*

[Citations of specimens in the Royal Academy of Science museum at Stockholm. This collection was later transferred to the Naturhistoriska Riksmuseet, Stockholm, but none of the species cited above are represented there today by material contemporary with Linnaeus.]

Mus. Ad. Fr

Ed. X. 94 references, thirty-one of which were the sole source of the name.

Ed. XII. 60 references, four of which were to unnamed species, of which two were the sole source of the name.

Car. Linnaeo 1754 *Museum S:ae R:ae M:tis Adolphi Friderici Regis ... in quo animalia rariora imprimis, et exotica: Quadrupedia, Aves, Amphibia, Pisces, Insecta, Vermes describuntur et determinantur* ... Tom 1. Holmiae, E. Typographia regia Direct. Pet. Momma, pp. xxx+1–96+[8]+33 pl.

Carolo v. Linne 1764 *Museum S3ae R:ae M:tis Adolphi Friderici Regis* ... Tomi secundi Prodromus. Holmiae, Laur. Salvii, pp. 110–[ii] (issued with *Museum ... Ludovicae Ulricae Regina ...*)

[References in the tenth edition of the *Systema* ...are mostly to the first volume of the *Museum ...Adolphi Friderici* (1754), recognised by the citation *Mus. Ad. Fr.* 1 (followed by references to page, plate and figure numbers). However, there are thirty-one references to *Mus. Ad. Fr.* 2 p. ... in the tenth edition which proves that the second volume (published in 1764) was in manuscript at least by the end of 1758. Seventeen of these references were the sole source of the species and for the typification of these species it is necessary to refer to the second volume of the *Museum ... Adolphi Friderici,* where they are described, although the binomen dates from 1758. In addition, there are thirty-two species in the tenth edition for which no literary citation is given (and which therefore appear to have been based directly on a specimen examined). In the twelfth edition these are credited to the second volume of *Mus. Ad. Fr.* and again for a full understanding of the Linnaean name of 1758 it is necessary to consult the second volume of the work (see Appendix).

In the twelfth edition of the *Systema* ... those species which were based on the second volume of the *Museum Adolphi Friderici* are cited as *Mus. Ad. Fr.* 2 (followed by a page number). There are twenty-seven new citations to the second volume (in addition to the thirty-two species for which no source was given and the thirty-one references to the unpublished manuscript of volume two, already mentioned). The second volume of the account of King Adolf Fredrik's collection was therefore the source or part source for ninety species in the two editions of the *Systema* ... A single name (: 508, *Loricaria plecostomus*) was introduced in the twelfth edition based partly on the description in the first volume of the *Museum Adolphi Friderici*, and partly on descriptions and illustrations by Gronovius (see *Gron. Mus.*). and in Seba (see *Seb. mus.*).]

Mus. De Geer

Ed. X: 281, *Sparus virginicus, Sparus capistratus;* :283, *Labrus auritus;* :284, *Labrus flacatus;* :291, *Perca nobilis;* :293, *Perca striata;* :295, *Gasterosteus occidentalis.*

[Charles de Geer (1720–1778) an influential Swedish nobleman had a large collection of natural history material including reptiles, fishes, and molluscs, although he is best known from his important insect collection. The latter still survives at least in part, but I have no reason to suppose that De Geer's fishes are still in existence. Most of those described by Linnaeus were from North America, one, *Labrus auritus,* being localised specifically as from Philadelphia.]

Musschenb. intr.

Ed. XII: 428, *Gymnotus electricus.* Petro van Musschenbroek 1762 *Introductio ad philosophiam naturalem* Tom. 1. Lugduni Batavorum, pp. [xx]+1–476, tabs. xxcii.

[Linnaeus's citation was to page 290 in volume 1 of this work. The discussion by Musschenbroek of the electrical properties of *Gymnotus electricus* begins on p. 289, paragraph DCCCCI and continues to p. 291; it is largely derived from Gronovius's account of 1758 (see *Uitgez. verhand.* below).]

Mus. Schlosseri

Ed. XII: 464, *Chaetodon argus.*

[See Brunnich, M.T., above.]

Olear. mus.

Ed. X: 236, *Lophius piscatorius;* :338, *Syngnathus hippocampus.*

Ed. XII: 430, *Anarhichas lupus.* Adam Olearium [Olearius] 1674 *Gottorffische Kunst-Kammer worinnen allerhand ungemeine Sachen, so theils die Natur* ... Schlesswig, Gottfriedt Schulkens ... pp. [x]+1–80+36 pl.

[This work was first published in 1666. In this later edition the numbers of the plates and figures agree with the citations given by Linnaeus but the pagination differs, for example Hippocampus appears on p. 41 (not p. 53), Anarhichas on p. 49 (not p. 53) as cited. Other editions of this work have not been examined.]

Osbeck. iter. or *Osbeck. itin.*

Ed. X. 21 references. Pehr Osbeck 1757 *Dagbok öfver en Ostindisk Resa åren 1750, 1751, 1752, med anmärkningar uti Naturkunnigheten, främmande folkslags språk* ... Stockholm, Lor. Ludv. Grefing, pp. [vi]+1–376+[xvi]+12 pl.

[References to *Osbeck. iter.* and *itin.* occur throughout both the tenth and twelfth editions of the *Systema* ...: I can see no significance in the two forms of reference.]

Pet. gaz.

Ed. X: 322, *Cyprinus auratus.*

Ed. XII: 403 *Lophius histrio;* : 410, *Ostracion cubicus;* : 433, *Callionymus lyra;* : 515, *Fistulsria chinensis.* Jacobi Petiver 1764 *Opera historiam naturalem spectantia;* or *Gazophylacium* 3 vols. London, John Millan.

[This work is virtually impossible to collate and the plate and figure numbers seem to be unchanged in this (1764) edition from the original printing of 1702–4. In the original edition the species cited are illustrated as follows; *C. auratus* Decas 7 & 8, tab. LXXVIII, figs. 6 & 7; *L. histrio* Decas 2, tab. XX, fig. 6; *O. cubicus* Decas 1, tab. I, fig. 2; *C. lyra* Decas 2, tab. XXII, fig.2; and *F. chinensis* Decas 7 & 8, tab. LXVIII, fig. 1. *Lophius histrio* appears to have been derived from Marcgrave through Willughby, both of which are cited as sources by Linnaeus.]

Pis. bras.

Ed. XII: 466, *Chaetodon saxatilis;* : 521, *Exocoetus evolans.* Gulielmi Pisonis 1658 *De Indiae utriusque re naturali et medica* ... Amstelodami apud Ludovicum et Danielem Elzeviries, pp. [xxii]+1–327+[v].

[The account of fishes occurs in Liber tertius (pp. 47–74). The description of *Chaetodon saxatilis* occurs on page 68 (not 88 as given by Linnaeus); that of *Exocoetus evolans* is 'pirabebé II', not 'pirabebé I' which is a dactylopterid. Piso's work was issued with Georgi Marcgravii *Tractatus topographicus & meteorologicus Brasiliae* ... and Jacobi Bontii *Historiae naturalis & medicae Indiae orientalis ..., both separately paged. (See Bont. jav.* and *Marcgr. bras.*).]

Plot. oxon.

Ed. XII: 394–5, *Petromyzon branchialis.* Robert Plot 1677 *The natural history of Oxford-shire, being an essay toward the natural history of England.* Oxford, at the Theater, pp. [viii]+1–358+[x].

[The page number (184) and plate and figure numbers (t. 10, f. 6, 7) quoted by Linnaeus are consistent with this edition of 1677; the pagination of the 1705 edition does not correspond.]

Raj. pisc.

Ed. X. 33 references.

Ed. XII. 11 additional references of which two were for new taxa. Joannis Raii [John Ray] 1713 *Synopsis methodica avium & piscium; opus posthumum* ... Londini, Gulielmi Innys.

[The part or this book concerned with fishes has a separate half title, *Synopsis methodica piscium* Londini, apud W. Innys, pp. 1–166, pls. [2]+[xiv]. Both parts of the book have separate pagination. At least one of the references to Ray's *Synopsis* ... in the twelfth edition is a substitution for a reference to Willunghby's *Historia piscium* in the tenth edition (see *Fistularia tabacaria*, p. 515 in twelfth edition, p. 313 in tenth).]

Rond. pisc.

Ed. X. 18 references.

Ed. XII. 1 additional reference, :467–8, *Sparus sargus*. Gulielmi Rondeletii [Gulielmus Rondeletius] 1554 *Libri de piscibus marinis, in quibus verae piscium effigies expressae sunt* ... Vol. II 1555 *Universae aquatilium historiae pars altera, cum veris ipsorum imaginibus.* Lugduni [Lyons], apud Matthiam Bonhomme, pp. [x]+1–242+[ix].

Russel. alep.

Ed. XII. 2 references, one of which was to a new taxon. Alex. Russell [Alexander Russell] 1756 *The natural history of Aleppo, and parts adjacent. Containing a description of ... the principal natural productions in its neighbourhood* London, A. Millar, pp. viii+1–266+A:ÅX∈.

[*Silurus cous* (ed. XII, p. 504) was based on the description by Gronovius of a specimen sent by Alexander Russell to Leiden, and on Russell's own description (above). A specimen sent to the British Museum by Russell on 8 July 1758 is still preserved in the British Museum (Natural History) and can be regarded as a type specimen of the Linnaean species (Günther, 1864).]

Ruysch. thes.

Ed. X: 296, *Gasterosteus volitans;* :338, *Pegasus volitans.* Frederici Ruischii [Fredericus Ruyschius] 1710 *Thesaurus animalium primus cum figuris aeneis* Amstelaedami, apud Joannem Wolters, pp. [liv]+1–40+pls. I–VII.

[A later edition of Ruysch's work was published in 1725 with identical plates but different pagination; Linnaeus cited the first (1710) edition.]

Salv. pisc.

Ed. X. 15 references. Hippolyto Salviano 1554 *Aquatilium animalium historiae, liber primus, cum eorumdem formis, aere excusis.* Romae pp. [xiv]+leaves 258.

[Salviani's work is numbered only on the rectos which makes citation of the pagination difficult. The citation of p. 146 for *Raja aquila* by Linnaeus may be due to this unusual pagination; the description occurs on p. 147. The date of the title page is 1554, 1557 is given on the colophon; the title page of the British Museum (Natural History) copy has been altered to 1557.]

Schaeff. ratisb.

Ed. XII: 482, *Perca zingel* (a new taxon); :487, *Perca cernua;* :488, *Perca schraetser.* Jacobi Christiani Schaeffer 1761 *Piscium Bavarico-Ratisbonensium pentas* ... Ratisbonae, impensis Montagii, pp. [x]+1–82+col. pls. I–IV.

[The new taxon, *Perca zingel,* is partly based on Schaeffer's excellent description and figure; the other two references were twelfth edition additions to taxa already named.]

Seb. mus.

Ed. X. 2 references.

Ed. XII. 50 references, seven of which were to previously undescribed species, one of which (: 503, *Silurus galeatus*) was based solely on the description in Seba. Albertus Seba 1734–1758 *Locupletissimi rerum naturalium thesauri accurata descriptio et iconibus artificiosissimus expressio, per universam physices historiam* ... Tom. I–III Amstelaedami.

[The majority of Linnaeus's references to Seba are to volume III (1758) the notes for which were compiled by Artedi. Two references in the tenth edition are to other volumes. *Lophius vespertilio* (: 237) was based in part on Seba's first volume (1734), plate 74 figure 2 (this plate comprises illustrations of one ogocephalid-cited by Linnaeus, and figs. 3–6 of antennariids, explanatory text is on pp. 118–119). *Muraena helena* (: 244) was based in part on Seba's second volume (1735), plate 69, figs. 4 & 5 (this plate contains five figures of eels; the explanatory text is on pp. 71–72).]

Sloan. jam.

Ed. X: 248, *Stromateus paru;* :269 *Pleuronectes lineatus;* : 292, *Perca guttata.*

Ed. XII: 463, *Chaetodon triostegus;* : 518, *Elops saurus.* Sir Hans Sloane 1707–25 *A voyage to the islands Madera, Barbadoes, Nieves, St Christophers, and Jamaica; with the natural history of the herbs and trees, four-footed beasts, fishes, birds, insects, reptiles, etc. of the last of those islands.* London, for the author. Volume II (1725 pp. [ii]+xviii+pls. XI+pp. 1–499+pls. 157–274.

The account of the fishes of Jamaica is comprised in Book V, part II, pp. 275–291, pls. 246–253. Sloane makes numerous references to Marcgrave's earlier work (see *Marcgr. bras.* above).]

Strom. sond. or *Strom. sondm.*

Ed. XII. 10 references all to existing species. Hans Strøm 1762 *Beskrivelse over fogderiet Søndmør beliggende i Bergens stift i Norge.* Soroe, Rotheste, pp. [xvi]+1–570+[ii]+tabs. I–IV.

[The chapter on fishes, 'Sondmors fiske' occupies pp. 263–325.]

Strussenfelt

Ed. XII: 440, *Gadus cimbrius.*

[Reference to Alexander Michel von Strussenfelt who gave Linnaeus a specimen of *Enchelyopus cimbrius* from the Atlantic coast of Sweden. Strussenfelt later (1773) published his own account of this fish making comparison with *Ciliata* *mustela* at the same time, see Beskrifning och ritning på tvänne fiskar af Torsk-slägtet. *K. svenska Vetensk. Akad. Handl. 35:* 22–27, tab. II.]

Syst. nat. 6

Ed. X: 264, *Cottus quadricornis.* Caroli Linnaei 1748 *Systema naturae ... editio sexta.* Stockholmiae, Godofr. Kiesewetteri, pp. ii+1–224+[27]+8 pl.

[Linnaeus's reference to p. 47, tab. 4, fig. 3 was to the illustration of this fish in this, illustrated, edition of the *Systema* ...]

Syst. nat. 10

Ed. XII. 8 references. Caroli Linnaei 1758 *Systema naturae ... editio decima, reformata.* Tom I Holmiae, Laurentii Salvii, pp. [iv]+1–824.

[Citations of the tenth edition of the *Systema* ... were all concerned with changes in the status of names. Thus *Raja altavela* (ed. X: 232) was reduced to the synonymy of *R. pastinaca* var. β (ed. XII: 396); *Centriscus scolopax* (ed. XII: 415) was formerly *Balistes scolopax* (ed. X: 329); and *Cepola rubescens* (ed. XII: 445) was a new name for *Ophidion macrophthalmum* (ed. X: 259).]

Uitgez verhand.

Ed. XII: 427, *Gymnotus electricus.* Gronovius, L. T. 1758. Van der Siddervis of Beef-Aal. *Uitgezogte Verhandelingen uit de Nieuwste Werken von de Societeiten der Wetenschappen in Europa,* Amsterdam. *3:* 468–478. [*Uitgez. Verh. Amst.*]

[Note: not seen; the above citation is copied from Dean (1923). Linnaeus gave the pagination for the description as p. 468, t. 26, fig. 8, I am unable to confirm that this is correct.]

Valent. amb. or *Valent. ind.*

Ed. X: 262, *Coryphaena pentadactyla;* : 296, *Gasterosteus volitans;* : 336, *Centriscus scutatus.*

Ed. XII: 453, *Scorpaena horrida;* : 507, *Teuthis hepatus;* : 507, *T. javus;* : 515, *fistularia chinensis.* The three last were undescribed taxa although none was based solely on this work.

François Valentyn 1726 *Omstandig verhaal van de geschiedenissen en zaaken het kerkelyke ofte den godsdienst betressunde, zoo in Amboina ..., Banda ..., Tonkin, Cambodia, en Siam ...* Derde deel, Dordrecht & Amsterdam, Johannes van Braam & Gerard onder de Linden, pp. [iv]+585.

[This is the third volume of Valentijn's 1724–26 *Oud en nieuw Oost-Indiën ...* Dordrect & Amsterdam, 5 deel in 8 volumes. In the tenth edition of the *Systema* ... Linnaeus cited this work as *Valent. amb.,* in the twelfth edition it was cited as *Valent. ind.* Of the three species which are in part based on this work *Teuthis hepatus* is cited from three figures (77, 383, and 404) the descriptions of which occur on pages 371, 466, and 473 respectively; *T. javus* is based on references to p. 339 and fig. 410, although the text relative to this figure occurs on p. 476; and *Fistularia chinensis* is based on figs. 3, 23, and 492, although the number of the figure of *Aulostomus chinensis* is 494. Valentijn's illustrations are of very poor quality.]

Vallisn. nat.

Ed. X: 261, *Echeneis neucrates.* Antonio Vallisneri 1733 *Opere fisico-mediche stampate e manoseritte del Kavalier Antonio Vallisneri* ..., Tomo primo, Venezia, Sebastino Coleti, pp. lxii + 1–469.

[Linnaeus cited pl. 44 in volume one of Vallisneri's work; this plate (page 456) shows a fish with body shape of a *Remora* sp. rather than *Echeneis neucrates.*]

Will. icht., Will. app., Will. icht. app. or *Will. pisc.*

Ed. X. 33 references

Ed. XII. 6 additional references, two of which were to previously undescribed species. Francisci Willughbeii 1686 *De historia piscium libri quatuor* [ed. Johannes Raius]. Oxonii e Theatro Sheldoniano, pp. [vi]+ 1–343 [continues as] *Appendix ad historiam naturalem piscium* ... pp. 1–30+[xii], [continues as] *Ichthyographia* [dated 1685] unnumbered plates.

[In the tenth edition of the *Systema* ... the great majority of the citations of Willughby's work were in the order Amphibia Nantes. One species, *Fistularia tabacaria* is cited as *Will. icht. app.* in the tenth edition (: 313) but is cited as *Raj. pisc.* in the twelfth edition (: 515). Two citations in ed. XII *Sparus dentex:* 471, *Scomber thynnus:* 493) to the *Ichthyographia* are given as *Will. pisc.*]

Linnaeus's sources and the development of the study of fishes

As we have seen, Linnaeus's early writings on fishes were heavily influenced by the posthumous work of Artedi which was edited by his friend and former fellow student (Artedi, 1738). Artedi's writings formed the cornerstone on which Linnaeus built, and examination of his *Ichthyologia* shows his deep interest in fishes, their anatomy, and above all the early literature concerning them. Artedi's grasp of foreign languages must have been considerable to make use of so many non-Latin sources.

The *Systema naturae* in its various editions virtually serves as an index to Linnaeus's knowledge of fishes and this topic has been fully discussed already (p. 168 *et seq.*). A significant increase in the number of recognised forms can be seen (Table 1) in the 1744 (Paris) edition of the *Systema* ... much of which stemmed from critical reappraisal of Artedi's work by the editor Bernard de Jussieu. Until the sixth edition (1748, Stockholm) most of the fishes included were western Palaearctic species, principally freshwater fishes from northern Europe, and marine species from the North Sea – Baltic Sea basin and the Mediterranean. With the sixth edition, however, there was a substantial increase in exotic forms, principally from the material deposited in the University Museum, Uppsala, by the Crown Prince, Adolf Fredrik (Linnaeus, 1746*a*). The ninth edition of the *Systema* (1756, Leiden) continued this process of addition of exotic forms, notably as a result of the publication of the *Museum Ichthyologicum* by L. T. Gronovius (1754, 1756) who was also involved in the production of this edition. In this edition were listed a number of species from the South American continent, South Africa, and the Indian Ocean, as well as European forms.

In the tenth edition of the *Systema* ... (1758), for some unimaginable reason, Linnaeus largely ignored the Gronovius innovations, substituting names of his own for the taxa previously described. However, in this edition he cited Gronovius's work frequently, often with other literary sources, and for this reason there were a considerable number of exotic forms introduced. These were supplemented by the material in the collection of King Adolf Fredrik (Linnaeus, 1754*a* & 1764) which contained many Neotropical species and by the Chinese collection of Magnus Lagerström (Linnaeus, 1754*b*). In the edition also the first results of the ichthyological studies of his students were cited, Hasselquist in the Nile region, Löfling in Spain and in the tropical Atlantic, and Osbeck from Ascension Island and the South China Sea. These were the first major collections or descriptions of fishes from exotic regions that Linnaeus could be said to have inspired, and with the exception of the South American tropical fish fauna, a fragment of which was already available in Europe, marked the beginning of ichthyological exploration outside Europe. The exception, that of the South American fauna, was due in part to the early trading links established between Holland and Sweden and Surinam, which provided specimens of the endemic fishes and other animals of north-eastern South America for the cabinets of collectors such as Albertus Seba, and Johan and Laurens Gronovius in Holland, and Charles De Geer, and the royal family in Sweden. These specimens provided tangible proof that many of the strange fishes described and illustrated by Marcgrave (1648) did in fact exist. Marcgrave's studies in Brazil provided the first glimpses afforded to European naturalists of the astonishingly rich Neotropical fauna, and for more than a century were virtually the only evidence available. The importance of Marcgrave's work is not well illustrated by Linnaeus's citations of it, which were few in number, but by the use made of it by other naturalists such as Ray (1686) and Sloane (1725), and through their citations by later authors.

The twelfth edition of the *Systema naturae* (1766) continued with this development and is in every way richer in exotic species. The publication of the second volume of *Museum ... Adolphi Friderici Regis* (Linnaeus,

1764) and of Laurens Gronovius's *Zoophylacium Gronovianum* (1763) had continued to supplement ichthyological knowledge with novelties from northern South America, southern Africa, and the East Indies. Linnaeus's correspondent in South Carolina, Alexander Garden, had sent him considerable collections of freshwater and coastal species from that area and the Bahamas. Many of them were undescribed, but others supplemented the rather inadequate descriptions of Catesby (1731–43), Browne (1756), and Sloane (1725) which, as may be seen in the earlier analysis of Linnaeus's sources, were cited for a number of additional species in 1766, evidently following a re-assessment of them after Garden's specimens had been studied. Another important source of exotic species was the eventual publication of Seba's third volume of the '*Thesaurus*' (Seba, 1758) which contained the descriptions prepared by Artedi before his death in 1735. Many of these species originated in Surinam and the East Indies.

Linnaeus's ichthyological publications after 1766 were few and virtually the only significant item was in the Appendix to the *Mantissa plantarum* (1771). He received several further consignments of fish from Garden in South Carolina up to 1771, and two of Garden's fish were described in the *Mantissa* ... Others were entered by Linnaeus (and by the younger Linnaeus) into his interleaved, annotated copy of the *Systema naturae* which would clearly have formed the basis of a future edition had Linnaeus's stroke, and death in 1778, not intervened.

However, although his major personal contribution to the study of fishes had ended in 1766 his influence continued, mainly through the travels and studies of his students. Pehr Forsskål travelled as naturalist on the Danish expedition to Egypt and the Red Sea in 1761. He died in Jerim, Yemen, in 1763, but his manuscript notes and part of his collections eventually reached Copenhagen, where the former were published by the expedition's only survivor Carsten Niebuhr (Forsskål, 1775). Forsskål's observations were the first made on the rich fauna of the Red Sea, and virtually the first made by a naturalist (as opposed to a casual collector) of coral reef fish in their habitat. Another student, Daniel Carl Solander accompanied Cook on his first voyage round the world as naturalist in the entourage of Joseph Banks. Although the published results of this voyage were minimal many of the specimens collected (which later found their way to the British Museum), manuscripts and paintings were used by nineteenth century students, such as George Shaw, Georges Cuvier, John Richardson, and Albert Günther. Although the direct contribution was small, this student of Linnaeus made an indirect contribution to the exploration of the world of fishes. Another student of Linnaeus's, Anders Sparrman sailed on Cook's second voyage with the naturalists Johann Reinhold and Georg Forster. Joining and leaving the expedition at the Cape of Good Hope (1772–1775), like Solander he must have seen the startling richness of the Pacific Ocean fish fauna, and particularly that of New Zealand. His contribution to the expedition's discoveries is not fully known, partly due to his junior position relative to the Forsters but also because their results lay largely unpublished for many years, and Linnaeus probably never received any information about them. Sparrman spent a further year exploring the interior of South Africa although without making any considerable notes on the fishes. It was, presumably, in recognition of his other considerable contributions to zoology and botany that in 1840 Andrew Smith named the South African cichlid fish *Tilapia sparrmani* Smith, 1840 in his honour.

Another of Linnaeus's students, Carl Peter Thunberg, also explored the interior of southern Africa between 1772 and 1775, before sailing for Java, Japan and Ceylon. His were the first collection of fishes from the latter countries to be seen in Europe, although he returned only after Linnaeus's death. Thunberg later succeeded the younger Linnaeus at Uppsala University and it was due to his care (and that of his successors) that so much of the early collections of the University, many of them Linnaean types, have been preserved.

Linnaeus's knowledge of fishes thus started as an amalgam of the earlier literature supplemented by his own observations as a traveller in Sweden and was thus basically confined to the European fauna. As eighteenth century commerce brought more contacts with foreign regions so specimens from distant areas, such as Surinam, came to be available in Europe. By the end of his life exploration by naturalists had extended knowledge of fishes to those of eastern North America, part of southern Africa, the Red Sea, the Nile and Palestine, China, Japan, and the tropical Indo-Pacific. The era of the naturalist explorers had already commenced. Virtually the only major untouched faunas were those of South America, tropical Africa, the Antarctic, and the deep sea, and, with the exception of the first, no serious exploration of these was attempted for a century and more after Linnaeus's death.

Perhaps more importantly with the development of ichthyology the emphasis had changed from the use of literary sources to the establishment of names based on specimens. Many of these type specimens are still available in collections in Uppsala, Stockholm, and London and provide a vital source of information for taxonomists concerned to establish the true relevance of Linnaean names of species of fish.

Appendix I

Taxa named in the *Systema naturae* (1758) without citation of source which were based on *Museum Adolphi Friderici* specimens (see page 164).

: 255 *Gadus mediterraneus*, : 262 *Gobius niger*, : 263 *Gobius aphya*, *Gobius jozo*, : 265 *Cottus scaber*, : 269 *Pleuronectes ocellatus*, : 274 *Chaetodon triostegus*, : 277 *Sparus aurata*, : 278 *Sparus sargus*, : 279 *Sparus hurta*, : 280 *Sparus salpa*, : 281 *Sparus spinus*, : 284 *Labrus julis*, : 288 *Sciaena cappa*, : 290 *Perca marina*, : 291 *Perca cottoides*, : 295 *Gasterosteus ductor*, : 299 *Mullus barbatus*, : 300 *Trigla cataphracta*, : 301 *Trigla cuculus*, : 313 *Esox sphyraena*, *Esox osseus*, : 314 *Esox brasiliensis*, : 315 *Atherina hepsetus*, : 316 *Mugil cephalus*, : 319 *Clupea mystus*, : 320 *Cyprinus barbus*, : 320 *Cyprinus gobio*, : 322 *Cyprinus niloticus*, : 325 *Cyprinus dentex*.

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CARL-OTTO VON SYDOW

Linnæus and Gmelin

Linnæus and his German contemporaries: this is the story of the meteoric rise of his youth and the established fame of his later years, a story of passionate opposition and devout admiration. It is also the story of the German-speaking world of that time, a scientific power soon to be the equal of Holland, France and England. On German soil the University of Tübingen, founded in 1477, the same year as the University of Uppsala, had quickly won fame through its early botanists such as Leonhard Fuchs and Rudolf Camerarius.

Tübingen was also the home of Johann Georg Gmelin. Let me hasten to admit that I did not know that before: as familiar as his name and deeds were to me, I had nevertheless paid little attention to Gmelin's origins, family, childhood or scientific education, nor to his fate after that heroic youthful journey to Siberia and—if I may be permitted to use the expression—his subsequent exile to a professorship in St. Petersburg, where he, like so many of his compatriots, had accepted a post from Peter the Great.

Gmelin was indeed a son of Tübingen, however, a scion of an old Tübingen family; he took his doctorate there, and later returned to take the chair of Botany and Chemistry there—I might well have remained ignorant of all this, had not the Universities of Uppsala and Tübingen simultaneously celebrated their quinquecentennials, which led me to more closely examine the relationship between these two famous contemporary botanists, at Uppsala and Tübingen, respectively.

My decision to concentrate upon Linnæus and Gmelin was bolstered by the discovery that their relatively extensive correspondence had been preserved, but—as far as I have been able to determine—not yet been examined by historians. Linnæus' letters, of course, have long been available in printed form, but Gmelin's letters have remained in the capable hands of the Linnean Society. Moreover, through a curious coincidence, the University Library at Uppsala some fifty years ago acquired all of Linnæus' letters to Gmelin from the latter's family.

Johann Georg Gmelin was born in Tübingen in 1709, the son of a university apothecary by the same name. In his youth, the father had studied chemistry in Stockholm under the skilful chemist Urban Hiärne, and according to Professor Sten Lindroth, who has studied the matter more closely, Gmelin Sr. apparently taught his children to share his veneration and respect for his chemical mentor. When the younger Johann Georg, called "Siberian" Gmelin, took his degree in chemistry in his native city in 1727, his dissertation was entirely based upon the laboratory techniques of Urban Hiärne; the young author had learnt these techniques both from Hiärne's printed works and from his father's personal instruction. This close connection to the Swedish chemist was by no means a short-lived phenomenon, as we shall see from Gmelin's letters to Linnæus.

The same year that he took his degree—before his eighteenth birthday, in fact—the young scientist left for St. Petersburg, attracted by two of his former teachers who had both entered its recently-founded Academy of Sciences. A rising star, Gmelin was also drawn into the Russian orbit. Well aware of his worth, they immediately gave him permission to attend the Academy sessions, and the following year appointed him to a teaching post which only three years later was converted into a full professorship in chemistry and natural history. Gmelin thus was one of the original members in this learned body founded by the imperial edict that the arts and sciences might take root in the far-flung reaches of the Russian Empire. The academy was an artificial creation, lacking roots in its native country and with foreigners as its mainstay, but nevertheless respectfully regarded by Western European scientists, who were somewhat jealous of the plenteous resources provided by that powerful monarch.

Nor did the Russians lack the energy and initiative to tackle a problem of considerable immediacy but frightening scope: the exploration of Siberia. The Dane Vitus Bering had previously carried out the so-called First Siberian Expedition, but now the time had come for a new attempt to reach the Kamchatka peninsula and, if possible, attempt to determine whether the continents of Asia and America were connected by an isthmus or divided by a strait. The purely geographical aspect of this Second Siberian Expedition turned into a journey of discovery with a notably Scandinavian emphasis: in addition to Bering, his countryman Spangberg and the Swede Waxell held important posts. As the expedition marched eastward, however, the investigation of the natural history of Siberia was just as clearly a German undertaking: command was assumed by the young Gmelin, who together with a fellow-countryman began the long journey in 1733. Gmelin in fact never did reach Kamchatka, but during nearly a decade of adventures and hardships he traversed the vast expanses of Siberia, returning to St. Petersburg in 1743 with immense scientific treasures, even though his first collection was lost in a fire at Yakutsk.

At a distance, writes Professor Lindroth, this adventure was eagerly followed by Charles Linnæus. His interest in this expedition derived from his views on the Siberian flora and which of its plants he believed could be imported into Sweden. Linnæus, a son of "the age of utility", had a purely scientific interest in the vegetable kingdom which was at all times closely linked with a utilitarian attitude towards its products. Thus the thought of high-yield Siberian buckwheat or the Siberian larch (useful for gun stocks) enthused him. Siberian plants seemed particularly appropriate to him because the endless plains of Siberia had the same latitude as Sweden, so that the plants that thrived in Siberia would presumably also thrive and multiply in Linnæus' own country. Linnæus did not—and could not—know that latitude was not the only determining factor: altitude and the presence or absence of e.g. the Gulf Stream were also decisive conditions for plants.

It was thus of the utmost importance for Linnæus to attempt to obtain some of the treasures piling up in the botanists' herbariums and the Academy's botanical gardens. Although these treasures had been collected by German scientists, this research had nevertheless been possible only with Russian permission and Russian money, so that the concrete results, the collections they brought home, were Russian property and thus to be communicated to foreigners only after special permission. This was particularly true of seeds and living plants in the Academy's botanical gardens, so that the Keeper of the gardens was a key figure in Linnæus' attempts to obtain access to the coveted Siberian material. This keeper was another German member of the Academy, Johann Siegesbeck. Unfortunately, this same Siegesbeck was Linnæus' bitterest scientific rival, fired with animosity and resentful indignation, feelings which were more than echoed in Linnæus' own breast.

The background was as follows: Linnæus had, of course, not achieved success without resistance. Many botanists immediately protested against the principles of his botany, particularly against his systemization based upon the sexual organs of plants; in this connexion objections were also at times raised to the underlying theory of the sexuality of plants, a theory ultimately derived from Camerarius. His first critic, and one never surpassed in bitterness, was that very same Siegesbeck, whose first attack came in 1737, only two years after the publication of the first edition of *Systema Naturæ*. Siegesbeck pointed out that dioecious plants can produce fully-developed seeds even when the male plant was incapable of producing pollen. He claimed that pollen had a nutritive function for the plant and a healing one for humans, so that it was superfluous to assign it a function in fertilization, as well.

Siegesbeck is best known, however, for his repudiation of Linnæus on moral grounds: the theory of fertilization arouses immoral thoughts in the reader. Moreover, it was not merely or even primarily the theory as such which outraged a mind such as Siegesbeck's, but above all the language in which Linnæus illustrated his theory: the poetic, yet extraordinarily graphic language, rich in anthropomorphic details, used by Linnæus in this connexion. Add to this the palpable enthusiasm he had for his subject: his unrestrained joy burst through whenever he was able to show how the fires of love sweep through the lives of plants, as well—*tantus amor florum!*

As was his custom, Linnæus did not counterattack directly, instead allowing his faithful disciples in Germany and Sweden to join battle. While remaining in the background, he provided them with the necessary ammunition: 1739 and 1740 marked the appearance of Browallius' and Gleditsch's rebuttals, which by 1741 had provoked Siegesbeck into producing a new anti-Linnæan polemic. All this of course meant that when Gmelin returned from Siberia in 1743, laden with rich booty for the botanical treasure-houses of St. Petersburg, the situation was the worst possible one for Linnæus' attempts to obtain access to these treasure troves.

There nevertheless proved to be one fruitful approach. Early in 1744 two of Linnæus' friends and colleagues left for St. Petersburg: Baron Sten Bielke, a zealous botanist and agrarian with an estate just outside Uppsala, and a young student, Per Kalm, who was one of Linnæus' future "apostles" and later to become famous for his botanical travels in northern America. Baron Bielke had family business in St. Petersburg and Kalm accompanied him in what amounts to the capacity of secretary. Nor were the twosome slow in contacting the men that Linnæus considered key figures in St. Petersburg: scarcely off the boat, they got acquainted with Gmelin, and Baron Bielke subsequently contrived to win the confidence of the crusty old Siegesbeck himself—which was no mean achievement!

And thus we come to the first contact between Gmelin and Linnæus. Baron Bielke paved the way for the already-famous Siberian explorer to commence correspondence with his celebrated contemporary in Uppsala, who at the time was the dominant figure in their field.

On February 14, 1744, with Baron Bielke as his go-between, Gmelin sent the first of a long series of letters to Linnæus. He described how throughout the lengthy journey he had used Linnæus' handbooks as well as possible, but bemoaned the fact that upon his departure he still pursued botany according to the old methods and was not able to thoroughly absorb the new, i.e. Linnæan, principles. It was therefore of importance to him that his forthcoming edition of *Flora Sibirica* should benefit from close contact with Linnæus, to whom he wished to turn whenever difficulties arose about determining new species and genera.

Naturally enough, Linnæus was entranced to find that the door to the hitherto unknown Siberian flora had suddenly swung wide. He immediately answered in his open, charming style:

> Your illustrious name, esteemed sir, had long been known to me, although I greatly feared you were no longer to be counted among the living. The loss of Amman [another German botanist also active in Russia] has long oppressed my soul, and thus the greater was my joy to find that you have been returned to us.
>
> The friendship of Siegesbeck was as short-lived as his botanical principles, but the friendship of Amman was as trustworthy as his research. It is my devout wish and prayer that your friendship may also be as enduring as your merits in botany.
>
> I have acquainted myself with your descriptions and can only marvel at the zealousness with which you have observed the most cunningly-hid stamens and pistils. The friendship which you tender me, I receive with open arms. Let not Siegesbeck perturb this friendship, which I shall ever be honoured to retain.
>
> You have done the greatest of services for our knowledge of botany; you alone have discovered as many new plants as many other botanists together. In botany none acquires his prizes at greater cost than he who journeys through unfriendly climes; in Lapland alone my health suffered more in the space of a half-year than during all my other journeys put together.

(Here Linnæus has allowed his lively temperament and his penchant for exaggeration to carry him away. We know that on the contrary he was in perfect health during his travels in Lapland. "Never did I feel better than in the mountains", he exclaims at one point in his dietary notebook. Although we know better, let us disregard such trifles. Linnæus continues:)

I await your *Flora Sibirica* with intense interest. Do not fail to order it into strictly divided genera and species, adding synonyms where such exist, and otherwise providing descriptions or illustrations. The place and growing conditions should be stated for each discovery. For the lesser-known species, you should note specific traits through which they may be distinguished from their nearest relations. In this manner your *Flora* of one of the remotest lands will take its place alongside the *Floræ* of the best-known lands. Nor should you hesitate to call up on my assistance: I shall always be at your service with the greatest of pleasure ... In the second edition of my *Genera Plantarum* I have called one plant genus *Gmelina,* so that your fame might be spread to all nations, for I feared (as I said) that Death had already stolen you from our sight.

Surely it was impossible for Gmelin to be other than pleased, flattered and encouraged by such a letter! His response came immediately, promising as a true vassal to serve and obey his new liege lord: "I promise you all my services, a friendship worthy of you; I shall eternally be true to you and not Siegesbeck." There follows a long harangue—admittedly provoked by Linnæus in his previous letter—about how quarrelsome and inept a botanist Siegesbeck was: he was "at most a gardener, but not a true botanist". and here, as some of you may already have noted, are echoes of the teminology of *Philosophia Botanica.*

It need hardly be said that this did not fall on deaf ears in Uppsala, and thus began a lively exchange of ideas and material across the Baltic. Although the Russians controled their own collection, Gmelin nevertheless was not without resources when it came to sending Linnæus herbarium specimens, seeds and—not infrequently—living plants in pots, chests or lumps of earth wrapped in bark, his couriers being Swedes in St. Petersburg. While he remained in town, Baron Bielke was an important mediator, as were Legation Secretary Lagerflycht and Legation Clergyman Bælter; the latter subsequently seems to have become particularly close to Gmelin. A number of anonymous ships's captains should not be forgotten, either. Box after box of dried specimens (duplicates, of course) arrived for Linnæus to determine and keep; an impressive amount of work clearly went into his letters in return, their pages filled with long taxonomic discussions. Only occasionally is their scientific tone lightened by more peripheral matters, and in this respect Gmelin's letters are much more rewarding, more human and of a wider scope. Moreover, their number far exceeds that from Linnæus! It should nevertheless be recalled that Linnæus' correspondence was much greater than that of Gmelin, and the former seems to have had a totally different capacity for desk work than Gmelin, who is said to have done justice to his motto, "Festina lente".

Seeds and printed botanical treatises crossed the Baltic in the reverse direction, as well: academic dissertations that were slender, yet often filled with scientific dynamite, compendious systematic handbooks or accounts of voyages and travels—the letter of course written in Swedish, leading Gmelin to lament his insufficient learning: he could not understand Linnæus' native tongue, although Bælter at times functioned as a translator for him.

These were the years during which Linnæus became preeminent among his colleagues. It has been said that he conquered merely by means of the volume of his published works. No other contemporary botanist had such a firm grasp of the entire world's plant kingdom, and no other reference works provided such an up-to-date review of the entire known field of systematic botany. If one wished to publish material that one claimed was new, as of course was Gmelin's desire, it was simply impossible to ignore the works of Linnæus.

But Gmelin was not able to obtain all of Linnæus' works: as early as his second letter, he inquired about *Hortus Cliffortianus.* He did not have a copy of his own and had to be content to use Amman's old copy, which the Academy had bought after his death. Gmelin had sought the work in Germany, but failed to obtain it, and his half-brother had fruitlessly inquired in the land where it was printed, Holland, the promised land of booksellers and publishers. Neither money nor prayers, "aut pretio aut precibus", had helped. He now hoped that the author could help him, but this was not to be. This magnificent volume, the only one of its kind by Linnæus, and one of the few volumes of engravings he chose to produce (although the genre was common enough in Europe), was already rare and difficult to come by even at that time. It is striking that although Sweden had begun to take its place as a major power within the natural sciences, it remained a poverty-stricken country on the outskirts of Europe, and could not offer Linnæus the external circumstances required for quality etchings. Finally he referred Gmelin to his own publisher, Salvius, in Stockholm, who apparently had a copy, but were asking a price of four Dutch gold ducats. "Frightfully expensive—I should not wish to pay such an amount", wrote Linnæus, who in his own way was opposed to expensive copper-etched illustrated volumes, as Professor Heller only five years ago reminded us at the Linnæan Symposium in Pittsburgh. Gmelin nevertheless held firm and said that he was willing to pay even so exorbitant a price for this indispensible work. The correspondence unfortunately fails to inform us whether he ever received his copy of the "Hortus".

It is in connexion with these book transactions that we again come upon the name of Hiärne. In addition to his position in natural history, Gmelin was also Professor of Chemistry, a combination frequently found at the time, and one which he was to retain even upon his return to Tübingen. On one occasion he requested Urban Hiärne's *Parasceve,* his "Prolegomena" for his laboratory experiments in Stockholm. Hiärne's *magnum opus* in chemistry was of course familiar to him from his years as a student and he now clearly needed it in St. Petersburg, as well. He returned to it and its continuation, *Acta et tentamina chymica,* on numerous occasions.

Throughout their correspondence a constant refrain is the animosity Linnæus and Gmelin bore towards Siegesbeck. This is not the proper occasion to deal with such matters, but it cannot be denied that for the non-partisan modern reader of these letters this animosity produces a somewhat manic impression. I shall confine myself to one episode as told by Gmelin, since I find that it gives us a living contemporary picture of Academy sessions; by all descriptions the Academy was a nest of intrigues of the worst sort, and Gmelin's sketch reveals the circumstances under which the foreign members had to work.

Siegesbeck—who, by the way, the two bosom friends in their letters often called Siegesbeckiodes, rather than Siegesbeckius (a jest whose point will at any rate hardly escape the systematic botanists present)—Siegesbeck, it seems, had during a session of the Academy become involved in a dispute with Gmelin concerning some botanical question. Gmelin finally cut him off, crying "There's too much talking going on here! Show us what you mean by bringing the plant to the next meeting." Siegesbeck answered, "It is not permitted to take plants out of the garden and bring them anywhere else." Gmelin: "But remember that the garden belongs to the Academy and not you, and that you cannot deny the Academy anything which is its own, above all [and here is the sting] in the manner in which you give away any plant at all to foreigners." Siegesbeck: "Oho, are your referring to Baron Bielke?" Gmelin: "Perhaps, perhaps—you have heedlessly given plants to him, although you should have known better."

I admit that the circumstances hardly seem crystal-clear to me, and that we are perhaps dealing with a triangular intrigue, or even a four-way one involving Linnæus and Gmelin, Siegesbeck and Bielke. But I think that this exchange of retorts—regardless of how sterile they may have been—seems so correct, so true, that I did not want to omit it here.

Let us leave such trivial quarrels, however, and turn to the higher and purer realms of science. After all, the greater part of their correspondence concerns news and discussions of the latter sort. One Uppsala dissertation that aroused particular interest in the scientific world was presented in 1745 and dealt with a newly-discovered plant, noted only the previous year, apparently a descendant of the species *Linaria vulgaris*, and whose inflorescence and arrangement of stamens clearly deviated from previously known specimens. To this flower Linnæus gave the name *Peloria* ("monster") and listed it as a separate genus. Quite clearly this empirically demonstratable case of change of species must have dealt a blow to his former belief in the immutability of species. Its five different and regularly placed stamens indicated that *Peloria* belonged, not merely to a new genus, but even to a class different from that of its parents. If this *Peloria* bred true, then a considerable part of established botanical theory would be overthrown: it would no longer be possible to base the genera upon fructification and the most natural classes would be torn asunder. In this same dissertation, however, Linnæus advanced the theory that this perhaps was a case of *hybridization* between *Linaria* and a completely different flower. If *Peloria* is a hybrid and produces germinative seeds, said Linnæus, then a new truth will dawn in botany, with important consequences for systematic classification.

Through Bælter, Gmelin swiftly learned of this treatise by means of a review in the Swedish paper, *Lärda Tidningar,* and immediately wrote to Linnæus about the matter: "Several years ago I had already come upon the idea that new plants can arise through crossings between different species of genera. I now possess five or six Siberian species of the genus *Delphinium,* whose *differentias* I can clearly demonstrate. But from Siberia I brought home only two species. There is much in botany which hitherto has indeed been impossible to explain, but which can be explained by this theory, if it can be accepted." Gmelin thus supported the concept that new forms can occur through hybridization. The problem was long to haunt him: he often came back to the question in letters to Linnæus and others, and ultimately adopted it as the subject of a printed oration upon his return to Tübingen, his "Sermo academicus de novorum vegetabilium post creationem divinam exortu".

The correspondence between the two friends took a more personal turn when Linnæus asked Gmelin for his portrait. He had received a copper etching of Haller's portrait and delighted in it, and now wished to have Gmelin's as well. "O, that I might have your portrait, too. You must indeed have one made, because this shadow-portrait alone will remain in this world, all else being subject to the law of mutability." And Linnæus did indeed receive a copy of the well-known copper-etching. "My own boldness never had sufficed to send it," said the modest Gmelin, "for I do protest my unworthiness and reject all vanity." But Linnæus was overjoyed: "I thank you for your portrait. I await it in the next shipment from our friend Lagerflycht. In my mind's eye I have often seen you, and the greater will be my joy truly to see your face and observe the most noble soul that does dwell therein. You shall receive your place among my botanic household gods in the room where I give my private seminars."

Surely that was overdoing it a bit, Gmelin felt: "I nearly burst out in laughter when I read that you had hung me there among your *Penates*, for I have rather regarded myself as a spirit which night and day interrupted your studies to beg services of you. Should *I* ever receive *your* portrait, however, I shall provide it with a place *above* my *penates*."

In this connexion it should be mentioned that in the recently-restored Linnæan house in Uppsala, the old lecture-room has also been restored to its original form, where the walls are decorated with copper portraits of Linnæus' colleagues, precisely in the manner described by him in his letters and other writings.

The time was approaching for Gmelin's departure. In the same letter in which he wrote those jesting lines about himself as a ghost in Linnæus' study, he mentioned that he was on his way home. His health was no longer satisfactory and he felt how the strenuous years in Siberia had exacted their toll. "Under such circumstances it is better that I dwell in my native land. We can continue our correspondence through Hamburg." He hoped to accomplish more during one year in Tübingen than five in St. Petersburg,where his medical practice continually interrupted his work on *Flora Sibirica*.

In 1747 Gmelin left St. Petersburg for good and two years later was hard at work in his home town. "I daily give lessons in botany for the students of medicine, who now commence to rejoice in the fundaments of true and correct botany. For doubtless there is much to do here. Since the days of Camerarius our university has scarcely been able to rejoice in botany, and my predecessor scarcely recognized three plants, and that only through their *habitus*!" There speaks a true Linnæan, if we may be so disrespectful, a man who recognizes a species by its stamens and pistils, rather than by anything as vague and doubtful as its outer appearance.

Gmelin's final letter to Linnæus dates from 1750 and concerns gardens. "We have here a small academic garden, which is miles behind yours in Uppsala. Here there is but one *tepidarium* [although Uppsala in fact had no more] and no *calidarium* at all. Time may perhaps change this for the better." (And indeed his wish has come true, as I myself had the pleasure of experiencing when precisely one year ago I visited Tübingen and its new botanical gardens, one of the very best-planned and endowed in all of Europe.)

Linnæus' final letter to Gmelin came the following year. Gmelin's accounts of his Siberian travels had just been published. "It was with the greatest pleasure that I devoted last evening to your *Iter Sibiricum.* No one has deserved better of botany than he who for a decade traveled in such barbaric lands." Linnæus' parting words in this correspondence are, "My regards to your charming wife. May God grant that your marital bed be blessed with sons worthy of their father's deeds."

And Gmelin did indeed have children and descendents who did honour to their father's name and spread glory over the family. Nevertheless, the interest in natural history descended to a collateral line: it was his nephews and their descendents who were to continue Johann Georg's passion. An important name in this connexion is Johann Friedrich, who edited new editions of Linnæus' *Systema Naturæ*, and who corresponded with Linnæus' successor in Uppsala, Thunberg. And we may perhaps say that the circle closed when another descendent from a collateral line, Christian Gottlob Gmelin, who died in 1860 as Professor of Chemistry in Tübingen, made the pilgrimage to Stockholm in the early 1800's, as did his ancestor Johann Georg the elder, in order to steep himself in the science of chemistry, this time at the feet of Berzelius.

HEINZ GOERKE

Linnaeus' German pupils and their significance

Linnaeus' relationships with German professors, physicians and natural scientists, especially with Albrecht von Haller, Johann Andreas Murray, but also with Johann Gottlieb Gleditsch, Lorenz Heister, Johann Georg Siegesbeck and Johann Christian Daniel Schreber have often been examined historically. His relationships to scientific academies and societies have also been closely studied. Here the question: How much did individual scholars contribute to the acceptance of Linnaeus' ideas (especially his sexual system) in German-speaking countries? On the other hand, of equal interest is the question how much these same scholars supported him through scientific communication as well as through relaying knowledge of the continental European literature and contributing to his natural science collections. The 18th century was—with respect to relations between scholars—a time of study-travels and correspondence. Only a few, however, were able to undertake scientific voyages several times, especially when these extended beyond their own homelands. Usually it was possible to make only one voyage abroad, that came at the very end of the studies or shortly thereafter, often undertaken to graduate, and through which the first personal contacts to other scholars were formed, which often led to decade-long correspondences. Such was the case with Linnaeus.

On his trip through Germany to Holland, Linnaeus made contacts with only a few people; among these that with Johann Peter Kohl (1698–1778) is untypical. Earlier he had had a correspondence with Kohl, in which he communicated about his scientific work, especially his trip to Lappland. Kohl, then, in his journal *Hamburgische Berichte für gelehrte Sachen* published a report about this. Linnaeus came into contact with other Germans in Holland and also in England. In Holland he met the anatomist, Johann Nathanael Lieberkühn (1711–1756) and the physician Johann Bartsch (1709–1738); in Oxford, the professor of botany, Johann Jakob Dillenius (1687–1747), as well as the flower-painter, Georg Dionysius Ehret (1708–1770). On the walls of the bedroom of Linnaeus' estate in Hammarby are flower-paintings by Ehret. Linnaeus wanted to interest him in working for the University of Uppsala later on, but this did not succeed. In all considerations about Linnaeus' ties with Germany, we must distinguish clearly between those scholars, who not only because of age but also because of position can be considered his equals, those who either supported or opposed him, and those who, in the true sense, were his pupils. Those latter were those, who attended his lectures, who took part in his demonstrations and shared and passed on his views. When we use such a definition, we should restrict ourselves concerning the German pupils to Johann Andreas Murray and Johann Christian Daniel Schreber, and perhaps also Johann Beckmann, who spent a long time in Sweden and studied with Linnaeus. Beckmann, however, became active in Economics later on and, in contrast to Murray and Schreber, was no physician. Among those in Germany with whom Linnaeus exchanged letters, there were many who not only sent him scientific news and objects but also answered specific questions for him.

Additionally, if we examine Linnaeus' relationships to his German pupils, we should not overlook the fact, that he was himself Professor of Medicine, and, thus, the other basic natural sciences belonged as well to his academic tasks. Science historians do not consider this often enough. For some educated people, Linnaeus emerges as merely a botanist, having occupied a chair only in botany. In his publications, especially dissertations of his pupils, which we know he generally wrote himself, his medical profession is unmistakable. His close relation to medicine is even more evident in his correspondence, especially with his good friend and president of the Royal Medical College in Stockholm, Physician-in-Ordinary, Abraham Bäck (1713–1795), demonstrating the great influence that Linnaeus had on public health and legislation concerning it.

In several publications, I have already referred to the importance of Johann Andreas Murray (1740–1791) for Linnaeus. These publications are mainly in German and Swedish and I want therefore to mention the more important facts concerning Murray's biography and especially the ties of his family to Sweden.

Johann Andreas Murray was a member of a Scotch family that, in the 17th century, emigrated to Prussia. Not far from Memel, in a region that later became East Prussia, Johann Murray (1665–1721) acquired an estate. Andreas Murray, one of his sons, studied theology in Königsberg and Jena and became a priest in Holstein. He then went to Stockholm as vicar of the German Church. A son from his first marriage, Johann Philipp Murray, became professor of philosophy in 1755 at the University of Göttingen, founded earlier in 1737. Through him, the relationship of the family to this new, very modern university was started.

Andreas Murray married in Stockholm the daughter of the first priest of the German Parish, Johanna Christina Golitz. They had three sons. The oldest was Johann Andreas. His brother, Gustav, seven years younger, became a theologist and later Bishop of Västerås. The third son, Adolph Murray, became Professor of Anatomy and Surgery at the University of Uppsala.

Johann Andreas Murray arrived at 16 at the University of Uppsala and became a student of Linnaeus'. Nils Rosén von Rosenstein (1706–1773), famous Physician-in-Ordinary and author of a basic work in pediatrics, and Rosén's son-in-law, Samuel Aurivillius (1721–1767), were among his teachers. In 1760, Johann Andreas Murray went to Göttingen to continue his studies. As Linnaeus' pupil and as a result of his good botanical conversance and also probably the assistance of his brother, he was appointed lecturer for botany in 1763, receiving his Doctor's Degree in the same year. Merely one year later, he became Professor Extraordinary at the Medical Faculty. In Göttingen, he earned special merit through further development of the botanical garden, which he enlarged and to which he added new plants. In 1765, Murray was called to the University of Altdorf, which belonged to the Independent City of Nürnberg, as Professor of Medicine. Murray remained in Göttingen, where, in 1769, he was appointed Full Professor at the Medical Faculty. It is interesting that Murray was first appointed Professor of Botany at the Faculty of Philosophy and that this professorship was then transferred to the Medical Faculty. In addition, Murray practised as a physician. That he had had medical experience is demonstrated in the letter to Albrecht von Haller, in which he describes the sickness and death of his brother, professor of philosophy, in 1776. Accordingly, Johann Philipp Murray died as a result of an advanced pulmonary tuberculosis. Johann Andreas Murray was a devoted disciple of Linnaeus' views, uncritically defending his teacher's sexual system. His own publications in botany are of lesser importance. His knowledge and ability in this field are however evident in his large work *Apparatus medicaminum*, which was published from 1776 to 1792 in 6 volumes. The last volume appeared after his death and was issued by Ludwig Christoph Althof (1758–1832), his pupil. This work, not only a collection of pharmaceutical and pharmacological facts, but also containing clinical and therapeutic observations, offers the best perspective of medical therapy in the second half of the 18th century. To what extent Johann Andreas Murray reports about new publications in all fields of natural science and about personal relations between scholars, their careers, etc. to his teacher Linnaeus, can be seen from their correspondence. Linnaeus recognised the devoted affection of his pupil in 1770 in naming a plant genus *Murraya.* Still, Murray had requested this honour, and Linnaeus exacted as fulfillment of the scholarly requirement some botanical papers from him. Thereupon Murray published in the Proceedings of the Swedish Academy of Science *Beskrifning på en rar ört Aletris Capensis* and in 1771 in the Proceedings of the Academy of Science in Göttingen *Commentatio naturam foliorum de arboribus cadentium expendens.*

Between 1774 and 1781 Johann Andreas Murray published his "Practical Medicine Library" (*Medizinisch-praktische Bibliothek*) in 3 volumes. In this he comments on publications in Swedish and on many personal news-items concerning Swedish scholars.

During a visit to Sweden, which Murray undertook in 1771, he met, of course, his teacher, Linnaeus, and the latter gave him the manuscript of the new edition of the botanical portion of his *Systema naturae.* Murray published it as the *Systema vegetabilium*, the 13th edition of the *Systema naturae* in Germany. Linnaeus' gratitude for the fact that the work could appear in 1774 and that Murray could send him a considerable fee for it through his brother-in-law, a merchant in Stockholm, is evidenced in his letters. Johann Andreas Murray translated several works of Swedish physicians and surgeons into German, among them the famous book by Nils Rosén von Rosenstein about pediatrics (*Anweisung zur Kenntniss und Cur der Kinderkrankheiten*), printed in 1766 in Göttingen and Gotha. After the death of Linnaeus junior in 1783, it was debated whether or not to appoint Murray his successor. Murray stayed on, however, in Göttingen, probably because of his health. He died in 1791 at the age of 51.

Among Linnaeus' favourite pupils was Adolph Murray (1751–1803), the younger brother of Johann Andreas, whom we have already mentioned. In 1772 to 1776 he undertook a large study-voyage to the continent and thus was able to visit his brother in Göttingen. On June 17, 1774, Linnaeus wrote to Johann Andreas Murray in Göttingen and asked him to inform his brother that he had been appointed Professor in Anatomy and Surgery in Uppsala.

Of greater importance for Linnaeus with respect to communication with German-speaking scholars was the association with Johann Christian Daniel Schreber. In his biography Fries placed him first among all foreign pupils Linnaeus had had. Schreber's significance is, indeed, extraordinary, not only because of personal contacts with Linnaeus and the resulting correspondence, but also because of the great influence he exercised on German academic life and as a scientific writer. Of special interest might be Schreber's engagement as translator and editor of a great number of papers written by Linnaeus and his pupils. A good many of these enjoyed an enormous circulation in Central Europe and greatly promoted Linnaeus' reputation. Schreber was one of the most important German scholars in Medicine and Natural Science in the second part of the eighteenth and at the beginning of the nineteenth centuries. He is well-known as Professor of Medicine, Botany, Natural History and Economics at the University of Erlangen and as President of the Imperial Leopoldina-Carolina Academy of Naturalists.

On January 17, 1739, Johann Christian Daniel Schreber was born, at Weissensee in Thuringia. His father, Daniel Gottfried Schreber, at that time an agricultural administrator, moved to Halle and Bützow where he was assigned a chair in Economics and Agriculture. Probably due to him, the young Schreber became interested in Linnaeus and his work. Daniel Gottfried had translated and published three papers of Linnaeus', the first one in 1761 in his *Sammlung in den ökonomischen, Policey- und Cameral-Wissenschaften*, referring to transformation of cereals, especially of oats to rye. Johann Christian Daniel matriculated at the University of Halle and published his first paper, entitled *Lithographia Halensis*, in 1758. In this same year, he started his correspondence with Linnaeus and arranged a journey to Sweden. But only as late as early June, 1760 did he arrive at Uppsala to visit Linnaeus and hear his lectures. Soon after his arrival, he passed the medical examination, on June 10, and defended his *Theses medicae* four days later. He received his M.D. on June 16. The dissertation is a very short one, the shortest of all defended under the sponsorship of Linnaeus. The circumstances involved in Schreber's graduation recall Linnaeus' own graduation at Harderwijk, in 1735—five days after his arrival he had received his diploma. Some facts concerning Schreber's visit to Sweden and his graduation are worth mentioning because they characterize Linnaeus and his relations with foreign visitors.

Schreber's name appears for the first time in a letter which Linnaeus wrote to Abraham Bäck (1713–1795), Royal Physician-in-Ordinary and President of the College of Physicians (Collegium medicum), dated March 2, 1759: Linnaeus reports that Schreber had published papers on mineralogy and insects, meaning the *Lithographia Halensis* (Halle 1758/59) and *Nova species insectorum* (Halle 1759). The most interesting reference to Schreber, however, can be found in a letter of Linnaeus to Baron Anders Johan von Höpken (1712–1789), Chancellor of the University of Uppsala from 1760 to 1764, dated May 14, 1760. Linnaeus announces the arrival of two students from abroad, both sons of professors. It refers to Nicolaus Laurent Burman (1734–1793), the son of the Professor of Botany at Amsterdam, Johan Burman (1706–1779), and Schreber. Linnaeus writes:

One of the young men, Doctor Schreber, is bright and fully qualified. He has sent me different, pleasant observations and rare insects during several years of our correspondence, as well as a little book with many pleasant observations.

He has tried to come to hear my lectures for three years and was ready to start last year, if measles had not stopped him. After he finally left and came to Hamburg, he wrote from there on April 30, that he hoped to be with me before Whitsuntide. I myself, always wary of theological and political matters, fear some one could criticize me or attack Your Excellency because of my welcoming him from Halle, a hostile country, although our innocent pleasures with flowers and insects are as remote as children's play from the trade of war. Therefore, I venture and presume submissively that Your Excellency inform me, whether I may meet this Doctor Schreber, as customary with students and foreigners, without offending the ordinances obtaining in the case of war, etc., for otherwise I would abstain from his company, even though I am convinced of his unique desire to learn, and it has been conventional among the most cultivated nations to permit students to pass through unimpeded.

Four days later, on May 18, the Chancellor answered:

His Maj. the King, who graciously appreciates this cautious behaviour, has granted permission to the student concerned to come into the kingdom, and to Uppsala, and therefore, there is nothing to defer you from displaying your gentleness in teaching and courtesy in your relations, which stimulate those eager to learn, and from attending to your guests. When Dr Schreber arrives, it should be easy for you to determine, if he is interested in Botany only or desires as well political news and discussion. In the latter case, you should select a qualified student to keep him company and watch his behaviour and give you information about it.

This should be the only consideration, that is required—and this for only a short time—until we have come to know the nature and interest of this stranger to our land.

From an additional letter addressed to the Chancellor of the University, written by Linnaeus as Dean and bearing his signature and that of his colleague, Samuel Aurivillius (1721–1767), dated June 10, 1760, we learn of further interesting details about Schreber's first weeks in Uppsala and the reasons as well for the hasty completion of his graduation:

Johann Christian Daniel Schreber, newly registered at the University, has applied for admission as candidate for graduation for the beginning of the next semester. The Faculty has examined him and decided, he is worthy of such a title, and that he possesses an unusual knowledge in the field of Botany and all the Natural Sciences, and especially of insects. Because, however, it is not usual here to have graduations every semester, [. . .] the Faculty considered it best that Schreber take his degree on the following Monday, with the other graduating students, especially since such ceremonies claim much time of teachers and students.

Thus it is a respectful request of the Faculty that Your Excellency grant the permission that next Monday Schreber graduate and that his "Theses medicae" be available for disputation next Saturday, even if it has not been made available for inspection for a complete 11 days before the day of disputation. Should your precious time and the greatly important events in the service of the Kingdom allow your agreement by the next mail-day, the procedure will be followed through. In addition, this licentiate Schreber, according to our careful examination of his nationality, is not a Prussian but a Saxon, for he was born in Thuringia, even if his father was an Extraordinary Professor in Halle, who recently transferred to the newly opened Academy in Bützow in Mecklenburg as Professor of Economics.

In a footnote to this letter, Fries states, that it was handwritten by Linnaeus, and signed by him and Aurivillius. He states as well that in the annals of the Medical Faculty, concerning the examination held on the same day, one sees, that Schreber, "in the field of Natural Sciences, had had at his disposal more knowledge than anybody else had been able to demonstrate up until this time".

Baron Höpken approved the application and, as a result, Schreber's graduation could take place. In Linnaeus' correspondence are to be found other references to Schreber, from which it can be seen how much his abilities and knowledge were valued by Linnaeus. We cannot go into further details here.

Schreber spent about half a year in Sweden. In this time he had apparently acquired sufficient knowledge of Swedish so that he could read and possibly translate his teacher's works.

Before we can treat further scientific relations between Schreber and Linnaeus, we have to discuss additional developments in Schreber's career. It should be clear that Schreber, immediately after his stay in Sweden, went to Bützow in Mecklenburg, where, as already mentioned, his father had become professor at the new university. As a result of a dispute between the City of Rostock and the Duke of Mecklenburg, based on differences between a scholastic-orthodox and a pietistic approach in the Faculty of Divinity, the Duke Friedrich founded in Bützow a university that bore his name. It existed from 1760 to 1789 and then was reunited with the University of Rostock, which had been founded in 1419. In different biographies there are varying figures for the length of time Schreber spent in Bützow. He seems to have practised there as a physician and, additionally, as an instructor of Natural Sciences. His relationship to the University remains, however, unclear. The most reliable information seems to come from Fikenscher, who wrote in Schreber's time, that the latter came "as physician to the college in Bützow in 1761" and "received the permission to hold lectures at the University".

Schreber remained in Bützow until 1764 and then went to Leipzig as Secretary of the Economic Society. Through his writings and as a follower of Linnaeus, he became well-known in Germany. He was elected a member of important learned societies, among those the Imperial Leopoldina-Carolina Academy of Naturalists, in which he later played an important role.

In 1769 he was appointed as the Third Professor of Medicine at the Friedrich-Alexander-University in Erlangen. This university was founded by the Markgraf of Bayreuth in 1743, in his small principality. The University was transferred to Prussia in 1791, was controlled by the French in 1806, and ended up in Bavaria in 1810. By this time the danger of its closing threatened, but it remained open, due in great part to the fact that it was protestant and the only one of its kind in the Kingdom of Bavaria. These difficult years, difficult economically and politically, were experienced by Schreber, and his reputation as scholar played a not insignificant role in the continued existence of the University.

On August 25, 1770, Schreber held his opening lecture about the relationship between medicine and economics (*De nexu scientiarum medicarum cum oeconomicis*). He then stayed in Erlangen 40 years refusing all other appointments. In 1773 he became Director of the Botanical Garden, newly created for the University and in 1776, Professor of Natural History. A year later, he became Curator of the Collection of

Naturalia. In 1791 he became Second Professor of Medicine and was selected as well, in the same year, President of the Leopoldina. Associated with this was an elevation to the nobility and a granting of the privileges of Imperial Councillor, Physician-in-Ordinary and Count Palatine, these awarded as special distinctions to the Society and its President. Schreber was appointed First Professor of Medicine in 1793, a substantial promotion in terms of income and status. In 1795, the King of Prussia—Erlangen belonged to this state in that time—appointed him Privy Councillor. Among the honours that famous learned societies bestowed upon him, we will only mention the Linnean Society of London's election of him as a member in 1800. Schreber died on December 10th 1810, only a few days after the King of Bavaria, Max. I Joseph had decided that the University of Erlangen could continue to exist.

Schreber occupied all the high academic positions of his University, and was twenty-one times alone Dean of the Medical Faculty. On the basis of his large scientific correspondence, he was able to increase the number of objects of the Collection of Naturalia, and the size of the Botanical Garden, as well as his personal herbarium. At the Medical Faculty he held lectures in Botany, Physiology, Dietetics and Alimentary Science (*Materia alimentaria*), and, at the Philosophical Faculty, in Political Science ("Kameralistik"), Agriculture, and Technology. His extensive knowledge of astronomy was famous. Schreber had mastered exceptionally Latin, but was also conversant with Greek and Hebrew. As a speaker, however, he was not very stimulating; his lectures were considered dry and not very attractive. He never had a large circle of pupils and was considered an introverted scholar.

His comprehensive literary work cannot be extensively handled here. A complete bibliography of his papers does not exist, but there are several compilations of his most important publications. Among his botanical works, his "Description of Grasses" (*Beschreibung der Gräser*) occupies the most important position. It appeared from 1769 to 1810 in 3 volumes, with 54 coloured plates.

On this occasion Schreber's translated and edited works of his teacher should interest us. Chronologically arranged, the translations of two travel-journals appear first; these Linnaeus wrote about his trips to the isles of Öland and Gotland, as well as through Westgothland. The trip to Öland and Gotland was made in 1741. The report about it appeared in Swedish in 1745, and Schreber's translation was published in Halle in 1764. The trip to Westgothland took place in 1746, and the dexcription of it ("Wästgöta-Resa") was printed by Salvius in Stockholm in 1747. Schreber's translation appeared in Halle in 1765. Schreber was living at that time in Leipzig. He dedicated this translation to the merchant of Lubeck, Peter Hinrich Tesdorf, feeling the important economic observations justified the dedication. Schreber wrote in his preface ("Vorerinnerung") that he had made a complete translation but that he had also adapted the work to Linnaeus' newest additions in nomenclature. Thus the animal nomenclature follows the second edition of the *Fauna svecica* and the 10th edition of the *Systema naturae*. In this context, the 10th edition (*Editio decima*), appearing in 1758/59 in Stockholm, printed by Salvius, was probably used. A reprint of this 10th edition was edited by Johann Jacob Curt in Halle in 1760, the same publisher who issued Schreber's two translations. The plant-names were adopted by Schreber from the second edition of *Species plantarum*, those of stones and minerals from *Museum Tessinianum* and *Systema naturae* of 1748, known as *Editio sexta*. Anyone who has mastered both languages and compares the two texts will observe with astonishment that the translation is a truly faithful one. It is scarcely to be believed that Schreber had been able to acquire such a thorough knowledge of Swedish in so short a time, so that the translation must have had the help of cooperating translators. Whether, during his stay in Sweden, Germans living there helped him in the task of translation, or, later in Bützow or Leipzig, Swedes, whose knowledge of German was sufficient, is a moot question. Neither assumption can be proved.

In the year 1749, the first volume of dissertations, called *Amoenitates academicae* and printed by Cornelius Haak appeared in Leiden. These dissertations had been defended under the sponsorship of Linnaeus and had up until then only been published as separates. Petrus Camper (1722–1789) was the editor. He distinguished himself later as Professor of Anatomy and Surgery at the Universities of Franeker, Amsterdam and Groningen. He is well-known through numerous publications in Anatomy and Natural Science. In this volume, heading the group, is Linnaeus' own dissertation *De febrium intermittentium causa*, with which he obtained promotion in Harderwijk on June 23, 1735. In the same year, the first volume of dissertations of Linnaeus' students, edited by Linnaeus himself, appeared in Stockholm and Leipzig. It has been shown that this edition appeared after that of Leiden. Furthermore, the Leiden publishing-effort ceased with the first volume.

The second volume of *Amoenitates academicae* was published in 1751 in

Stockholm by Lars Salvius, and at the same time in Amsterdam by Wetstenius. In 1785 Schreber began an *Editio tertia,* whose first part agreed entirely with Linnaeus' own edition. The dissertation *Flora oeconomica,* the penultimate one, offers the only change. It is one page longer and thereby responsible for the increased length of the book. The three editions agree entirely in volume three to seven. Schreber's edition appeared, thus, after the demise of Linnaeus (vol. 1: 1785, vol. 2: 1787, vol. 3: 1787, vol. 4: 1788, vol. 5: 1788, vol. 6: 1789, vol. 7: 1789). Linnaeus' 7th volume of his own work was published in 1769. From 1785 to 1790 Schreber published still three additional volumes of *Amoenitates academicae*. Linnaeus junior wanted to publish as a continuation of his father's collection these theses but was prevented by his early death. In the preface to the 9th part, Schreber discusses details about the publishing. In the 10th part, he included Linnaeus' own dissertation, the one with which he graduated in Harderwijk. It is clear from this fact that Schreber supplied an alternative date to the one to be found in the original, namely June 24th instead of June 23rd. Why Schreber settles on this date, which Linnaeus also notes in his autobiography, is unclear. Afzelius' "Egenhändiga anteckningar" appeared first in 1823. The citation of the 24th of June in the Memoirs was considered by Gustaf Drake, in 1933, as a slip of remembering. In this last volume Schreber also printed three dissertations that had appeared under Linnaeus junior's sponsorship. Thus it is only through Schreber's edition that the papers in volumes 8 to 10 of *Amoenitates academicae* became known in broader circles. Schreber had preserved the text throughout, making changes only where nomenclature had undergone changes since the appearance of the dissertations. In some instances, he attached better illustrations than those to be found in the originals. He had to have the first seven volumes reprinted a second time. This explains some discrepancies between dates of title-pages and forewords.

The publication with which for posterity the names of Linnaeus and Schreber will be closely identified is the *Materia medica*. This textbook of drugs and pharmacology Linnaeus published in Stockholm in 1749, through Lars Salvius, as a collection of his lectures. In 1772 Schreber produced a second edition, with 266 text-pages and a 70-page index. This work was published by Wolfgang Walther in Leipzig and Erlangen. In 1782 Schreber was able to produce a 4th, and, in 1787, a 5th edition, using the same publisher. An edition produced in Vienna in 1773, a copy of the second edition, and, thus by Schreber, serves as the third edition. Concerning the appearance of the second edition, that is to say Schreber's, Linnaeus said, in a letter to Abraham Bäck dated March 12, 1773: "Recently I received the Materia medica, which was newly published in Leipzig and is rather small and almost identical. Had I been able to publish it, it would have been certainly different."

In Linnaeus' *Materia medica* of 1749, he treated only those drugs which were obtained from plants. As a complement to this, a paper appeared in 1763, *Caroli Linnaei Materies medica Liber 2* [secundum] *de animalibus et 3* [tertium] *de mineralibus*. Stockholm is supplied as place of publication, and Lars Salvius as publisher. According to the large bibliographies of Hulth and Soulsby, this paper is not only a rarity, but contains possibly some doubtful imprimatur-information. Were one to compare the contents of Jonas Sidrén's dissertation, *Materia medica e regno animali*, published on May 25, 1750 and Johan Lindhult's dissertation *Materia medica e regno lapideo*, published on May 18, 1752 with the above-mentioned paper, it would be apparent that the publications of these two pupils of Linnaeus were used. On the last page, one finds a coded reference to the editor (*D.S*^{xxx}, *Doct. Med.*), which makes it rather likely that Johann Christian Daniel Schreber is the one involved. There are references, as well, to the fact that the book was not published in Stockholm, but in Vienna, as Hulth notes. Stoever states that the publication was in Venice.

In the second edition of 1772, Schreber treats drugs of the animal and mineral kingdoms, and an analysis of this text supports again our supposition. He refers in notes to these dissertations as well. Otto Hjelt carefully analysed Linnaeus' ideas about pharmacological properties of plants and published his analysis in his paper *Carl von Linné som läkare*, which appeared first in 1877 and, later in completed form, in the memorial-publication for the Linnaeus Jubilee in 1907 in Swedish and 1909 in German.

Linnaeus had arranged herbs in his *Materia medica* according to his system and supplied, thus, hints for detecting healing effects on the basis of family-membership. He stresses in his introduction the value of simple drugs and warns about mixing plants with different properties. As his correspondence shows, he asked famous scholars what they knew about the healing-effects of certain plants, for example, Albrecht von Haller and Bernard de Jussieu.

Actually, Linnaeus wanted to bring out a second edition of *Materia medica* himself which is obvious from a letter of Afzelius to Johann Andreas Murray, dated January 24, 1765, printed in his *Egenhändiga anteckningar* (1822). Giseke was also able to report about such plans, as Stoever relates. This was, of course, prior to the Schreber edition. The

Materia medica had received such recognition from contemporaries as no other Linnaean work. Schreber himself referred to the work as *liber aureus* (golden book), and even Albrecht von Haller, whose critical opinions of Linnaeus have reached us in abundance, did not suppress his recognition. This book, the most important of Linnaeus' works for physicians, achieved a wider distribution in Central Europe through Schreber's edition. Its success is understandable when one compares it to earlier text-books on drugs. The clarity and simplicity of description and the conciseness of tabular arrangement are impressive. Many of the drug-indications Linnaeus describes obtain even today. Thus, to give only one example, Sabadill-seed, which Linnaeus recommended for lice, remained in the official German pharmacopea until 1968, actually to be used for the same purpose ("Läuseessig"). On the other hand, many indications are cited which, according to later views, imply great disease-classes.

In 1789 and 1791 Schreber published in 2 volumes the 8th edition of *Genera plantarum*. These appeared in Frankfurt-am-Main, printed by Varretrapp and Wenner. He had worked them through in the same manner as the other publications of Linnaeus. He dedicated this edition to the Royal Academy of Science in Stockholm, which had elected him a member in 1787.

The Hamburg physician, Paul Dietrich Giseke (1745–1796), published a dissertation in 1767 during his time in Göttingen as a student, *Systema plantarum recentiora*, in which he stated that he could not understand the characteristics of some of Linnaeus' natural plant-families. He forwarded this paper to Linnaeus, who admitted his incapability to clarify certain characteristics. Giseke therefore went to see Linnaeus in Uppsala in the summer of 1771. He discussed with him extensively arguments supporting construction of a natural system. We learn from Giseke that, in his later years, Linnaeus occupied himself seriously with the question of a natural botanical order. 20 years after visiting Linnaeus, Giseke published his impressions of and discussions with his teacher under the title *Caroli a Linné praelectiones in ordines naturales plantarum* (Hamburg 1792). In this paper, Giseke also uses notes of Johann Christian Fabricius (1745–1808), who had attended Linnaeus' lectures in Uppsala from 1762 to 1764.

Fabricius, born in Tondern, was Professor of Economics in Copenhagen from 1768 on, and was called to Kiel in 1776, where he also gave lectures in Natural History, and, additionally, in Political Science and Economics. He is also famous because of his *Systema entomologiae* (Copenhagen, 1775–98). He reported about his visit with Linnaeus and his impressions of him, his living-style, and his family in 1780 ("Einige Umstände aus dem Leben des Ritters von Linné", Deutsches Museum, Leipzig). We owe important insights into living-conditions surrounding Linnaeus to this publication, as well to the above-mentioned diary of Johann Beckmann, that, as is well-known, was printed shortly before the first World War.

If one is familiar with the political and cultural conditions of the geographic area, in which Fabricius was born, the question whether he was a Dane or German is without importance. What is important here is Giseke's use of Fabricius' lecture-notes.

Isaak Grüno (1756–1783) was a pupil of Giseke's. He became so enthused over his teacher's lectures about Linnaeus that he, in 1776, travelled to Uppsala to hear the master himself. He stayed for a total of 3 years in Sweden. In any case, he could not have learned too much from Linnaeus, for after Linnaeus' first stroke in 1774, he was certainly unable to lecture or conduct lengthy discussions. Linnaeus himself mentioned this fact in his autobiographical notes. There we find, entered under 1776, that the Danes, Horrebow and Berger, as well as Grüno from Hamburg, had come to him as pupils, although he was so sick that he could scarcely speak, the result of a combination of intermittent fever and the after-effects of paralysis and physical debility. Grüno, also interested in chemistry, attended Torbern Bergman's (1735–1784) lectures. He opened a practice in Hamburg in 1780, but died 3 years later at the age of 37. He had no lasting effect as a pupil of Linnaeus.

Even if there is only a small overlapping in biographical dates, still we have to consider one more German scholar as a true pupil of Linnaeus'. They were not contemporaries. This man is Joseph August Schultes (1773–1831), Professor of Medicine at the University of Landshut from 1809 to 1826. Schultes came from Vienna, where he studied and obtained his Doctor's Degree. In 1806 he became Professor of Botany and Chemistry at the University of Cracow, which was then Austrian. In 1808 he became professor at Innsbruck, in the following year at Landshut. The University of Innsbruck belonged then to Bavaria, so that Schultes actually remained in the same state. He had enormous difficulties with the government at both places, caused, of course, by his anticlerical statements. When the University of Landshut was transferred to Munich, in 1826, Schultes had to remain in Landshut and was there appointed Director of a newly created School of Surgeons.

He was a faithful follower of Linnaeus and edited in 7 volumes a new edition of *Systema vegetabilium*, which appeared from 1817 to 1830. In the editing of the first 5 volumes, Johann Jakob Roemer (1763–1819) of Zürich joined Schultes. Roemer had received his medical training at Göttingen and was a pupil of Johann Andreas Murray. After Roemer's death, Schultes published the 6th volume alone, and then the 7th together with his son, Julius Hermann Schultes (1804–1840). As a supplement to the *Systema vegetabilium*, Schultes published a *Mantissa*, which appeared in 3 parts, in 1822, 1824 and 1827.

Schultes played, in addition, an important role in the publication of *Flora capensis* by Carl Peter Thunberg (1743–1828). He had had a friendly relationship with the Stuttgart publisher, Johann Friedrich Cotta (1764–1832), who is known today as publisher of Goethe's and Schiller's works. *Systema vegetabilium* was also published by Cotta. On December 30, 1820, Schultes informed Thunberg in a letter that Cotta was ready to print *Flora capensis*. He was thus an intermediary. A few weeks later (January 24, 1821), Thunberg offered the publisher his manuscript for 150 Dutch florins. Cotta accepted this arrangement and contracted Schultes as editor. In the years 1823 and 1824 *Flora capensis* appeared in 2 parts, edited by Johann August Schultes. The letters we have referred to here are to be found in the possession of the University Library at Uppsala.

As a pupil of Linnaeus' in the broadest sense, one scholar must be especially considered who has meant much in bring about acceptance of Linnaeus. This is Johann Gottlieb Gleditsch (1714–1786), physician and botanist in Berlin. He gave very important support to the notion of plant-sexuality. From 1746 on, Gleditsch was Professor of Botany at the Collegium medico-chirurgicum and Director of the Berlin Botanical Garden. He was able to fertilize a female palm-tree, *Chamaerops humilis L.*, in his garden with the pollen from a member of the same family from the Leipzig Botanical Garden. The *Experimentum Berolinense* brought much success to Gleditsch and Linnaeus. The palm existed into the 1920's as living testimony of a great struggle between scholars in the 18th century.

Scarcely younger than Linnaeus was Carl August von Bergen (1709–1759), Professor of Medicine at the University of Frankfurt an der Oder. In 1738 he succeeded his deceased father as Professor of Anatomy and Botany. In 1750 Bergen published *Flora Francofurtana*, but he stands out more because of his anatomical writings. From 1743 to 1752 Bergen corresponded with Linnaeus. Plant-seeds as well as writings were exchanged. Bergen had also forwarded in 1744 the newly published catalogue of plants of the Frankfurt Botanical Garden. In the year 1746, Bergen reports as well about a Rhinoceros, which had been displayed at the Frankfurt fair and about which he published a paper (*Oratio de Rhinocerote*). He had informed Linnaeus that the latter's system had won his total support. The relationship between the two is not so much one of pupil–teacher, but that of two equally important scholars, with one advocating the other's ideas. Of course, there existed as well a direct relationship between Bergen and Gleditsch. The latter had received his Doctor's Degree under Bergen in Frankfurt.

Soon after Linnaeus' death, there sprang up numerous scientific societies which bore his name. A year following the founding of the Linnean Society of London (1788), a scientific society was formed in Leipzig with the name *Linneische Sozietät*. Its founder was Christian Friedrich Ludwig (1751–1823), who in 1786 had become Professor of Natural History at the University of Leipzig. His father, Christian Gottlieb Ludwig (1709–1773), was, at the beginning, an opponent of Linnaeus, only to become later one of his followers. Christian Friedrich, the son, was a physician who later served as professor in Pathology, Materia medica and Therapy, as well as Surgery. The *Linneische Sozietät* had a membership of 15 to 20, the majority originating not from Leipzig. Nobility was disproportionally represented. Today we know relatively little about the scientific activity of this society. Of the 11 lectures held there whose titles are known not one dealt with medicine. The *Linneische Sozietät* existed until 1825, thus outliving its founder by 2 years. It was merged with the *Leipziger Naturforschende Gesellschaft*, which had been founded in 1818.

It has not been possible within the bounds of this short overview to provide more than a collection of biographical references and a culling of important data concerning Linnaeus' contacts with German pupils and the importance of these. Relations between scholars in the 18th century were facilitated by the use of Latin which made it possible for Linnaeus, who knew, surprisingly, in addition to Latin only his mother-tongue, to build up an important network of correspondents. Confining this paper to Linnaeus' pupils leads, unfortunately, to only a brief mention of the strong disagreements in Germany over his views. Arguments with Siegesbeck and Heister and differences of opinion with Albrecht von Haller, in addition to other controversies, are repeatedly handled in the literature, but a more profound knowledge of these discussions would be of great value in estimating Linnaeus' role in European intellectual life at the second part of the 18th century.

JOHN L. HELLER

Bibliotheca Zoologica Linnaeana

As many of you know, I have been working for many years at a bibliographical guide to the documentary sources cited in the zoological works of the great teacher of botany and medicine whose memory we cherish even today, two hundred years after his death. In any report on the progress of Linnaean studies I ought to explain why its publication has been delayed so long. In what follows I hope to outline something of the nature and extent of this compilation, too apply materials drawn from it to complete my study of a dissertation (*Incrementa Botanices,* resp. J. Biuur, 1753) in which Linnaeus protested at the excessive cost of illustrated books on botany and zoology,[1] and to add some remarks on the Latinity of Linnaeus and the accuracy of his text in another dissertation (*Inebriantia*, resp. O. R. Alander, 1762).

In the first place, I must plead that my profession is not that of zoology or botany or medicine, or even of the history of science, but merely that of a student and teacher of classical languages and literature, specializing, if at all, in the history of words. I can claim to have been a lexicographer, that is, in Johnson's words, a harmless drudge. I have just completed a long article (so long that I don't know where it can be published) on the meaning of the Greek word coined by Seneca as a title for his satire on the death and deification of the Emperor Claudius. In the last ten years much of my time has been devoted to editorial work in the preparation for the press of a technical volume of international classical scholarship honoring my distinguished colleague, Alexander Turyn, to the direction of students' doctoral theses at Illinois and at the University of Pittsburgh, and to one other article of my own.[2] In the

[1] "Linnaeus on Sumptuous Books", *Taxon* 25 (1976), 33–52; a paper delivered at the Linnaean Symposium, held June 2–3, 1973, at the Hunt Institute for Botanical Documentation.

[2] *Serta Turyniana* (x, 624 pp.), University of Illinois Press, 1974; R. L. Den Adel, The Latin Vocabulary of Non-articulated Sounds, 1971; J. J. Prentiss, Linnaeus's *Senium Salomoneum:* Text, Translation, and Commentary (University of Pittsburgh), 1971; H. H. Parker, Linnaeus on Intoxicants: Pharmacology, Sobriety, and Latinity in 18th-Century Sweden, 1977; "Classical Poetry in the *Systema Naturae* of Linnaeus", *Trans. Am. Philol. Assn.* 102 (1971), 183–216.

second place, my study of Linnaeus's references to zoological authorities has been greatly enlarged since it was begun over twenty years ago. This was well before my compilation of an "Index auctorum et librorum a Linnaeo (*Species Plantarum*, 1753) citatorum" which was eventually published in 1959 as part of an *Appendix* to the second volume of the Ray Society facsimile edition of the *Species Plantarum*, whose first volume contains Dr. Stearn's epoch-making *Introduction*. And it was constructed on the model of that index, being restricted to the usually binomial and always abbreviated references to author and book in the first volume of the 10th edition (1758) of the *Systema Naturae;* compare an article on two of the most puzzling abbreviations, *List. Loqu.* and *List. mut.,* which were finally resolved by an inspection of Linnaeus's notations in one of his own books, preserved in the Library of the Linnean Society.[3] The first step towards enlargement was taken in the interests of palaeontologists, extending the coverage to the sections on (*Fossilia*) *Petrificata*, pages 156–74 in the third volume (1768) of the 12th edition. This was soon followed by the inclusion of the whole first volume of the 12th edition (1766–67) and the *Appendix Animalium* in the third volume. While making numerous additions to the descriptions of books, I was attempting to get accurate biographical data for all the authors mentioned by Linnaeus, with references to the contemporary and modern discussions of their works, and to add entries for the authors whose names Linnaeus did not mention, i.e. part authors or editors of books, authors of articles in learned journals or of dissertations, whether as presiding officer (*praeses*) or student examinand (*respondens*). And I was also intent on adding information which I had scanted in my previous index, that is, about all the persons mentioned merely in passing in footnotes, in the sections introductory to the whole volume and to each of the six classes of animals, and especially in the descriptive notes which often supplement the synonymy and supply the name of an informant concerning a particular species and its habitat. At the same time I prepared a second alphabetical index covering all the places mentioned in the paragraphs headed *Habitat,* with some reference to the modern geographical terminology and the Latin adjectives derived from the place-names and often used as trivial names—and occasionally, I must add, to a few corrections that should be made in Linnaeus's text.

[3] *Proc. Linn. Soc. London*, 173 (Pt. 1, 1962), 61–63 with plates 1–4 prepared by Dr. Stearn.

A final step, taken only recently, has made the coverage complete for all the zoological works of Linnaeus. First I moved forward in time to Linnaeus's very last treatment of animals, the "Regni Animalis Appendix", pp. 521–52 in the *Mantissa Plantarum Altera* (1771), then backwards, through the two editions of the *Fauna Svecica* (1746, 1761), earlier editions of the *Systema* (ii 1740 and vi 1748), the principal museological works, such as the *Museum Adolphi Friderici* (1754) and the *Amphibia Gyllenborgiana* as reprinted in the first volume of *Amoenitates Academicae* (1749), and so all the way back to Linnaeus's first extensive listing of species, "Animalia per Sveciam observata", pp. 97–138 in the fourth volume of the *Acta Upsaliensia*, nominally for the year 1736 but not actually published until 1742 and regularly cited by the page-numbers of Linnaeus's manuscript. This resulted in quite a few additional bibliographical entries, notably to classical, mediaeval, and early modern authorities (e.g. St. Hildegard's *Physica* (first printed in 1533) and William Turner's *Avium Historia*, Coloniae 1544) which Linnaeus did not think worth mentioning in the 10th edition of the *Systema*. For by this time, as we will see later on, he had enlarged his own library and his bibliographical control over illustrated works on zoology.

It also involved considerable revision of my paragraphs describing other books and supplying locations to illustrate the abbreviated references, for Linnaeus was anything but consistent in his designations. Over the years he often had different abbreviations for a given work and sometimes a given abbreviation denoted different works.

And of course, over the years my index has had to be copied from one notebook to the next and recopied through several typed versions, with numerous possibilities for error. Correcting these as best as I can, I will say only that the present version runs to about 400 somewhat messily typed pages, and that it contains bibliographical data with commentary on Linnaeus's citations for about 450 separately titled books, monographs, or dissertations. Twenty-five of these titles are serials or journals, some of them (e.g. the *Philosophical Transactions of the Royal Society*) running to many volumes, and I think I have run down every single one of Linnaeus's not always accurate references (except for one blank reference to *Act. holm.* at *SN* xii 220 Colymbus 2 Troile), so that the number of articles analyzed comes to about 300. The total does not approach the *libri plus mille* which Linnaeus claimed to have reviewed in his *Bibliotheca Botanica*,[4] but it is at least respectable. The main entries will number

[4] See my article in *Taxon* 19 (1970), 363–411, especially fig. 2 (p. 373) and §2.16, where I showed that an actual count reached only to 833.

nearly 600 and will include every person mentioned or implied anywhere in all the zoological publications of Linnaeus. For some few of these, biographical data are scanty, and there are four names—J. Åman, R. R. Angerstein, Bergh Isacson, and C. G. Kaekeritz, all cited as informants on habitat and the last of them even honored by a trivial name, *SN* xii Phalaena 291 Kaekeritziana—which I have been unable to identify except in terms of possible Swedish relatives. There is one more name, Joh. du Fay, cited (at second hand?) under *Habitat* (*in* Ucrania) at xii 355 Rana 3 Bufo, which I cannot identify at all, and, lastly, one word which may not represent a personal name, so that I enter it only in the marginal gloss as an undeciphered reference: *Hwitt.* 79; see *FnS* ii 13 Viverra Lutreola. I will be very grateful if any reader can supply information about these names.

One important point of similarity to my bibliographical index of the *Species Plantarum* deserves mention. The title and collation (volumes, parts, pages, illustrations, and height of a page) of nearly every book is taken from a definite copy inspected in a location which I have named. In most cases these are libraries in London, where I was privileged to work during two sabbatical leaves and a number of summer visits: the British Museum, the British Museum (Natural History), the Wellcome Medical Library, and of course the Linnean Society, where the books once owned by Linnaeus are identified by Smith's signature. In my indexes these books are marked by the symbol LS*, after a systematic examination of every book kept in the old cabinets, that is, before their relocation in the present strong-room. It was thus that I discovered the identity of *List. mut.*, and I think I can say with some confidence that if a book in my index is not marked by this sign it is not one of the books which Linnaeus possessed in his lifetime. This brings us back to the dissertation *Incrementa Botanices*.

In the last few pages (390–93 as reprinted in *Amoen. Acad.* 3) of this dissertation Linnaeus entered a protest at the high cost of the richly illustrated botanical books then in vogue, as compared with the books printed from the woodcut blocks which sufficed for the older botanists, down to and including Rudbeck, and which were often re-used by other printers, with consequent savings in cost. This was an old theme with Linnaeus. Already (1737) in the *Critica Botanica* (§ 237), while justifying generic names taken from poetry or mythology, kings and others who had advanced the study of botany, Linnaeus had emphasized the need of botanists for wealthy patrons (such as Clifford) because they must have many books, which were especially expensive when illustrated by copperplates.[5] And on this occasion, after listing the sumptuous books on botany and zoology, Linnaeus concluded by exhorting systematists to continue and extend the methods of purely verbal description which he had initiated, and thus to come to the aid of science, "lest she be ruined by her own splendor".

My previous article in Taxon (see note 1), then, had raised the questions of Linnaeus's accuracy with respect to the botanical books and especially of the extent to which he himself owned any of them. In general, he was shown to have been quite accurate in his designation of the books in their several classes, even to that monstrous title *Phytanthozaiconographia* which burdened Weinmann's magnificent four volumes, partly through a printer's error and partly through his own lack of taste: it could have been, more simply, *Phytanthozographia* 'Plants and flowers painted to the life'. Then, with respect to the botanical books of the first class (woodcut illustrations), I concluded, after an elaborate tabulation, "It will be seen that Linnaeus did own and use at least one illustrated work of all the authors he names here, and that for some authors (Lobelius and Clusius) he had really an outstanding collection. Moreover, one of these books (Mattioli's *Commentarii* in a 1570 edition), is shown by his dated inscription on the flyleaf to have been one of Linnaeus's earliest possessions, acquired during his year of study at Lund" (1727).

The books of the second class (copperplate illustrations), which for the most part date from the closing years of the 17th century and the beginning of the 18th, at a time when exotic plants were being cultivated and studied in European gardens, as by the Commelins, Breyne, Dillenius, and Plukenet, or described and illustrated in the field by botanical explorers like Barrelier, Plumier, Rheede, Rumphius, and Sloane, were indeed large in physical size and, as Linnaeus himself said (*Bibliotheca Botanica,* p. 55 (1736) = (1751) p. 77), their rare plants were equipped with "ample and sufficient descriptions, resplendent and large-size figures; hence these books, especially since they are bought only by the more scholarly Botanists, have these features in common, that they are rare, magnificent, and very expensive". Nevertheless, my tabulation showed that Linnaeus possessed almost all of them, at least at the end of his life (although we cannot tell about the state of his library in 1753),

[5] Compare the very pertinent remarks by Agnes Arber, *Herbals* (Cambridge 1953), 245–46; also Linnaeus's tribute, in the dedication of the *Hortus Cliffortianus*, to wealthy patrons who took care to publish their gardens handsomely as well as to cultivate them: see *Taxon* 17 (1968), 670–72 and 682–85.

and that, with one exception, he cited from every one of them, as early as the composition of the *Hortus Cliffortianus* (1737) as well as in the *Species Plantarum*. The exception is Marsili's *Danubius*, which does not belong in this group at all, since the beautiful plates are concerned entirely with the topography, antiquities, minerals, fish, birds, and sources of the middle Danube. Here—we have to face it—Linnaeus's memory was at fault.

In his third category (illuminated copperplates) Linnaeus named just six books: Catesby's *Carolina*, Martyn's *Centuria*, Seba's *Thesaurus*, Ehret's *Tabulae*, Mrs. Blackwell's *Herbal*, and Weinmann's misnamed *Phytanthozaiconographia*. They are all large in physical size, ample in extent (though Martyn's color-printed *Historia Plantarum Rariorum*, issued in parts (1728–32) and by subscription, reached only five decades of plates), and exquisitely illustrated. "The books were then, in the prosperous first half of the 18th century, the prized possessions of any owner."[6] Mrs. Hunt in Pittsburgh had collected fine copies of all but one of them, and that one (Seba's *Thesaurus*) is not primarily botanical. The Linnean Society of London also has fine copies of five of the books (not Weinmann's, from which Linnaeus did not cite, but including Ehret's plates, 72 of which were collected and published (1750–53) by the Nürnberg physician and naturalist, C. J. Trew, with annotations to the extent of 56 pages), but only one of them, and that the smallest of the six, Martyn's half-century, is marked by Smith's signature as having come from Linnaeus's Library. Since Linnaeus did cite frequently from all the works except Weinmann's and Mrs. Blackwell's, the problem arose as to where he had seen them. In the case of Catesby and of Seba, whose first two volumes had appeared before 1736, the answer was obvious: Linnaeus had catalogued them as being in Clifford's library and cited them in the synonymy of the *Hortus Cliffortianus* of 1737, from which he simply copied on later occasions. Ehret's beautifully drawn and hand-colored plates, however, did not begin to appear until 1750 or possibly 1749, and Linnaeus did not cite from them until the second edition of the *Species Plantarum* (1762–63). The answer to this part of the problem, I suggested, is to be found at Linnés Hammarby. Linnaeus did own them, after all, and admired them so much that when he purchased Hammar-

[6] I noted from the bookseller Zeitlin's article in *Bibliography and Natural History* (ed. T. R. Buckman, 1966), p. 143, that "a copy of Catesby's *Carolina* sold in 1956 for $110, another in 1957 for $1 297, and a third in 1958 for $2 000. At this rate one shrinks from contemplating a current price." But I can now add that in 1972 a fine copy was sold at Sotheby's for £11 500!

by in 1758 he papered his bedroom with them, so that he could see them on waking every summer day.[7]

Similar problems will arise with the books on zoology, where Linnaeus does not discuss the older and less expensive works but only names persons, mostly of his own 18th century, as having produced sumptuous books in only three of his six classes of the animal kingdom: Rumphius, Gualtieri, d'Argenville, Buonanni, Lister on the Testacea; Swammerdam, Réaumur, Roesel, Albin, Edwards, Mme. Merian, Wilkes, Willughby, and a long line of others on Insects and Birds.[8] Before trying to fill in these obvious gaps, I will digress for a moment to consider some points of Latinity and the text of another and later Linnaean dissertation, remembering that in this one we encountered some variation in the text. In particular, where Linnaeus in the *Amoenitates* (1756) concluded his long sentence (above) with a factual coin-of-the-realm estimate ("whose total cost certainly exceeds a thousand ducats"), in the original version (1753) he had been metaphorical and whimsically abrupt: "whose prices an Irus cannot pay" (*quorum pretia Irus non perfert*). Irus was the insolent beggar who opposed Odysseus returning as a stranger to his own home, but in Latin poetry (Ovid, Martial) he became the proverbial poor man.

My first point about the dissertation *Inebriantia*, however, is simply that it is dated to 1762, not, as has been alleged by all bibliographers from Lidén to the present, to 1761.[9] It is true that towards the foot of the title-page, which is really an invitation to *D(omini) D(octores)* to attend the oral disputation at the usual hour in the morning *(H(ora) A(nte) M(eridiem) S(olita))*, the printed date is ANNI MDCCLXI, but this follows by a considerable space the expression AD DIEM, on which the genitive ("of the year 1761") depends. If one examines the title-page of a copy which was actually issued as an invitation from the Strandell Collection at the Hunt Botanical Library, it will be seen that this space is filled with the manuscript date, VII April(is), as noted by Soulsby in his transcription (no. 2157), but also that an extra vertical bar has been added by hand to the Roman numeral for the year. Thus the date of the oral disputation

[7] See W. Blunt, *The Compleat Naturalist* (New York 1971), p. 222; T. Tullberg in the very first issue of *Svenska Linnésällskapets Årsskrift* (1918), fig. 9 and p. 60.

[8] See the alphabetized tabulation below, where it will appear that only Lister, Mme. Merian, Rumphius, Swammerdam, and Willughby really belong to the 17th century.

[9] Lidén's 1778 list is reprinted by W. T. Stearn in his *Introduction* (vol. 1 (1957) of the Ray Society's facsimile edition of the *Species Plantarum*), 55–61. See also (B. H. Soulsby) *A Catalogue of the Works of Linnaeus* (London 1933), no. 2157.

corresponds exactly with the date indicated in the title of the dissertation as reprinted in the *Amoenitates: Upsaliae:* 1762. *April.* 7.

My second point about the dissertation as edited by Dr. Parker (above, note 2) is that the Latin text is far from perfect even after revision by Linnaeus in the 6th volume (1763) of the *Amoenitates.* Thus on p. 182 the original in 1762 had defined Opium as the milky sap ... of *Papaver somniferum,* adding a clause, *quo propter opio conseruntur agri in regno Turcico.* The 1763 text changed *quo propter* to *quapropter* 'wherefore'. But surely the fields in Turkey are not sown with opium but with seeds of the plant for the sake of the opium, and we should read *quo propter opium,* as Boerman and Fredbärj saw when they translated as "med vilken för opiums utvinnande".[10]

On page 189, the author introduces the first of his two dramatic skits, showing how repeated drinks (*pocula*) of alcohol will carry an old man backwards, down through the seven ages of man (which Linnaeus had tabulated just above, each grade being described in a table by five adjectives), until he is completely helpless and has to be carried home. Here both texts have: *Sequamini, L(ectores) B(enevoli), quaeso me* (Follow me, kindly readers) *ad Sellam vinariam.* Here *Sellam* 'armchair' is hardly the right word with *vinariam,* but it was left to J. C. D. Schreber in his "second edition" of the sixth volume (Erlangae 1789) to make the obvious correction to *cellam*—a word which the student making the fair copy for the press could have misinterpreted as Linnaeus was dictating it.

A little later (191), when the hostess (no other than the fabled Medea) is pouring a fifth cup, to be drunk *in fausta rerum bonarum omnia,* Schreber makes two more excellent emendations, shown at the right of the passage as it stands in both editions:

> Addit puella poculum quintum, in fausta rerum bonarum omnia exhauriendum; senex vero, hoc e poto, sedere praeoptat, titubat gressu, haesitat sermone, cui jam ...

Here Gilibert in his edition (1786)[11] had been puzzled by *omnia* and printed *memoria* in its place, but Schreber is obviously and effortlessly right with *omina* ("to be drunk to the favorable prospects of our estates",

[10] *Berusningsmedel* (1963), no. 40 in the series "Valda Avhandlingar av Carl von Linné".

[11] *Systema Plantarum Europae,* vol. 6, pt. 2 (Coloniae Allobrogum 1786). This is Soulsby's no. 2161 and can safely be neglected in an apparatus, as can the Leiden edition of volume 6 (1764, Soulsby's no. 2159), which is absolutely identical with the Stockholm edition (1763) except for a new title-page. But I think that Schreber's editions of the *Amoenitates* should always be consulted.

as Dr. Parker translates), as he was with the single participle *epoto* for the two words *e poto*.

The second half of this passage exhibits a rhetorical figure (asyndeton) which is a notable feature of Linnaeus's prose style. He often omits the connectives which we expect in a series of words, phrases, or (as here) clauses: "But the old man, after draining this cup, prefers to sit down, he is unsteady on his feet, stumbles in his speech, which now (is in disorder, since he has descended to the second rung of the ladder)." A better illustration may be found at the end of the second dramatic skit, where (193) the author describes how the men who had taken part in the drunken brawl feel when they wake up the next morning:

> mane sequenti evigilant corpore vulnerato, facie lacerata, vestibus vomitu conspurcatis, crumena vacua, manibus tremulis, capite dolente, faucibus aridis, corpore febricitante ...

I need not translate this purposefully distasteful passage, but its series of unconnected phrases (noun plus adjective or participle) in the ablative case will remind botanists of the phrases regularly seen in Linnaeus's diagnostic or "true" specific names; e.g. Plantago caule ramoso, foliis integerrimis, spicis foliosis (*SP* 115 Plantago 15 Psyllium).

A third point about the editing of Linnaean dissertations may be made through an earlier passage from *Inebriantia*. Here (183), in continuing the commentary on vegetable intoxicants which began with Opium (above), Linnaeus inserts a story about a communal *Bolus* or fist-sized lump of edible material which was passed around at a luncheon served to Kaempfer by his Persian hosts. Linnaeus conjectured that it had been drugged with the seeds of Peganum Harmala; at least, it had a marvellous effect on Kaempfer after merely tasting of it:

> unde gaudio inexplebili, quali antea numquam, implebatur, inde amplexus, risus, jocusque (no asyndeton here, but no verb either) &c.; at finita coena, dum (read *quum*, required by the following subjunctive) adscendisset equum, virtus aliam ideam ipsius cerebro inplantabat, haud aliter ac si Pegaso insidens volitasset per nubes & coloratissimos Iridis arcus, ac si cum Diis coenasset; crastino die oblitus (as usual in Linnaeus's rapid style, the verb *est* is omitted) gestorum omnium.

Dr. Parker was able to compare the passage in Kaempfer's *Amoenitates Exoticae* (Lemgoviae 1712, p. 652) which narrates his innocuous "good trip" on a hallucinogen. It will be seen that Linnaeus, who did own a copy of this book, drew his mythological references from it and even the rhetorical figure (litotes) *haud aliter:*

> Repleti sumus ... gaudio quodam inexplicabili .... Soluto sub noctem convivio, ubi equos conscenderamus, virtus pharmaci ... alia cerebris nostris creavit phantasmata. Haud enim aliter nobis visi fuimus, quam, cum Pegaso, volatu per nubes & irides ferri .... Postridie, gravedo, qualiter solet post crapulam, nulla cerebrum infestavit.

My point about editing is that one should always look closely at Linnaeus's sources. Evidently Schreber had not done this, and while he made the automatic correction of Linnaeus's *crastino die* 'tomorrow' to *postero die* 'next day', he also changed *virtus* ('virtue' or 'power') to the superficially attractive *virus* ('poison' or 'narcotic drug'). But Linnaeus's *virtus* stood for Kaempfer's *virtus pharmaci* and should be left unchanged. With *crastino*, however, Linnaeus unaccountably got the wrong word for narrative in the past, and this error cannot be charged to the student's misunderstanding of oral dictation. Later in the dissertation (193) there is an error in case usage which can perhaps be charged to the student. When defining the anatomical expression *systema nervosum* both texts have an instrumental ablative: *Systemate nervoso* (*intelleximus Cerebrum cum Medulla* etc.), where Schreber printed the grammatically correct *Per systema nervosum.* But the very next sentence began with the same two words in the ablative of specification: *Systemate nervoso* (*differunt Animalia a vegetabilibus*), and the second expression may have misled the student, looking back, to alter the first one.

This is doubtful, however, and I think it must be admitted that sometimes Linnaeus's Latin syntax was a bit shaky and that occasionally he did come up with the wrong word. On the other hand, as I have pointed out in an essay on the *Hortus Cliffortianus* (*Taxon* 17 (1968), 663–719), his prose style has many positive virtues. These may be seen in the imaginative and even lyrical dedication to Clifford, although it is marred by misprints and an occasional slip in Latinity. One of the virtues is his sparing but effective use of the rhetorical figures of chiasmus and antithesis. Compare a sentence in the dedication arranged in short lines like this:

Serit alter,	alter laboriosus collegit,
alter exserit;	alter consumit piger.

If in the first contrasting pair one draws a line to connect the two verbs and another to connect the subjects, the lines will intersect and form the

Greek letter *chi* (X). In the second pair the contrasting elements are again the verbs (*collegit* : *consumit*) on the one hand, but on the other the adjectives (*laboriosus* : *piger*), which translate idiomatically as adverbs: "The one man gathers in laboriously, his neighbor lazily feeds himself."

In the *Inebriantia* (189) we have a nicely balanced antithesis, with superficially contrasting verbs but their objects (*veritates* : *experimenta & observationes*) and ablative modifiers (*experimentis* : *placitis*) arranged in chiastic order:

Ut Physici veritates suas experimentis superstruunt,
sic Medici quoque suis placitis experimenta & observationes substernunt.

Or a little later (194) on the good effects (only temporary, of course) of odorous substances like strong drink:

Odora ut Pocula ... stupidos & obliviosos
memores & ingeniosos reddunt.

But we also have to admit that on the very last page (196) of the dissertation, where Linnaeus concludes his lecture on the dangers of intoxicants with quotations from Scripture and Allen's fine encomium of Temperance, there are several grievous errors where Linnaeus himself failed to refresh his memory of the originals.

The English physician and inventor, John Allen (c. 1660–1741), had included a composition of his own in his one great book, *Synopsis Medicinae* (Londini 1719, often reprinted), which is mainly a compendium of practical advice culled from various medical authorities. His p. 165 contains an apostrophe to Temperance, elaborately composed with echoes from the classics and all the devices of classical rhetoric—anaphora, antithesis, assonance and even rime quite in the manner of the prose-poetry of Tertullian or St. Augustine. I reproduce parts of it below, in short lines and with a literal translation:

O beatam temperantiam,	O blessed temperance,	
nunquam satis laudandam,	never to be praised enough,	
nunquam satis admirandam,	never to be admired enough,	
primaevae aetatis,	the glory and the safeguard	6
quam fecisti auream,	of that primeval age,	4
decus et tutamen!	which thou madest golden!	5
(Verg. *Aen.* v 262)		
tui ipsius suadelam utique	of thyself the sure exemplar	7
& pretium!	and the reward!	
laetis aliquando Saturni temporibus	revealed long ago	10
visam!	in the happy times of Saturn!	9

puris piisque animis	by righteous and obedient spirits	11
in omni aevo	in every age	
cultam usque	continually cherished	
& colendam.	and to be worshipped.	
Tu es . . . conservatrix	Thou art . . . the preserver	
mentis sanae in corpore sano.	of a sound mind in a sound body.	
(cf. Juven. 10. 256)		
Tu recta deducis tui cultores	Thou leadest thy devotees straight on	
ad longam & jucundam	to a long and pleasant old age.	
senectutem		
. . . . . .	. . . . . .	
Tu denique	Thou, finally,	
tui ipsius inimicorum laudibus	art adorned	21
ornaris,	by the praises of thine own enemies,	20
& amabilis etiam ab ipsis	and mayest thou be called lovable	22
dicaris, quibus,	even by those very people, for whom,	22–23
te imprudentissime repudiata,	if unwisely thou art spurned,	
manet Satyrici maledictio, ut	there remains the Satirist's curse:	
Virtutem hanc videant	"Let them regard her as Virtue	
intabescantque relicta.	and pine away if she is lost from sight."	

(Cf. Pers. 3.38: Virtutem videant intabescantque relicta. Allen had cleverly inserted *hanc* into Persius's line without disturbing the meter, so that the one-and-only Virtue of the Stoic poet appears to be Temperance. For the ellipsis of the ablative *ea,* commentators compare Verg. *Aen.* iv 692, of the dying Dido: quaesivit caelo lucem ingemuitque reperta.)

Linnaeus did not own a copy of Allen's compendium, but he had cited it in the *Systema* (617 Acarus 15 Siro) and long before that he had copied the passage with almost perfect accuracy into his notebook of useful quotations and observations, *Diaeta Naturalis, 1733* (ed. Uggla, Stockholm 1957, p. 19), under the heading *Encomium temperantiae.* On this occasion, however, he seems to have trusted to his memory. His abridgments and slight alterations of the text are defensible, as is his omission of Allen's ascription of the line of verse to the *Satyricus,* since for Linnaeus and his contemporaries this satire of Persius was quite familiar.[12] But he also omitted two key words, *auream* in our line 5 and *inimicorum* in line 20, with disastrous results for the sense, especially for the para-

[12] See the article cited above (note 1), p. 209, for Pers. 3.71–73 cited in the *Systema* and commonly in moralistic literature from St. Augustine to Rousseau (1755).

doxical conceit of Allen's last sentence, where the Linnaean text now has *Tu denique tuis ipsius laudibus ornaris,* "Thou art adorned by thine own praises!"[13]

And just before this passage, when quoting from the Vulgate New Testament (*Luc.* 21.34), *Attendite autem vobis, ne forte graventur corda vestra in crapula et ebrietate* ("But take heed to yourselves lest your hearts be weighed down with dissipation and drunkenness" Am. Rev. Stand. Vers.), Linnaeus ascribed Christ's familiar injunction to the twenty-first chapter of Matthew! A very odd slip of the pen, to get the wrong evangelist with the right chapter! And even more oddly, Linnaeus had also copied this sentence into his notebook (*Diaeta Naturalis,* p. 212), but there he ascribed it to the twenty-first chapter of Mark! Somehow he had failed to note that the sentence occurs only in the third synoptic gospel. I think that the important point for Linnaeus was not the name of the evangelist but the fact that these were the Savior's words; *quare etiam Salvator ipse,* he had said in opening the quotation. His error here is disconcerting in a man so intent on accuracy as he generally was, but it is no more reprehensible than that which caused the poet Keats, on expressing his wonderment at a literary discovery, to name Cortez rather than Balboa as the explorer who stared at the Pacific from a peak in Darien.

But Linnaeus's errors in quoting Allen's eloquent passage are reprehensible, since he could easily have avoided them, and we must admit that Linnaeus was not infallible either in his Latinity or in his memory of historical fact. Linnaeus himself, no doubt, would never have admitted this much, but I think that was part of his stubborn character. I pass now to the problems raised by his two lists of authors of sumptuous books on zoology, whose cost no Irus can bear. One wonders, first, about "the long line of others" who published expensive works on insects and birds. Who were they, and did Linnaeus own any of their works? Secondly, why is there no mention of beautifully illustrated books on other animals, fish, for instance? And lastly, what were the inexpensive works, with woodcut figures or no illustration at all, to which Linnaeus referred for brief descriptions or at least synonyms?

Answers to these questions are suggested by the lists of respected authorities which Linnaeus added to his introductory discussions in the first volume of the tenth edition of the *Systema Naturae* (1758), under

[13] I am sorry to add that Dr. Uggla, who translated this passage for Boerman and Fredbärj, followed the 1763 text (which Schreber here left unchanged) and did not notice either the omissions or the quotation from Persius.

Mammalia (p. 17), *Aves* (80), *Amphibia* (195), *Pisces* (241), *Insecta* (341), and *Vermes* (643). (The last class, of course, was Linnaeus's catchall for what we now call the Invertebrates, including what he called *Intestina, Mollusca, Lithophyta,* and *Zoophyta* as well as *Testacea.*) Although we cannot here examine these sections in detail, we may note a few points about the various books on which Linnaeus relied, as shown by his citations in the synonymy of the *Systema.*

Among his authorities for *Aves*—to begin with our first question—Linnaeus did list the early woodcut-illustrated volumes of Belon, Gessner, and Aldrovandi—all of them large in size and richly illustrated, also (as my bibliographical index will show) cited frequently in the *Systema,* though Linnaeus did not own copies either of Belon's two works on birds (1555 and 1557; Niss. *Vogelb.* 86 and *Zool.* 306)[14] or any volumes of Aldrovandi's encyclopedia of zoology (1599–1640; Niss. *Vogelb.* 18, *Zool.* 66–78). The same or similar early authorities are also listed under *Mammalia* and *Pisces,* where we may note that Linnaeus did own (1) the first volume (in the 1564 reprint) of Rondelet's work on fish (1554; Niss. *Fischb.* 105) and cited both volumes, though for everything else—aquatic mammals, amphibians, insects, and "worms"—except fish and, of course, birds; (2) a complete set of Jonston's abridgment of Aldrovandi (1650–53; Niss. *Fischb.* 82, *Vogelb.* 481, *Zool.* 2131–35), which he cited (again) for everything else, including birds, but omitting fish.[15] (On the "oft grotesk verzeichneter Bilder" engraved in the senior Merian's workshop from Gessner's woodcuts, see Nissen, *Fischb.* p. 16.) Linnaeus did not own Salviani's work, a very early (1554; Niss. *Fischb.* 112) example of copperplate illustration, but he cited it, though for *Amphibia* rather than *Pisces.* This is true also of Aldrovandi's work on fish. Evidently Linnaeus did not think highly of the illustrations, whether woodcut or engraved, in the works of the early naturalists, referring to them occasionally for the more common European species of various kinds of animals, but not for fish.

[14] Here, and in the tabulation below, the indispensable works of the late Claus Nissen, all of them published at Stuttgart, are cited by the following abbreviations:

Bot.: Die botanische Buchillustration (1951–52; revised ed. 1966).

Fischb.: Schöne Fischbücher (1951).

Vogelb.: Die illustrierten Vogelbücher (1953).

Zool.: Die zoologische Buchillustration, Bd. I (Bibliographie, 1966–69).

[15] It was only in the 10th edition of the *Systema* (p. 440) that Linnaeus got the correct classical form (see Cicero and others as cited by Aldrovandi) for the scorpion-like aquatic insect genus *Nepa* which in earlier editions he had called *Hepa,* reproducing an unfortunate misprint on p. 128 in the 1653 edition of Jonston's *De insectis* (Niss. *Zool.* 2135), which he owned. For the subsequent confusion, see *Trans. Am. Philol. Assn.* 76 (1945), 338 fn. 12.

This answers our third question, at least with respect to woodcut illustrations. For the rest of it, we note that for accurate descriptions of fish (and references to all earlier authorities) Linnaeus relied primarily on the unillustrated work of Artedi (1738), as every page (244–338) of the *Systema* attests, and for descriptions of fish and other animals on the works of Ray and others mentioned under mammals, birds, fish, and insects—all of them, including his own *Fauna Svecica* (1746) published inexpensively, that is, with little or no illustration. Of course Linnaeus was also relying on unpublished materials, that is, on his own or his students' observations of living animals made in the field and communicated to him by letter, or of specimens preserved in the various museums to which he had access. These Linnaeus acknowledged on the second page of the *Ratio Editionis* prefixed to the first volume of the tenth edition of the *Systema*, under *Collectanea*. The list is long and includes his own journeys to Lapland, Oeland, Scania, and elsewhere, accounts of most of which he had already published before 1753, though never sumptuously, also the rich museums of his patron, Greve Tessin, and of his King Adolf Fredrik, which he proceeded to publish in 1753 and 1754. In this case the collectors of the museums also supplied funds to illustrate the volumes handsomely (*Museum Tessinianum,* 1753; 36 cm, 12 cprpls. with figures) and even sumptuously (*Museum ... Adolphi Friderici,* 1754; 50 cm, 33 cprpls.). Though we do not include these in our discussion of expensive works published down to 1753, we must remember that Linnaeus will have used similar published works (a) on the natural history of a given region (like his own *Skånska Resa*, 1751) or (b) museological works (like the *Museum Tessinianum*), which he might not think to include in his lists of sumptuous books on molluscs, birds, and insects, or may already have included under botany.

Examples are readily found when we return to the authorities for *AVES* listed in the *Systema.* Here Marsili's work on the Danube region (1726) and Catesby's on the Carolinas (1731–43) are mentioned prominently, along with some others and Seba, whose work (Vols. 1 and 2, 1734–35), an excellent example of museology, is also discussed under *Amphibia,* while Catesby's work is also mentioned under *Amphibia* and *Pisces.* All three works had been listed previously for their botanical illustrations (though it was a mistake to include Marsili, as we have seen). So too had Petiver's *Gazophylacium* (1702–09), listed among the authorities for *Vermes* in the *Systema* and actually cited there for animals in all classes except *Amphibia,* and Barrelier's *Plantae per Galliam ... observatae* (1714), listed in the *Systema* under *VERMES* and cited there for an appended section with figures of marine insects and *vermes*. Sloane's *Jamaica* (Vol. 1, 1707; 2, 1725), also listed previously under botanical illustration, is another example of regional natural history which was in fact cited in the *Systema* for all six classes of animals, as was Seba's *Thesaurus* and, be it noted, the magnificent work of Edwards, rightly praised here for its birds but including also other rare animals not known in Europe, "quadrupeds, reptiles, fishes, insects &c."—to cite the rest of its title.

The answer to our second question is now becoming clear. Linnaeus did not mentioned beautifully engraved and expensive works on other animals—aside from insects, birds, and *testacea*—either because they were not yet published (like his own *Museum Tessinianum*) or because he had already mentioned them for their botanical illustrations (like Seba's *Thesaurus* or, mistakenly, Marsili's *Danubius*). It is true that he might have made a sumptuous trio on fish from (1) the fourth volume of Marsili's *Danubius;* (2) Willughby's *Historia piscium* (edited by Ray, 1686) which add to the tabulation below, since Willughby is already there by virtue of his *Ornithologia*—and possibly (3) the third part of Valentijn's *Oud en nieuw Oost-Indien* (Amsterdam, 1724–26; Niss. *Zool.* 4213, with 528 numbered species of fish, each illustrated by a figure)—but it is not clear that Linnaeus's remark under *PISCES* in the *Systema* (p. 241, At *Valentinus* defectum artis exposuit) is really complimentary, and in any case, he cited only three figures from it. Otherwise, however, the works which qualify in this period (to 1753) as both sumptuous in format and beautiful for numerous engravings are almost in every case the product of one or another of the authors named in Linnaeus's two lists. That is, Swammerdam's posthumous *Bybel,* sumptuously edited by Boerhaave (1737–38), can be subsumed in the tabulation below along with his earlier (1669) *Historia insectorum*, which was not sumptuous; Marsili's *Histoire physique de la mer*, also edited by Boerhaave (1725) and cited by Linneaus for a few corals and zoophytes, can be tabulated along with his *Danubius;* whereas the important works on insects by Goedaerdt (Niss. *Zool.* 1602–03) and De Geer (Niss. *Zool.* 1500) are not really sumptuous, though Goedaerdt's plates (1662?) were beautifully colored by hand.

An interesting passage from a much later message (Jan. 3, 1765) to the Royal Swedish Academy will place before us the one exception hinted at above.[16] Here Linnaeus speaks out once more on the cost of beauti-

[16] From Fries, *Bref och Skrivelser* ... vol. 2, no. 367, pp. 272–73, as translated by H. K. Svenson, *Rhodora* 47 (1945), p. 370.

fully "illuminated" books on natural history, and not without a touch of envy that their authors could enjoy such patronage:

> "I am not speaking of the old illuminated figures which made all leaves the same shade of green, or all yellow flowers the same kind of yellow; but I refer to the Surinam insects of Merian, Seba's paintings, Frisch's birds, Catesby's fishes, Ehret's plants, Roesel's insects, Edwards's birds, Regenfuss's snails, in which the objects stand as though living, as well as the best portrait painter delineates the human face. Among all these, Roesel is best in the insects, Regenfuss in shells, Ehret in plants—all of which are so beautiful that the most stupid Hottentot could stand in admiration and affection for the master's work."
>
> "If I ask, furthermore, what has brought this kind of literature to such a height, I will reply that patronage has been entirely responsible. Wealthy Englishmen supported Catesby's voyage to America and paid well for his pictures. Roesel was supported by a baron. Ehret's plates brought a guinea apiece, as fast as he could produce them. His Majesty of Denmark's generosity brought us Regenfuss's shells. Edwards's patron can be read about in his preface. The English boast of their Edwards, the Germans of their Roesel, the Danes of their Regenfuss, and with much reason."

Except for Regenfuss, whose work was not published until 1758, all of the publications named fall within our period, and all but one of their artist engravers have already appeared in our discussions. This is the German Frisch, whose *Vorstellung der Vogel Deutschlandes* began appearing at Berlin in 1739 in folio (Niss. *Vogelb.* 339) and eventually included 256 colored copperplates with a total of 307 figures of birds. We have no hesitation, then, in adding Frisch to the tabulation below, both for his work on birds and his earlier uncolored work on insects, which Linnaeus did list among his authorities in the *Systema.* And for the sake of comparisons to be drawn later, we also include Regenfuss.

These authors are arranged below, alphabetically for ease of reference. If we look at their works chronologically, we can draw a few conclusions about the history of the publication of expensive books in this field, corresponding to those we have drawn for botanical books.

(1) The books on the *testacea* do form a notable series, just as Linnaeus said. Ranging in date from Buonanni's works (1684 and 1709) through d'Argenville's (1742) and beyond to Regenfuss (1758), they are all large in size (folio or broadsheet, except for Buonanni's quarto) and stress illustration rather than text (note Lister's 1057 figures on 468 leaves), though only Regenfuss used color. Their sumptuousness and their specialization on shells reflect the pride of the collector and dilettante rather

than any scientific interest. As Dance stated in his recent history,[17] p. 53: "During the late seventeenth and early eighteenth centuries men and women of widely different vocations were attracted to curiosity collecting and soon Europe bristled with cabinets containing shells and other natural objects. In fact a cabinet of natural and artificial curiosities was considered as indispensable to the well-appointed household, mansion, or palace as was a collection of art treasures; and large sums of money were squandered on both indiscriminately." The *Conchyliologie* of Antoine-Joseph Dezallier d'Argenville, himself Secretary to the King of France, biographer of painters, and a noted collector of naturalia and art, is typical. "The text is useless from a scientific point of view although the plates, executed by d'Argenville himself, are very well engraved" (Dance, 59). Shells were an important part of Seba's collections and were arranged in the drawers of his cabinet to produce bizarre effects; compare the satyr's head reproduced in Dance's frontispiece from the third volume (1758) of Seba's *Thesaurus*, pl. 37. Dance adds (63) that in order to "meet the considerable expense entailed in publishing the *Thesaurus* (i.e. its later volumes) it was necessary to sell the collection. This was sold, sixteen years after Seba's death, on 14 April 1752 and following days; and the entire sale realized 24 440 guilders",—generally at much higher prices than were realized from similar sales in the troubled years after the French revolution. These unscientific interests are also reflected in the posthumous publication of Rumphius's *Amboinsche Rariteitkamer*, which was unhappily adulterated by his editors, Halma and Schijnvoet, both in the text and the engravings, though Rumphius himself was a devoted and even brilliant field naturalist (Dance, 48).

(2) Alongside the shells, there was a marked interest in the production of books illustrating insects, especially the colorful butterflies; see below under Albin, Frisch, Merian, Réaumur, Roesel, Swammerdam, and Wilkes. In part, this interest was genuinely scientific, aroused by the wondrous metamorphosis from caterpillar to cocoon to moth which fascinated mystics like Swammerdam or spiritual individuals like Mme. Merian or true scientists like Réaumur; but the really notable point about these books is that most of them were produced by professional artists, including Mme. Merian herself, Albin, Frisch, Roesel, and Wilkes, all of whom made much use of color. The series in fact begins at an early date,

[17] S. P. Dance, *Shell Collecting, an Illustrated History* (Berkeley & Los Angeles 1966); cited simply as "Dance" below and in the tabulation.

with the *Metamorphosis Naturalis* of the Dutch painter and engraver Jan Goedaerdt (1620–68), which began to appear about 1662 (Niss. *Zool.* 1603) and eventually included 648 pages of Dutch text and 127 hand-colored copperplates with 164 figures. We have excluded this book because of its small size, but Linnaeus owned a copy (15–16 cm) which he annotated extensively and cited frequently, as well as a copy of the later edition by Lister (1685). One may doubt whether the later and more sumptuous books in this series were intended to serve as guides to collectors, like the works of Buonanni and d'Argenville just mentioned. Rather, they became collectors' items in themselves, prized by their aristocratic owners for display in their libraries. Hence beautiful books on birds—themselves not likely to be a popular object when stuffed and displayed in the cabinets of collectors—were also produced by the same artists (e.g. Albin and Frisch) or others (Edwards). And the repeated editions of Mme. Merian's plates, with text in German, Dutch, French, and Latin (see below), speak eloquently for the existence of a strong international market for sumptuous illustrated books.

(3) Like the botanical books with colored copperplates, the illuminated works on insects and birds tended to be issued in parts or fascicles and by subscription, as publishers' ventures. In fact this trend is observable somewhat earlier in zoology than in botany. Nissen cites Albin's *Proposals for printing by subscription a Natural history of English insects*, which the British Museum Catalogue dates to 1714. The actual work appeared in 1720; compare Martyn's *Centuria* (1728) and Catesby's *Carolina* (1731–32). Yet the pioneers were not entirely British artists. Frisch's *Beschreibung von allerley Insecten in Teutschland,* though its plates were not colored and its author was not a professional artist, appeared in 13 fascicles, a few plates at a time, between 1720 and 1738. The Nürnberg engraver Roesel, for all his support by a baron, offered his beautifully illustrated *Insecten-Belüstigung* to subscribers in monthly issues, 1746–61; compare Weinmann's successful venture, and Ehret's plates, snapped up at "a guinea apiece, as fast as he could produce them". The works of Edwards on birds and of Wilkes on insects were also issued in parts, and Dance notes (59) that Regenfuss had invited subscriptions to his promised book as early as 1748 in Nürnberg, before he was called to the Danish court.

(4) When the trade in illustrated books had developed to such a point in the prosperous first half of the 18th century, one wonders whether there was not some commerce also in the illustrations themselves, similar to the exchange of woodcut blocks that had occurred in the 17th cen-

tury. While I cannot point to any instance of the purchase of a copperplate or its reprinting with or without acknowledgment, I think it is likely that a few such transactions did occur, and we can certainly point to the copying by other engravers of illustrations from earlier books. Trew had criticized Weinmann's production because some of the models in his *herbarium pictum* were evidently not drawings made from living plants but copies of earlier illustrations, and inferior copies at that. Yet Nissen notes (*Bot.* p. 169) that Trew himself had encouraged artists at Nürnberg by making the resources of his library readily available for inspection by others and for copying. It was claimed that this was done in the interests of science and the diffusion of accurate knowledge, but sometimes there were objections. Nissen refers (*ibid.*) to a letter to Trew from George Edwards, whose ornithological paintings, along with those of Catesby, Trew had allowed to be copied by J. M. Seligmann; Edwards begged him not to let them be published until after the completion of all the parts of his own publication. This point was not reached until 1761. Unhappily, Seligmann's work began to appear in 1749: *Sammlung verschiedener ausländischer und seltener Vögel* (Nürnberg 1749–76). Nissen (*Zool.* 843) notes that it contains 473 plates, 109 of them after Catesby, and that there were other printings with text in French, Dutch (Amsterdam 1772–81), and Latin and German (nos. 844–46). Such was the trade in beautifully illustrated books on natural science, objects of art in themselves.

Edwards's *Birds,* strangely enough, was one of the few sumptuous books in this class which Linnaeus owned. He also owned—to recapitulate from the table below—a copy of the 1693 Latin edition of Swammerdam's small and relatively inexpensive *Historia Insectorum,* a copy of Frisch's quarto on insects but not of his admired folio on birds, a complete set of Réaumur's six volumes but in the smaller Amsterdam edition, and an incomplete set of Roesel's monthly issues on insects. On shells he was much better off, owning a fine copy of d'Argenville's *Lithologie,* which he had bought in 1743, and most of the others except the two most important authors, Lister and Regenfuss. Yet in his *Systema* he cited plates and figures from every one of these books, including Marsili's *Danubius.* Where, then, had he seen them in 1758? Footnotes in the *Systema* supply a few answers, and for the rest we can make some guesses. On p. 744 Linnaeus acknowledged, after citing Lister's *Conchyliorum historia* on numerous occasions, that he had not obtained a copy and had made his citations at second hand; *aliorum oculis tantum vidi.* Perhaps this indicates d'Argenville or Gualtieri, or perhaps correspondence from one of his affluent Dutch friends who knew his methods, Johannes Burman or J. F. Gronovius or his son, L. T. Gronovius. Under the bird, Merops cafer (117), Linnaeus acknowledged receipt from Burman of more than 150 beautifully drawn figures of animals. One remembers that Burman had also supplied figures of plants for Weinmann's artists to engrave; in such generosity he was much like Trew. In the case of Mme. Merian's important and beautiful works on insects, Linnaeus may have made his notes on one of them during his stay in Holland, for he had catalogued the *Metamorphosis insectorum surinamensium* (1705) in Clifford's library and cited plates from it (for the plants depicted along with the insects) in the *Species Plantarum* as well as in the *Hortus Cliffortianus*. For the other, we know that he used a copy of the Latin translation (*Erucarum ortus* ...; Amsterdam 1718) of all three parts of *Der Raupen wunderbare Verwandelung* with its 153 colored copperplates, as Bryk has shown from the annotations in the copy which was once in the library of the Queen Lovisa Ulrika (reference in the tabulation below). In short, the likeliest places in which Linnaeus may have consulted the costly books which he did not own are the libraries of his royal patrons or of Greve Tessin, to all of which he had access when he visited Stockholm. "Shells were the principal ornament" of the Queen's cabinet (Dance, 56), "and in 1751 she commissioned Linnaeus to describe them. Linnaeus had completed his manuscript by 1754 but the descriptive catalogue, often referred to as the *Museum Ulricae,* was not published until 1764." Doubtless it was in the King's library that Linnaeus had seen "only the first 12 of Regenfuss's plates in Kratzenstein's edition, at the time of writing", as he says in the *Systema* (1758, p. 643 fn.), and he adds, "than which there is nothing more beautiful". And it was in the King's library that, perhaps ten years later, Linnaeus first saw the first 144 plates of what eventually became the illustrations for Buffon's *Histoire naturelle des Oiseaux* (1771–86); a set of these plates, which Linnaeus entitled AUBENTON MISCELLANEA, are now in the library of the Linnean Society of London and bear the notation that they been presented to Linnaeus by the king himself on a visit to Hammarby, June 11, 1770. The story is well told by C. F. Cowan, *J. Soc. Biblphy Nat. Hist.* 5(1).37–40 (1968).

Again we have to do with the issuance of magnificent plates in parts, as with Ehret, and with the circulation of costly volumes through the hands of wealthy and even royal personages. To own more than a few such books was indeed beyond the powers of a mere professor like Linnaeus, and his protests in this academic dissertation were justified. Unfortunately we have to add that there are large areas of zoology over which his proposed solution, by way of a reform in the methods of purely verbal description, was not really effective. As Dance says (36 fn.) of the species of mollusc described in the tenth and twelfth editions of the *Systema,* "Linnaeus's written descriptions are usually so inadequate that the identification of many of his species depends upon the quality of the cited figures".

Precisely: the typification of Linnaean species is still proceeding, slowly. In concluding this discussion, which I fear has paid too much attention to Linnaeus's mistakes, I will say that in general I have found his bibliographic references to be reasonably accurate; and I hope that my laborious compilation of a Linnaean *Bibliotheca Zoologica* may be of some interest to taxonomists. As for the errors, when set beside his real achievements, they are mostly trivial and only serve to show that he was no superman but thoroughly human. And in his use of the Latin language I think we may call him a somewhat imperfect but still a practicing humanist. Indeed, even today, the classicist who has spoken to you has always found that his botanist friends are the most humanistic of all scientists.

Tabulation of authors

Eleazar *Albin,* fl. 1713–59. Naturalist, watercolor painter, and engraver of London.

A Natural History of English Insects ... London 1720 (Niss. *Zool.* no. 58; BM(NH) 29 cm: 100 hand-colored cprpls., text on facing pages); 2nd ed. with notes by W. Derham, London 1724, repr. 1735, 1749; Latin tr., London 1731. Cited several times for *Insecta,* though Linnaeus did not own this or any of the works of Albin.

A Natural History of Birds ... 3 vols., London 1731–38 (Niss. *Vogelb.* 14–16; Crerar (Chicago) 29 cm: 96 pp. and 101 col. cprpls., (2) 92 pp. and 104 col. cprpls., (3) 95 pp. and 101 col. cprpls.); repr. 1738–40; French tr., La Haye 1750. Cited several times.

Filippo *Buonanni,* 1638–1726. Jesuit instructor and scientist of Rome.

Recreatio mentis et oculi in observatione animalium testaceorum ... Romae 1684 (Niss. *Zool.* 754; LS* 22 cm: 270 pp. and about 150 cprpls. in part 4 with 527 figs.). Cited frequently under *Vermes.* The "many illustrations of shells ... are reasonably accurate and the majority of them were referred to subsequently by Linnaeus" (Dance 43). Linnaeus did not own two other works of Buonanni: *Observationes ... cum Micrographia curiosa* ... Romae 1691 (Niss. *Zool.* 752); *Musaeum Kircherianum* ... Romae 1709 (Niss. *Zool.* 2198: 40 cm, 522 pp. and 172 cprpls.)—though he cited their figures occasionally for *Mammalia, Amphibia, Insecta,* and (especially the latter) for *Vermes.*

Antoine-Joseph Dezallier *d'Argenville,* 1680–1765. Collector of naturalia and art.

L'histoire naturelle éclaircie ... la lithologie et la conchyliologie ... Paris 1742 (Niss. *Zool.* 144; LS* 29 cm: 492 pp. and 36 cprpls. with figs., "Carl Linnaeus 1743" with notations on most of the plates). Cited several times under *Vermes.* Nouvelle édn., Paris 1757.

George *Edwards,* 1694–1773. Watercolorist and naturalist of London.

A Natural History of Uncommon Birds and of some other rare and undescribed animals... London 1743–51 (Niss. *Vogelb.* 286; LS* 29 cm: 248 pp.

and 210 col. cprpls. (189 of birds). Cited frequently under all six classes. French tr. 1745–51 (same plates, Niss. 287).

Johann Leonard *Frisch,* 1666–1743. Pastor and rector of a gymnasium in Berlin.

Vorstellung der Vögel Deutschlandes ... 2 vols., Berlin 1739–63 (Niss. *Vogelb.* 339; BM(NH) 35 cm: 244 col. cprpls. with 12 more plates in a *Supplement* for a total of 307 figs.). Cited several times but not owned by Linnaeus, though he did own and cite frequently the 13 parts of Frisch's *Beschreibung von allerley Insecten in Teutschland* in the first edition (Berlin 1720–38; Niss. *Zool.* 1436; LS* 21 cm: 506 pp. and 38 cprpls. with 272 figs.). Linnaeus's copy, bought at Uppsala in 1730, contains his (later) binomial designations throughout.

Niccolò *Gualtieri,* 1688–1744. Physician and professor of Pisa and Florence.

Index testarum conchyliorum quae adservantur in museo ... Florentiae 1742 (Niss. *Zool.* 1736; LS* 46 cm: 110 cprpls. with figs. explained by letterpress on verso of preceding plate). Cited frequently under *Vermes.*

Martin *Lister,* 1638–1712. Physician and antiquary of York and London.

Historiae sive Synopsis methodicae conchyliorum ... *liber primus* ... *(–quartus)* ... *Londini* [1685–97](Niss. *Zool.* 2529; BM(NH) 31 cm: 468 leaves including title-page, with impressions of 1057 cprpls., often 2 or 3 to a leaf, and 22 anatomical plates in an Appendix). For the history and dating of these sets of copperplates, engraved and in many cases printed by Lister's daughter(s) Susanna and (his wife?) Anna, see L. G. Wilkins, *J. Soc. Biblphy Nat. Hist.* 3(4). 196–205 (1957), and a further note by F. C. Sawyer, *ibid.* 4(1). 28–29 (1962). Linnaeus did not own a copy of this work but cited it frequently under *Vermes,* using the references of others who had seen the plates, as he explained in a footnote in the *Systema,* X: 744.

Luigi Ferdinando, conte *Marsili,* 1658–1730. Naturalist and geographer of Bologna, long in Austrian service.

Histoire physique de la mer ... préface de Herm. Boerhaave, Amsterdam 1725 (Niss. *Zool.* 2699; BM(NH) 38 cm: 173 pp., 12+40 cprpls. with figs.); Dutch tr., 's Gravenhage 1786, with col. cprpls. Linnaeus did not own this work but cited it for a few *Vermes.*

Danubius pannonico-mysicus ... 6 vols., Hagae Comitum & Amsterodami 1726 (BM Banks, 59 cm); vol. 4, *De piscibus* (Niss. *Fischb.* p. 93; 92 pp. with 33 interleaved cprpls.); vol. 5, *De avibus* (Niss. *Vogelb.* 593; 154 pp. with 74 interleaved cprpls.); French tr., La Haye 1744; plates of vols. 4 and 5 reprinted at Bologna, no date (Niss. 94). Linnaeus did not own this beautiful work but cited from vol. 5 not infrequently in the *Systema.* The plates of vol. 4 are not cited under *Pisces* in the *Systema,* except indirectly by the references to the *Fauna Svecica* (1746), where they had been cited frequently.

Maria Sibilla *Merian* (Graff, for a time), 1647–1717. Painter, engraver, and housewife of Frankfurt, later Amsterdam; in Surinam 1698–1701.

Der Raupen wunderbare Verwandelung und sonderbare Blumen-*Nahrung* ... Nürnberg, Leipzig & Frankfurt a. M., 2 parts, 1679–83 (Niss. *Bot.* 1342; BM Sloane, 21 cm: 102, 100 pp. with engraved title and 50 unnumbered cprpls. in each part, hand-colored in the Sloane copy); Dutch tr. (*Der rupsen begin* ...) Amsterdam 1713–14, followed by a third part [1718] with 50 additional cprpls. and a Latin translation (*Erucarum ortus* ...) of all 3 parts, Amsterdam [1718] (BM Banks, 20 cm: 64 pp., 153 cprpls., engraved title and 50 plates in each of the 3 parts; Arabic numerals in parts 1 and 3, Roman numerals in part 2; plates reversed). Linnaeus did not own any of these or either of the folio editions in Dutch (*Die europische insecten* ...; BM(NH) 52 cm) and French (*Histoire des insectes de l'Europe;* BM Banks, 52 cm), both published at Amsterdam in 1730 and containing 184 cprpls. (hand-colored in the Hunt copy, no. 483) on 47 sheets, but he cited from them in the *Systema* and is known to have used and annotated the copy of the Latin translation once in the library of the Queen Lovisa Ulrika. See F. Bryk, *Linnés Randaufzeichnungen zu M. S. Merianins "Erucarum ortus"*, Stuttgart 1920.

Metamorphosis insectorum surinamensium ... Amsterdam 1705 (Niss. *Bot.* 1341; BM 49 cm: 60 pp., engraved title and 60 cprpls., hand-colored in the BM copy), also issued at the same time with text in Dutch (BM 53 cm, same plates). Linnaeus did not own either of these or any of the later editions with 12 additional plates executed by the artist's daughters from materials left at their mother's death: *Dissertatio de generatione et metamorphosibus insectorum surinamensium,* Amsterdam 1719 (BM 52 cm: 72 cprpls.), also issued at the same time with text in Dutch

(BM(NH) 52 cm: 72 hand-colored cprpls.); repr. 1730 with 72 uncolored cprpls. = Hunt 484) and later (La Haye 1726) with text in Latin and French (BM(NH) 53 cm: 72 pp. and 72 hand-colored cprpls. = Hunt 467). In the *Species Plantarum* Linnaeus cited the plates of 1705 for the plants depicted therein, with names drawn from the descriptions by Caspar Commelin (see my *Index*, p. 36), doubtless using the copy in Clifford's library (no. 189 in the *Hortus Cliffortianus*); and in the *Systema Naturae* he cited the plates (including some from the enlarged editions) for a few *Amphibia* and many *Insecta*.

René-Antoine Ferchault de *Réaumur*, 1683–1757. Scientist of Paris.

Mémoires pour servir à l'histoire des insectes ... 6 vols., Paris 1734–42 (Niss. *Zool.* 3315; BM Banks, 25 cm: 654, 514, 532, 636, 728, 608 pp. and 50, 40, 47, 44, 38, 48 cprpls. (267 in all), each with many figures). Linnaeus owned only the smaller Amsterdam edition (1737–48; LS* 16 cm, with the same plates but fewer pages per volume), but his many references to the plates fit either edition. His copy contains some marginal identifications.

Frants Michael *Regenfuss*, 1713–80. Engraver of Nürnberg, later at Copenhagen.

Auserlesne Schnecken, Muscheln und andre Schaal-Thiere ... / *Choix de coquillages et de crustacés* ... Kopenhagen 1758 (Niss. *Zool.* 3338; BM(NH) 61 cm: 22, lxxxvii pp. and 12 col. cprpls. with 67, 78 figs. and in a second volume (black) with 64, 62 figs.). An advertisement had been issued at Nürnberg in 1748 (see Dance 59) "in which the study of shells was greatly recommended" and subscriptions for his forthcoming book were invited. This authorized edition contains references to the 10th edition of the *Systema* (under *Vermes*) by page and species-number, but not using the trivial name. But at the time of publication of the 10th edition, Linnaeus acknowledged (643 fn.) that he had seen only the first 12 plates, which he cited a number of times and admired greatly (see above, 256). Evidently these were the plates of the suppressed edition (*Sammlung von Muscheln* ... / *Recueil des coquillages* ...) of which there are traces in a few libraries; see W. S. S. van Benthem Jutting, *Zoolog. Meded.* 39.168–79 (1964). The book "was an immediate success, principally, one suspects, for the superb quality of its plates and, perhaps, for the size of the book itself which has a larger surface area per page than any conchological work published before or since" (Dance 60).

Augustin Johann *Roesel* von Rosenhof, 1705–49. Miniaturist and engraver of Nürnberg.

Der monatlich-herausgegebenen Insecten-Belüstigung erster (–vierter) Theil. Nürnberg 1746–61 (Niss. *Zool.* 3466–3466 c; BM Banks, 21 cm: (vol. 1, pts. 1–6) 64, 60, 64, 312, 48, 48 pp. with 10, 10, 8, 63, 13, 17 col. cprpl. figs.; (2, praefatio and pts. 1–8) 24, 72, 28, 16, 32, 76, 200, 64, 52 pp. with col. cprpls. A, B, and 9, 3, 6, 4, 16, 30, 13, 10 col. cprpl. figs.; (3) 624 pp., col. cprpls. I–CI; (4) 48 pp. (*Vita*), 264 pp. with col. cprpls. I–XL). Copies (e.g. at LS, BM, and BM(NH)) vary in arrangement and completeness, according to whether they were collected by subscribers to the monthly issues, beginning in 1740, or by the printer for a collected edition. Nissen (under 3466) notices a 2nd edition of the first volume, edited by C. F. C. Kleemann (after 1759), with 121 figs. on 79 plates. Linnaeus had an incomplete set (22 cm, vol. 1 and part of vol. 2), with a few identifications on the plates, but he cited frequently from all four volumes.

Georg Eberhard *Rumphius* (Rumpf), 1628–1702. Dutch merchant and naturalist in the East Indies.

D'Amboinsche Rariteitkamer, behelzende eene beschryvinge van allerhande 300 weeke als harde schaal-visschen ... t'Amsterdam 1705 (Niss. *Zool.* 3518; LS* 39 cm, a few marginalia: 340 pp., 60 cprpls. with numerous figs.; plates repr., Hagae Comitum 1739). Linnaeus owned this and cited it frequently under *Insecta* and *Vermes*.

Jan *Swammerdam*, 1637–80. Physician, naturalist, and mystic of Amsterdam.

Bybel der Natuure ... of Historia *insectorum* ... (2 vols.) Leydae 1737–38 (Niss. *Zool.* 4055; BM(NH) 40 cm: 910, 124 pp. and 53 cprpls. with numerous figures; German tr., Leipzig 1752; English tr., London 1758). Linnaeus did not own these sumptuous volumes, but he cited them in the *Systema* under *Insecta* and *Vermes*. He did own a copy (19 cm) of the 1693 reprint of the earlier *Historia insectorum generalis, ofte Algemeene verhandeling van de bloedeloose dierkens* (Utrecht 1669; Niss. *Zool.* 4052), with 13 cprpls.

Benjamin *Wilkes*. Draftsman and engraver of London.

The English Moths and Butterflies ... (issued in parts) London [1749] (Niss. *Zool.* 4410; BM 31 cm: 26, 63 pp. and 120 col. cprpls. with numerous figures numbered by classes and sections). Not owned, but cited frequently in the *Systema*.

Francis *Willughby*, 1635–72. Naturalist of Middleton, student and patron of John Ray.

Ornithologiae libri tres ... (ed. J. Ray) Londini 1676 (Niss. *Vogelb.* 991; BM(NH) 37 cm: 307 pp. and 77 cprpls. each with figures; English tr. with additions, London 1678, 78 cprpls.). Not owned, but cited several times in the *Systema*.

De historia piscium libri quattuor ... (ed. J. Ray) Oxonii 1686 (Niss. *Zool.* 4417; BM(NH) 38 cm: 343, 30 pp. and 188 cprpls. with figures). Again not owned, but often cited for *Mammalia, Amphibia*, and *Pisces*.

E. G. BOBROV

On the works by and on Linnæus published in Russia and the Soviet union

The data on translations of works by Linnæus which have been pulished in Russia as they are presented in catalogues are both incomplete and inaccurate. This can be equally applied to the monumental catalogue of the works of Linnæus published by the British Museum in 1933, and to recent bibliographies printed in the USSR to celebrate the Linnæus jubilee in 1957. These shortcomings had induced us to review these bibliographies as well as to examine them in more detail.

Contacts with the Petersburg scientists, members of the Academy of Sciences were established by Linnæus in 1736, that is, during the Dutch period of his life. For many years the correspondence of Linnæus with Petersburg was motivated mainly by his interest in the Siberian collections at the academic museums. Since 1754, after Linnæus was elected the honorary member of the Petersburg Academy of Sciences, his relations with the Petersburg scientists became closer.

Speaking of Linnæus' publications in Russia, it is necessary to mention that the first two of them were of purely business nature dealing with his contacts with the Academy. These works will be considered below in more detail. The first translations of articles and speeches by Linnæus appeared in Russian scientific magazines while he was still alive. An interest to translation or rendering of the works by Linnæus did not cease to exist throughout the whole of the 19th century; moreover, it is evident today.

The works by Linnæus published in Russia are naturally divided into the following groups:

1. works originally published in Petersburg,
2. translations into Russian of the works by Linnæus himself,
3. translation into Russian of some dissertations,

4. translations and renderings into Russian of the works by Linnæus as scientific handbooks.

1. Nitraria planta obscura explicata a Carolo Linnæo.—Novi Commentarii, Academiæ Scientiarum Imperialis Petropolitanæ, t. 1758–59, pp. 315–320, tab. X, 1761.

In 1758, in connection with preparation of the tenth edition of "The System of Nature", Linnæus sent to the Petersburg Academy of Sciences an article to be published—"Zagadochnoe rastenie Selitrianka razyasneno". This paper was published Vol. 7 of "Novi Commentarii", 1758–1759, printed in 1761. The paper dealt with the Selitrianka—a species of Nitraria genus. This most interesting plant was first found by Gotlieb Schober, Peter the I's doctor, during his journeys in the semiderserts of the northern Caspian seacoast in 1717–1720. Schober who called this plant Nitraria collected its fruit which were sent to medicinal gardens of Russia.

Later they reached Uppsala where Linnæus tried hard to make them germinate. He tried to cultivate the plants both in hot houses and in open ground as well as in different types of ground, but the plant did not produce flowers and could not therefore be defined. Linnæus reported in his comments that his fruitless attempts had lasted for 12 years before he introduced salt into the ground as there were reports that Selitrianka grows on salty soils. Only after this the plant produced flowers and was. consequently determined.

Having suggested for Nitraria the specific epithet "Schoberi", Linnæus preserved for science the name of Gottlieb Schober, one of the first explorers of Russian flora. Selitrianka Schoberi—Nitraria Schoberi became the type species of Nitraria genus, one of the genera of Zygophyllaceæ family so characteristic for the desert flora of the Eastern hemisphere.

Since the time of publication of this paper in Petersburg, more than two hundred years passed but still one cannot claim that "The mysterious plant Nitraria is explained". I had to look into the systematics of this genus three times. In my most recent work (Bobrov, 1965) I examined Nitraria as related to the problem of origin of the desert flora in the Old World. A very interesting fact should be mentioned here. Of ten species of the genus, the type series Schoberianæ includes four which should be considered as genetically the closest ones. The distribution of these species is amazing: N. Schoberi populates the flat deserts of the Soviet Middle Asia and some adjecent areas: N. Komarovii is a very young species, originating from the southern coast of the Caspian Sea; N. billardieri is found in the deserts of the south-western Australia; N. senegalensis is an element of the West African flora.

Such diverse distribution of the closely related species puts forward a question of common elements in the flora of the Old World deserts and, possibly, of even uniform or relatively uniform xerophyte flora of the Old World in the Upper Cretaceous period, that is, at the start of the age of Angiosperms.

Thus, Nitraria Schoberi is still a mysterious plant. This species can at the same time be regarded as a symbol of the flora of the flat deserts in the Middle Asia.

Caroli Linnæi. Disquisitio de questione ab Academia Imperiali Scientiarum Petrop. In annum 1759 propræmio proposita: Sexum plantarum... Petropoli 1760, pp. 30.

The Academy of Sciences in Petersburg announced in 1759 a competition on the theme: "By new evidence and experiments on sexes in plants to prove or disprove if plants can, similar to animals, be divided into male and female ones, having presented historical and physical description of all parts of plants which are recognised as capable of fruiting and developing." A reward of 1 000 roubles was offered to a winner.

For the contest which was held in 1760 were submitted three works, two of which were immediately rejected as completely unsound. The authorship of the third work—"De sexu plantarum..." was beyond any doubt as the manuscript was submitted under the well-known motto of Linnæus—"Famam extendere factis" (Fame is extended by facts). The popularity of the motto broke the rules of the contest but, nevertheless it was decided to award the prize to Linnæus. The decision was made on the basis of review by the adjunct of the Academy Kölreuter who pointed out that though the theory on which the work was based was witty rather than correct and that the evidence on hybrids reported there was doubtful, it was better that the rejected works and should therefore be considered worth the award.

It should be said that research into plant hybrids in connection with the general theory of sex in plants had been carried out for 4 years by the young adjunct of the Academy of Sciences Joseph Gottlieb Kölreuter (1733–1806). It was in 1760 when he completed the work titled "The preliminary report of some experiments and observations referring to sex in plants", which was published in 1761 in Leipzig (Kölreuter 1761). This publication was followed by "The Sequels" as well as other works partly published in the Petersburg Academy editions.

In 1760 Kölreuter obtained in the Botanical Garden of the Academy of Sciences in Petersburg a hybrid between two tobacco species—Nicotiana paniculata and N. rustica. These hybrids were morphologically transitional between the parent species, being quite sterile.

Experiments by Kölreuter were so thourogh that in his work he already stated the necessity of pollination by insects, the existence of cross pollination, the dichogamy phenomenon (simultaneous germination of pistils and stamens), the importance of nectar for attraction of insects, etc.

Moreover, he started, also in Petersburg, experiments that led him to the conclusion that conversion of one species into another is possible. Kölreuter reported this is "The Third Sequel" published in 1766 in Leipzig. This was also clearly stated in the foreword and in § 24 (Nicotiana rustica in Nicotianam paniculatam penitus transmutata). It is reported here that a tobacco hybrid was converted, through four-time back crossing with one of the parent species, into the latter. Thus, the possibility of one species absorbing the other was demonstrated for the first time.

The research of Kölreuter (Wulf, 1940) was conducted as a serious scientific experiment and was, obviously, much superiour to speculations by Linnæus. The dissertation by Linnæus on the competition theme "On the sex plants ..." was exquisitely published in 1761 in Petersburg. Academician Müller wrote to Linnæus sending to Uppsala copies of the book:

"Your book is printed on the very best paper; nobody hold it in his hands yet as I sent to you the first copies. The Academy decided that I had to abandon my usual negligence and take care that the work worth gold and marble be printed on a special paper."

In 35 years the translation of this book into Russian was published: "Karolya Linneya rozyskaniya o razlichnom polye proizrasteniy, udostoyennoye nagrazhdeniya ot imp. Spb. Akademii Nauk v 1760 g. perev. s latinskogo P. Lepekhina. "Novye ezhemesechnye sochineniya" 1795, chasti 107–112.

2. Opisaniye burnoy ptitsy, sochinennoye Schvedskim Archiaterom i Professorom Karlom Linneyem. Iz sochineniy Shvediskoy Akademii Nauk na 1745 god. — Sochineniya i perevody k polze i uveseleniyu sluzhaschiye. Spb. pri imp. Akademii Nauk. 1761, mai: 577–580.

This is translation of the small paper by Linnæus: Storm-väders-fogeln. Beskrifven af Carl Linnæus. — Kungliga Svenska Vetenskaps-Akademien. Handlingar, a.c. vol. 6, 1745: 93–96.

Rech o dostopamiatstvach v nasekomych, chitannaya v Shvedskoy Akademii Nauk gospodinom Archiaterom Linneyem. Iz knigi ego — Amoenitates Akad. vol. 11: 388. — Sochineniya i perevody k polze i uveseleniyu sluzhaschiye Spb. pri Imp. Adademii Nauk. 1762, iun.: 67–96.

The Russian translation was made from the Latin text of the speech published in 1751 in the series Amoen. Acad. The original version is dated by 1739 and is a famous presidential address by Linnæus at the meeting of the Royal Swedish Academy of Sciences on October 3, 1739. The original publication is titled: Carl Linnæi ... Tal om märkvärdigheter uti insecterna hållit för Wettenskaps Academien ... då Första Præsidentskapet aflades 1739 d. 3 October.

Karla Linneya ... Nastavleniya puteshestuyuschemu s latinskogo na rossiysky yazyk perevyol Vasiliy Ruban. Spb. Tipografiya Suchoputnogo kadetskogo korpusa. 1771: 1–14.

The translation is dedicated to "His Excellence Prince Ivan Petrovich Tyufiakin travelling in strange lands under the name of Bokov". The publication of "Nastavleniye puteshestvuyuschemu" was possibly connected to a certain extent with the work of famous physical expeditions of the Academy of Sciences in 1768–1774 which attracted great interest. The original text of the speech was published in 1741 in Uppsala: Caroli Linnæi... Oratio, qua peregrinationum intra patriam asseritur necessitas habita Upsaliæ ... MDCCXLI octobr. XVII, quum medicinæ professionem regiam et ordinariam susciperet. Upsaliæ 1741: 1–18.

Linnæus started his professorship at the Uppsala University which lasted 35 years with this speech which was published in many editions later.

Karolya Linneya rozyskaniye o razlichnom pole proizrasteniy, udostoyennoye nagrazhdeniya ot Imp. Spb. Akademii Nauk v 1760 g. perev. s latinskogo P. Lepekhina. Novye Ezhemesyachnye sochineniya. 1795, ch.: 107–112. This is translation of the work by Linnæus presented to the Petersburg Academy of Sciences to be submitted to the contest: Caroli Linnæi Disquisitio de questione ab Academia Imperiali Scientiarum Petrop ... in ann. 1759 pro præmio proposita: sexum plantarum ... Petropoli. 1760 pp. 30.

Braki rasteniy. Botaniko-fizicheskoye razsuzhdeniye Linneya, ostavavsheyesya do sikh por neizdannym. — Otechestvennye Zapiski. 1844, 37 otd. *8*: 112–117.

This paper consists of 27 numbered paragraphs with short foreword containing the description of the circumstances which caused its publication. The name of translator is not mentioned. This paper was not published while Linnæus was still alive and it is possible that Linnæus himself did not attach great importance to it. However, this work was known as Linnæus mentioned it in his autobiographical notes. In the autumn of 1729 the librarian of the Uppsala University Georg Vallin presented his philological dissertation "On marriages in Trees"—"De Nuptiis Arborum". Being a student, Linnæus could not participate in the dispute. However, he wrote an essay on actual sexual relations in plants from the botanical point of view bearing on Wallin's dissertation. He forwarded his manuscript to Dr. Celsius. This essay was published only in one hundred years, in 1828, in Swedish, with translation into Latin by his pupil J. A. Afzelius under the title: Caroli Linnæi, Exercitatio botanico physica de Nuptiis et Sexu Plantarum. Edidit et Latine vertit M. Johannes Afzelius. Uppsaliæ 1828, p. 50.

Basn' slavnogo Linneya. Sankt-peterburgskiy vestnik, 1781, fevral: 111–114.

Basn'.-Novye Ezhemesyachnye Sochineniya, v Sanktpeterburge Izhdeveniyem Imp. Akademii Nauk, 1790, ch. LII; oktiabr: 90–94.

These are two different translations of the same text, it being mentioned in the first one that it is translated from "Aglinsky" by I. A. Neither of the publications has any reference as to the original. The contents of the paper is a somewhat didactic description of seven Greek wisemen travelling to the Moon for three days. They are reprimanded in the paper for not having paid attention to the local plants. It is highly doubtful that the paper belongs to Linnæus and the authorship is a mystery.

3. Seven "dissertations" by Linnæus' pupils were published in Russian translation which had been considered in the 18th century to be the works of Linnæus himself and consequently attracted attention of translators and publishers.

A booklet containing translation of two dissertations was published in 1777 in Petersburg.

Karla Linneya razsuzhdeniye pervoye o upotreblenli koffea, vtoroye o chelovekoobrazykh, perevedeny S. korrektorom Ivanom Tredyakovskim. V Sankt-Peterburge pechatana pri Artilleriyskom i Inzhenernom shlyakhetskom korpuse izhdeveniyem tipografii soderzhatelya H. F. Kleena. 1777: 1–25.

Dedicated: "To His Excellence Prince Alexandre Alexeyevich Viazemsky." Dissertation on primates is on pp. 26–47 of the same booklet.

The first dissertation is the translation of Dissertatio medica in qua Potus Coffeæ leviter adumbratur quem... sub præsidio... Caroli Linnæi... publico submittit examini Henricus Sparschuh... ad d. decemb. anni MDCCLXI. Uppsaliæ 1761, pp. 19.

The second dissertation was originally titled Dissertatio academica in qua Anthropomorpha ... Præside Carolo Linnæo ... publico examini submittit Christianus E. Hoppius... die VI Septembr. anno MDCCLX. Uppsalia 1760, pp. 26.

Another dissertation was published in Petersburg as a book:

Linney Karl. Vodka v rukakh filosofa, vracha i prostolyudina. Sochineniye prelyubopytonoye i dlya vsyakogo poleznoye. V Sanktpeterburge tip. Bogdanovicha, 1790: 1–44.

This work was originally titled: Dissertatio Diætetica, in qua Spiritus Frumenti proponitur, quam ... Præside Carolo von Linné ... publico examini ... sistit Petrus Bergius Wermelandus ... die XIX decembr. anni MDCCLXIV. Uppsaliæ 1764, pp. 20.

Blagoustroyeniye Prirody. — Akademicheskiye izvestiya. Pri S. Peterburgskoy Imp. Akademii Nauk. 1779, ch. 1: 49–90.

There is no mention of either the original or translator's name. However, it is acknowledged that "this article is taken from the works of Linnæus. This is the translation of the dissertation: Dissertatio academica de Politia Naturæ, quam ... Præside ... Carolo Linnæo ... publico examini submittet H. Christ Daniel Wilcke ... die XXIX martii anni MDCCLX. Uppsaliæ 1760, pp. 22.

Yestestvennoye lyubopytstvo. Perevedeno s latinskogo iz sochineniy Linneya, tit. sov. Ivanom Isayevym. — Novye Ezhemesyachnye Sochineniya. V Sanktpeterburge Izhdeveniyem Imp. Akademii Nauk. 1790. ch. LI (str. 62–78), LII (str. 78–89), LIII (str. 57–71). This is the translation of the dissertation: Specimen academicum de Curiositate Naturali, quod ... sub Præsido ... Caroli Linnæi ... publice curiosorum censuræ submittit Olaus Söderberg ad diem (XXX) junii 1748. Holmiæ, 1748, pp. 25.

Dieta cheloveka v raznykh ego vozrastakh. Perevyol s latinskogo iz Linneyevykh sochineniy, sobrannykh pod imenem Amoenitates Academiæ tit. sov. Ivan Isayev. — Novye Ezhemesyachnye Sochineniya. 1790, ch. LIX (str. 13–31). Originally titled: Dissertatio diætetica de Diæta per scalam ætatis humanæ, observanda ... Præside ... Carolo von Linné ... offert D. J. Öhrquist ... die [XX Decembr.] anni MDCCLXIV. Uppsaliæ, 1764, pp. 12.

Vrachebnaya Piyavitsa. Perevedeno s Latinskogo Yazyka iz Linneyevykh sochineniy, nazyvayemykh Amoenitates Academicæ Imp. shlyakhetskogo sukhoputnogo kadetskogo korpusa uchitelem tit. sovetnikom Ivanom Isayevym. — Novye Ezhemesyachnye Sochineniya v Sanktpeterburge Izhdeveniyem Imp. Akademii Nauk. 1791, ch. LVIII: 50–54. This is the translation of the dissertation titled: Dissertatio medico-hirurgica de Hirudine, quam... sub Præsidio... Caroli v. Linne... exhibet... Daniel Weser ... die (VI) Mayi (Martii) anni MDCCLXIV. Upsalia 1764, pp. 3–15.

4. The first in the series of works of Linnæus which can be considered as handbooks, is the two-volume work:

Sistema Prirody Karla Linneya.

... Tsarstvo zhivotnykh na Rossiyskom yazyke izdal s primechaniyami i dopolneniyami Alexandr Sevastyanov... akademic. V Sanktpeterburge. Pri Imp. Akademii Nauk, ch. 1: XI+376, 1804; ch. 11: II+377–729, 1805.

This two-volume work is the translation of small part of the thirteenth edition of Systema naturæ (1788) and includes only Mammals. Descriptions of many animals were added, numerous notes were introduced as well as descriptions of new animal species discovered after publication of this Leipzig edition of Systema Naturæ. This two-volume work of 729 pages is considerably larger than the corresponding part of the original edition. The book was edited by academician Al. Sevastyanov.

It is sometimes mentioned in literature and bibliographies that the known work by Linnæus "Fundamenta Botanica" was translated into Russian which is incorrect. The book by Ivan Dvigubsky, Nachalnye osnovaniya botaniki. Moskva. V tipografii Ponomaryova. 1805: VIII+240, tabl. 1–13, is not the translation of the mentioned book by Linnæus. In his short foreword Dvigubsky himself indicated that he had followed Willdenow while "illustrations of various plants are taken from Jacquin and some from Willdenow". Nearly half of Dvigubsky's book is the glossary af terms. It should be also said that the small book by Linnæus, Fundamenta Botanica published in one twelwth folio had only 37 pages while the book by Dvigubsky is seven times larger in volume and contains, furthermore, 13 tables of illustrations.

Filosofiya botaniki, izyasnyauschaya pervye onoi osnovaniya. Sochineniya Karla Linneya, izdannaya na rossiyskom yazyke Timfeyem Smelovskim. V Sanktpeterburge pri Imp. Akademii Nauk 1800 g. str. III+195+XLI, ill. 11,—is not the translation of the known handbook—Caroli Linnæi, Philosophia Botanica ... 1751. The book by Professor T. Smelovsky was published as the handbook for medical students. This book contains an abridged rendering of the work by Linnæus with some chapters omitted and some newly written ones included, with most of notes and comments excluded. The book includes, as examples, many plants which could be demostrated to students in the Medical Garden (now the Botanical Institute of the Academy of Sciences) in Petersburg. Smelovsky reproduced in his book illustrations taken from Linnæus work and gave translation of Latin terms by which he contributed greatly to the development of botanical terminology in Russian language. The system of plants by Linnæus is quite thouroughly presented in the book. When comparing these two books it should be noted that the book by Linnæus has 362 pages of the principal contents while the book by Smelovsky has 195 pages, both books being printed in one eighth folio.

Some bibliographies also mention as a translation the following book: Nachalnye osnovaniya Botanicheskoy Filosofii, izdannye Glavnym Pravleniyem uchilisch dlya upotrebleniya v Gimnaziyakh Rossiyskoy Imperii. v Sanktpeterburge pri Imp. Akademii Nauk 1809 goda: str. IV+156+16. Prof. S. P.-burskogo Pedagogicheskogo Institua nadvorny sovetnik Teryayev. This is not the translation of Philosophia Botanica by Linnæus. In his foreword the auther himself warns that the general concepts were taken from works by Jacquin and Jilibert while in terminology "the order of Linnæus was followed reverently". This botanical handbook by Andrey Teryayev is very extensive even by present requirements.

An interest towards complete translation of Philosophia Botanica did not disappear and in 1975 the Botanical Institute of the USSR Academy of Sciences suggested to translate this book into Russian language and to publish it in the series "Classics of Science". It was soon revealed that the translation of this book was made in Moscow in the 1930s and that it was preserved. The "Nauka" Publishing House started the preparation work; however, it was found out that the manuscript needed some editing which delayed the publication. It is supposed that the book will see the light in 1978 thus celebrating the bicentenneal anniversary of Linnæus' death.

The number of publications on Linnæus in Russian is actually infinite, the beginning of them having been put a century and a half ago. Mostly these are magazine publications of biographical essays or discussions of this most important works—Systema Naturæ, classifications of plants and animals, theories of sex in plants, etc. Classification systems of Linnæus are frequently discussed in papers and even books as compared to those by other authors. Such papers are found most often in popular biological magazines and literature for school teachers. Journals of more pronounced scientific character naturally published more essential articles.

The works by Linnæus were presented at the highest level in the handbooks for university students as well as in the studies on the history of natural science. More or less extensive articles are included in all encyclopædic dictionaries, both general and specialized ones.

In the twentieth century, beginning from 1907 biographical dates and jubilee dates of Linnæus' most important works were noted by special publications. A series of publications in the early 1930s was dedicated to the bicentennial of the first edition of Systema Naturæ. Papers devoted to this work were published in a few Soviet scientific and popular journals. In 1953 the Academy of Sciences published the book by the author of this essay containing the analysis of Species Plantarum in connection with the bicentennial of publication of this most important work.

In 1957 the 250 jubilee of Linnæus birth was celebrated in the USSR on a specially large scale as the World Peace Council decided to celebrate the birth of the outstanding scientist whose life and work had the utmost importance for science and humane civilization. Articles published in May of 1957 by mass editions can hardly be reviewed. Jubilee articles were also published in main scientific and popular journals. A few books were publiched for this special occasion.

It is needless to repeat in this brief essay the bibliographical references given in the papers by A. A. Scherbakova (1958) and I. I. Nazarenko (1958). Our immediate task is to fill in some gaps and to correct some traditional mistakes. However, we must note that there is no certainty that all translations of Linnæus works into Russian were presented in this essay.

To conclude this study, it would be useful to refer the reader to some Russian editions devoted to Linnæus all the more so as some of them were not included into the bibliography by Scherbakova:

1. V. A. Fausek. C. Linnæus, his life and scienfific activity. Izd. *Obschestvennaya Polza.* Moscow 1891: 1–79.
2. V. L. Komarov. *Life and Works of Linnæus.* GIZ RSFSR, Berlin, 1923: 1–88 (reprinted in the series Collected Works by V. L. Komarov, vol. 1; 1945: 377–425).
3. E. G. Bobrov. The Bicentennial of Species Plantarum by Carl Linnæus 1753–1953. — *Komarovskiye Chteniya* VIII. Izd. Ak. Nauk SSSR Leningrad, 1954: 1–39.
4. S. S. Stankov. *Linnæus, Rousseau, Lamarque.* Moscow, 1955: 1–139.
5. E. G. Bobrov. *Linnæus, his life and works.* Izd. Ak. Nauk SSSR, Leningrad 1957: 1–217.
6. Collection of papers. — *Carl Linnæus.* Izd. Ak. Nauk SSSR, Moscow, 1958: 1–258 (the collected prepared by the Institute of History of Natural Science and Technology, the USSR Academy of Sciences).
7. E. G. Bobrov. *Carl Linnæus.* Izd. "Nauka", 1970: 1–286.

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Bobrov E. G., On the origin of the Flora of the Old World deserts as illustrated by the genus Nitraria L.—*Botan. Journ. 50,* 8: 1053–1065, 1965.

A Catalogue of the Works of Linnæus . . . British Museum, London, 1933: XI+246+68.

Kölreuter Joseph Gottlieb., *Vorläufige Nachricht von einigen das Geschlecht der Pflanzen bettrefenden Versuchen und Beobachtungen.* Leipzig, 1761.

Nazzrenko I. I., The first Russian translation of Linnæus works (250 Jubilee of Linnæus birth).—*Bull Mosc. obsch, isp. prirody. Otd. obsch. biol.* 1958, v. 63, 2: 155–158.

Scherbakova A. A., Literature on Carl Linnæus and his works published in Russian language. Coll. "*Carl Linnæus* . . . British Museum, London, 1933: XI+246+68.

Wulf E. V., Joseph Kölreuter, his life and scientific works. In: *Kölreuter. The theory of sex and plant hybridization.* Selkozgiz, Leningrad, 1940, pp. 9–55.

GEORGE H. M. LAWRENCE †[1] and
ROBERT W. KIGER

Linnaeus and the Computer

I. *The Linnaean collection at the Hunt Institute*

The Hunt Botanical Library, the gift of Mr and Mrs Roy A. Hunt, of Pittsburgh, to Carnegie-Mellon University, was founded in 1960. Within ten years the scope and activities of the Library had so far expanded beyond those of a conventional library that a change in name was required, and the name Hunt Institute for Botanical Documentation was adopted in 1970. The library itself, one of four divisions of the Institute, continues to be identified as the Hunt Botanical Library.

In 1968 the Library purchased from Dr Birger Strandell of Stockholm his well known collection of Linnaeana, the nucleus of which he had acquired in 1936 from Dr Emil W. Lindell, then a psychiatrist in Wäxjö, Sweden. Since 1968 this collection has more than doubled in size (partly through merging with it the Hunt Instutite's own Linnaeana), and it stands today second only to the holdings at the University of Uppsala library.

When the Strandell Collection came to Pittsburgh, Dr Strandell was made its Honorary Curator and given charge of its acquisition program. Shortly thereafter, work to compile a detailed descriptive catalogue of the holdings was begun. That Catalogue is now completed. It will be published later this year, jointly by the firm of Almqvist & Wiksell of Stockholm and Uppsala, and by the Hunt Institute.

This paper is an account of the application of the computer to production of this new Catalogue.

[1] To the great regret of his colleagues and friends, Dr Lawrence died on 11 June 1978, little more than a week after delivering this paper at the Symposium. In consequence, revision and preparation of the manuscript for publication have been done by the junior author.

II. *The computer: its applications*

The question may well be asked, Why use a computer? Excellent catalogues have been produced in the past without it. This Catalogue accounts for about 9 000 items. For ease of use, there are additionally some 2 000 hand- and machine-generated cross-references. Students of Linnaeana are familiar with one or more of the four catalogues or bibliographies of Linnaeana published in this century. Only one of the four has an index, and one so inadequate as to meet only the most basic of needs. For so large a body of material as is in this Catalogue it was decided early that not only should it have an index, but two indices: one an alphabetic list of titles, in short form; the second an analytic subject index to much of the work's content, including data supplied in the descriptive notes. It was further decided that 11 of the 12 appendices would include data pertinent to any collection of Linnaeana and otherwise relatively unavailable.

The two indices and all but one of the appendices were wholly computergenerated from data in the machine files. To have produced them by hand would have added years to the production time, and uncalculated amounts to the cost. These, plus the many computer-generated cross-references, and the many lesser but most useful editorial applications of the computer, have more than justified its use for this volume.

A few explanations about the computer and its use for such work are in order. A computer is an electronic machine that does three basic things:

accepts coded information, the raw material—called *input;*
holds that information (in storage areas called *memory*) and reorganizes it as may be directed (in an area called the *central processing unit*); and
produces that information, reorganized and in a predetermined format—the *output,* often in the form of a *printout.*

One characteristic of the computer must be understood. It has no brain. It performs no acts of magic. It is composed of memory cells and a most intricate maze of wires, of circuitry in miniature, connected to electronic devices (such as transistors, diodes, etc.) that function as valves or switches, turning electric current on and off, directing where it goes, and what it does.

The computer does its work in conformance with instructions that are fed into it. Sets of such instructions are known as *programs.* These are prepared by a specialist, a programmer, who is an applied logician, often of strongly mathematical inclination. He analyzes a given job to be performed by the computer, resolves it into a sequence of individual verbally expressed logical steps (an *algorithm*), and then translates that sequence into instructions expressed in some standard code "understood" by the computer. Such programs are often highly complex. As many as forty were required to produce this Catalogue; some took hundreds of hours to write, test and refine. The services of a highly competent programmer are vital to the sort of computer work we required.

Wonderful as the computer is, remember, there is nothing it can do that, given enough time, man could not do before it was invented. Basically, the value of a computer rests with the speed at which it operates—often ten thousand times faster than if done by hand. At the same time, careful study is required to determine if, in fact, it is economical, or even advantageous, to use the services of a computer. For realizing any great benefit from electronic data-processing, textual material must lend itself to organization by identifiable standard components, such as exist in catalogues, directories, bibliographies, or inventories. Conversely, works of narrative format are very limited in the extent to which component data can be searched for, identified, extracted, and permuted efficiently.

Other limitations of computer applications must also be recognized. First, the computer can give back no more, and no better, than was put into it. Second, the *software* (programs) that may be needed for a particular project can be costly, especially when it must be designed de novo, or when its use is limited to the one application. And third, computer *hardware* (the equipment itself) should be no larger or more sophisticated than is needed to do the job. Ideally, and for maximum efficiency, all planning for the project, all initial preparation of copy, and all development of software should be completed before any output of the product is produced. At the Hunt Institute we have learned to our sorrow that to proceed otherwise opens the gates to high costs for both programming and computer time, as well as for editorial iteration, incurring delays beyond all expectation.

A lesson learned after preparation of this Catalogue was well advanced deserves to be reported here. It is that rarely are authors and editors adequately informed of the complexity of computer programming. Too seldom do they appreciate how vital is the need of the programmer for explicit detailed and written instructions for every aspect of what is to be produced by the computer. Likewise, it became equally apparent that most computer programmers have no greater appreciation of the author's requirements. Most programmers are mathematically oriented in background. Their usual dataprocessing work deals far more with arithmetical or mathematical forms than with verbalized textual materials. Their experience is more with numbers than with words. The reverse is true for the editor or author. The result is inadequate communication between the two.

To provide a satisfactory interface between the two disciplines we learned rather late that the services of a third party were needed, those of a person who understood and who could articulate the needs of both editor and programmer. Fortunately, such a person was available from the Hunt Institute's staff. In a sense we commandeered his services. Today he is Acting Director of the entire Institute, and is here as co-author of this paper: Dr Robert W. Kiger.

To bridge the gap between editors and programmers, his first and immediate contribution was to write a "Production Manual" for this Catalogue. Obviously, we should have provided one at the beginning, for great economies in man-power and machine-time would have been effected.

From the editors Dr Kiger determined the content and format desired for intermediate and final products: details of layout, typography and punctuation, of cross-references (some hand-generated, others by computer), of appendices, and of the two indices—one by title and one by subject. Detailed instructions by which to achieve every requirement were written, and in the jargon and vocabulary by which programmers communicate, leaving no detail for question or interpretation. Kiger's "Manual" became the bible for both editors and programmers. From its directives a wholly new set of unified programs was produced; order displaced chaos.

So far as we know, this Catalogue is the first of its kind to have utilized so extensively the capabilities of the computer. The programs designed for it are being used for other bibliographic and cataloguing productions from the Hunt Institute. With modifications, they can be applied to comparable projects elsewhere. Comprehension of the capabilities and limitations of electronic data-processing provides a base from which to follow the procedures essential to the production of this volume.

III. *The Catalogue: its organization*

This Catalogue provides an annotated record of the printed holdings of Linnaeana among all collections at the Hunt Institute: those of the Strandell collection as acquired in 1968, those acded to it since then, and those that remain in the general collection of the Hunt Botanical Library. Their arrangement is alphabetical, by author and title. Duplicate titles by the same author are listed chronologically. Anonymous works are intercalated among the rest by title.

The basic unit of the Catalogue, termed an *entry,* comprises the description and all other information about any one item. Each entry is assigned a unique serial number, the means by which the computer identifies one entry from another. In recognition of Dr Strandell's work in assembling this Collection and in the preparation of this Catalogue, these sequence numbers are designated Strandell numbers.

In output form, the contents of each entry are divided among four sections (or paragraphs), as follows:

1. Description of the item: a book or an article—author, title, publisher, place of publication, date, pagination, illustrative content;
2. Citations of references having other accounts of the same item;
3. Notes about the item: content, other editions or translations, or biographic data about author, illustrators, or other associated persons; and
4. Supplemental information essential to generate appendices, indices, and separate lists for in-house needs. None of these data will appear in the published entry itself.

Every numbered entry is composed of standard data elements—as many of the total element suite as are pertinent. Just as the entry has its identifying number, so does each element have an identifier: a single letter enclosed also by slash marks. As instructed, the computer will search the entries for specified elements, extract them and process them as required.

The entry's first section describes the book or article, and is composed of data from up to 13 elements (Fig. 1). An understanding of the uses made of these elements is helpful.

Elements /a/, /b/, /e/, and /f/ contain names or pseudonyms of authors; the first two identify authors of books and the last two, authors of articles.

Author names are given in full in the Catalogue entry. From each the computer can generate a short form (e.g., surname and initials) for use in the appendices and subject index.

/a/	Author name, when of a book or independent publication.
/b/	Pseudonym [or initials] of a book author.
/c/	Title, when of a book or independent publication.
/d/	Title, when of an article in or from a journal or newspaper, of a chapter or section in or from a book.
/e/	Author name, when of an article, or a chapter or section of book.
/f/	Pseudonym [or initials] of an article author.
/g/	Title of periodical or newspaper.
/h/	No. of volumes, when more than one.
/k/	City of publication [cited as spelled on titlepage].
/l/	Publisher [cited from title-page or copyright statement].
/m/	Date of publication.
/n/	Pagination, illustration content.
/y/	Title(s) of a book other than primary title: often in another language, or alternate or second title(s).

Fig. 1. Element designators, for components of the book or article description.

Elements /b/ and /f/ are for pseudonyms or signature initials of an author name. Their separation as individual elements enables the computer to include or exclude them when generating a condensed citation of an item. From these elements the computer can also generate a list of pseudonyms, equating each to the author's real name, when known. From that it can generate cross-reference entries, as needed.

Elements /c/ and /d/ contain titles of books or articles, respectively separately identifiable by the computer.

The capability for the computer to distinguish entries for articles from those for books (by author and/or title elements) facilitates computer-generated permutations such as title lists of articles, distinct from those of books, or actual counts of the number of books by any author.

Element /m/ contains the publication date. The ability to select it from the file makes it possible to arrange any other categories of data from the entries in chronological sequence.

The last element, /y/, identifies titles of an item other than that in element /c/. Many older works have two or more titlepages, often with one in latin, the other(s) in one or more modern languages. Each such alternate title is included in the description of the item. Equally important, its isolation in a separate element enables the computer to extract it and to generate from it a reference (with that entry's Strandell number) which will appear in the title index in alphabetic sequence as appropriate.

The entry's second and third sections supply elements of information supplemental to the description (Fig. 2). Two basic types of information are treated: references (see elements /L/ through /W/) and notes (element /q/).

Refs: to bibliographies or other catalogues important for their accounts of the same entry.

/L/ Pritzel *Thesaurus literature botanicae* (ed. 1) number. /B/ Pritzel [same] (ed. 2) number.
/C/ Hulth *Bibliographia Linnaeana* page reference.
/D/ Krok *Bibliotheca botanica sueciana* page reference.
/F/ Lidén *Catalogue disputationum in academiis Scandinaviae et Finlandiae* number.
/o/ [Soulsby] *A catalogue of the works of Linnaeus* ... number.
/p/ Lindell *Bibliotheca Linnaeana* number.
/W/ Rudolph & Williams *Linnaeana* number.

Notes:

/q/ Information about the work, its editions and translations, biohistorical data on author or persons concerned. There is no limit to the number of notes, and there is complete flexibility in their format.

Fig. 2. Element designators, for supplemental data to be part of the published entry. Appendices VII–XII provide finding lists equating sequence numbers cited in such works as Soulsby or Pritzel to the Strandell numbers of entries for the same works in this Catalogue.

For each reference citation, the editors recorded only the element identifier and the respective sequence or page number for the item in that reference work. The print program, however, directs that for each of these reference citations, the author(s) of each reference be cited, followed by the page or sequence number(s).

Element /q/ contains one or more notes and may be of any length or format. No provision was made for the computer to extract any data from it. Information in a note may be, and often is, referenced in the subject index through use of pertinent index heading numbers included in the /Z/ element, as reported below.

/j/ respondent(s) of dissertation(s). For Appendix II.
/M/ author(s) of preface, foreword, or introduction, when not the author of the primary work. For Appendix III.
/G/ editor of a work when not the author of that work. For Appendix IV.
/z/ illustrator(s) (artist, engraver, sculptor, etc.) whose work is reproduced in the entry. For Appendix V.
/E/ biographee(s) (substantial biographical accounts). For Appendix VI.
/Z/ subject heading numbers for Subject Index.

Fig. 3. Element designators, for data to be extracted in appendices or subject index. This information appears in computer printouts of the Catalogue, but only that used in appendices will be in the printed volume. The unpublished data of these elements are available from the Hunt Institute.

/r/ binding description, useful for identification of individual copies.
/t/ source of the item: *i.e.,* from Lindell or Strandell collections, or acquired since 1968, or in the Hunt Botanical Library collection.
/A/ translator of book or article.
/N/ dedicatee(s) of book.
/O/ autograph(s) or hand written inscription(s): originator(s) of.
/P/ ex libris.
/S/ shelf location at Hunt Institute.

Fig. 4. Element designators, for in-house requirements. Data from these elements are not included in the published Catalogue.

The fourth section of an entry (Figs. 3, 4) contains those elements provided for various data-processing needs relating to appendices, indices, and in-house requirements. these include the /Z/ element, which accommodates sequence numbers of related subject index headings.

This section could conceivably have had many more useful elements. For any work such as this, the total number should be anticipated early, erring on the side of having too many rather than too few. For this Catalogue, one serious omission from this group affected the treatment of book reviews. An index heading "book reviews" was provided, but the inclusion of its sequence number in /Z/ elements allowed only generation of an author/title list of items in which reviews were published. Provision should have been made for producing an author/title list of the books reviewed, with Strandell numbers of the entries containing those reviews. For works by Linnaeus, and those by a few others, this omission is partially compensated by including some of these individual titles of books reviewed in the subject index as separate headings.

The remaining elements of this section contain data which are not required for appendices or indices. These are topics for which lists are useful for in-house needs (Fig. 4).

In its ultimate format, the Catalogue is printed with a final consecutive suite of Strandell numbers, paralleling the final sorted order of entries, and with the element identifiers and numbers for cross-references suppressed. The copy for publication is "typeset" by computer from a print file on magnetic tape, produced via one of the output options in the Institute's master text-handling program. Under this option, the magnetic tape file contains, embedded in the data, the codes needed to govern formatting and font control in the computer typesetter. The computer typesetter produces full-size camera-ready copy (12×30 cm) from which are made the photo-offset plates used by the printer.

≫1	≪1	To enclose the substantive part of a title, by which a book is alphabetized and indexed. Also direct that those words be italicized. Example: ≫1Species plantarum≪1
≫2	≪2	To enclose any word or words to be italicized, but carry no instruction for alphabetic sort or extraction. Example: ≫2Linnaea borealis≪2
≫3	≪3	To enclose author names, to be set in caps and small caps. These delimiters are added automatically by the computer. Example: ≫3Johnsson, Axel≪3
≫4	≪4	To enclose all Strandell sequence numbers, to be set in bold [black] face type. These are added automatically by the computer.

Fig. 5. Delimiters to signal an extraction and/or a change in typography. Sets of these are placed at beginnings and ends of words or word groups.

The variations in type font required in the published text are identified in the master files and in the editing printouts by special signals, called *delimiters*. These are placed around any word or words to be set in a type face other than the roman text face (Fig. 5). When generating the magnetic tape file for computer typesetting, the master program automatically converts these delimiters into the control codes recognized by the typesetter.

The substantive portion of a long title, to be set in italic as a visual aid, is so delimited. This also enables computerized extraction of that same short form of the title for use in appendices and indices. It is also the only portion used for alphabetic sorting. Any such portion of a title—to be used for these three concident purposes—is enclosed in type 1 delimiters.

The common convention for identifying words to be set in italic is to underscore them in manuscript. This can be done by computer on a line printer, but is costly. The underscore itself is added after the words are printed. This requires the paper feed to stop, even if momentarily, so that the same line of printing can be struck by the type train again to add the underscore. Using a pair of delimiters instead eliminates this at a considerable saving in machine-time. It also saves a great deal of file storage space in the computer, since the underscore for each individual character requires two additional codes in the file immediately following the single code for that character itself. The extra codes are those for a backspace and for the underscore.

The use of double acute and inverted brackets as a part of the delimiter is a signal to indicate that a font change and/or extraction is involved; the accompanying number specifies the kind of change or extraction to be made.

The type 1 and type 2 delimiters in the files were specified entry by entry as part of the editorial process, then entered at the keyboard along with the element texts.

Type 2 delimiters also specify setting the enclosed text in italic, but are ignored in sorting and extracting procedures.

Delimiter types 3 and 4 were inserted in the various files by computer. The presence of the first specifies setting the enclosed text in caps and small caps (as for author names). Type 4 delimiters indicate bold (black) face type (as for Strandell numbers).

One other special device was required to meet editorial needs: one to specify a sorting position for an entry other than where it would fall in strict alphabetic sequence. It was desired to bring together all the works by one author that have the same title. This the computer can do with precision, if the titles are truly identical. However, sometimes minor spelling variants exist among titles in the same series (e.g., *Amoentitates* and *Amaenitates*). This may cause some titles to sort out of the desired sequence (especially when common titles are listed chronologically). To "correct" this a new element, /X/, was employed. Any entry having to be positioned out of strictly alphabetical sequence is assigned an element /X/. This element contains the Strandell number of the entry in the general sequence that is chosen as a fixed point of reference within that sequence, plus a two digit number that stipulates placement in a subsequence of fixed order immediately following that reference point (a 01 if it is to be the first to follow, a 02 if the second, etc.). This convention is used to position both main entries and cross-references out of normal sequence.

Each entry in the Catalogue was drafted with the book or article in hand, to ensure agreement with the title-page text. Title spelling is retained as on the title-page, but no attempt is made to retain original capitalization or punctuation, features for which conventions have changed with time.

The diversity among kinds of items treated in the Catalogue required different entry formats. Three were adopted: for (1) books, (2) journal or newspaper articles, and (3) items by authors in (or from) works by others. In addition, a fourth format is used for cross-references.

Entries for books (Fig. 6) require all four delimiter types and many elements. The delimiters and element designators are purged from the final copy.

/a/ ≫3Linnaeus, Carl≪3 /c/ Carl Linnaei ... ≫1 Öländska och Gotländska resa≪1 på riksens högloflige ständers befallning förrättad åhr 1741. Med anmärkningar uti oeconomien naturalhistorien, antiquiteter &c. med åtskillige figurer ...
/w/ [... Journey to Öland and Gotland made in 1741 by order of the high estate of the realm. With notes on the economy, natural history, curiosities, etc. With several figures ...]
/k/ Stockholm och Upsala; /l/ Hos Gottfried Kieswetter; /m/ 1745.
/n/ [xiv], 344, [30] pp., 1 engr. pl., 2 maps.

Refs: /C/Hulth: p. 44; /D/Krok: no. 91; /p/Lindell: no. 304; /L/ Pritzel (ed. 1): 5991; /o/Soulsby: 202; /W/Rudolph & Williams: 67.

/q/ Note 1: The first edition. For Linnaeus' account of the plants seen on this journey see —— (6914). In this ≫2resa≪2 he reported the severe winters of 1658, 1687, and 1709 as shown in the growth rate of oak trees (by study of annual growth rings in trunk cross-sections).
Note 2: Readers concerned with chronological sequence of events should note that Linnaeus' departure from Öland on 21 June is on p. 156; his return to Öland on 25 July is on p. 157. His account of departure from Gotland (for Öland) on 25 July is on p. 302. For his days on Öland see pp. 157–160.
Note 3: The work is dedicated to Crown Prince Adolph Fredrik, of Sweden.
Note 4: For german translation, see —— (6903). For dutch translation, see —— (6905). For english translation, see–(26198). For later editions of his ≫2Gotlandska resa≪2 see —— (6475).

/Z/ 25, 176, 248, 274, 321, 364, 745, 746, 775, 859, 1245, 3380, 4001.
/X/ 06693, 01.

Fig. 6. Entry format for a book.

Note the element /X/ in last line of the fourth paragraph. It instructs the computer to position this entry immediately after Strandell no. 6693. In Note 1 of element /q/, the number in parentheses (round brackets) is the current sequence number of an entry; others are cited in Notes 3 and 4. When the final version of the master file is sorted alphabetically, and the entries then renumbered in that sequence, these reference numbers within the text of entries will automatically be replaced with the corresponding new Strandell numbers of the referenced entries. On the penultimate line of the entry is the /Z/ element. The numbers it contains are those of the index headings under which this entry will be listed. Throughout the Catalogue, titles in scandinavian languages (including finnish) are accompanied by an english translation enclosed in square brackets. The translation is contained in a separate element; those for book titles (element /w/) are distinguished from those for titles of journal or newspaper articles (element /x/). This separation from the title in original language allows the computer to extract a short title from the latter without having to first distinguish and disregard the translation, which is not wanted for indices and appendices.

Formats for journal or newspaper articles are simpler (Fig. 7).

/e/	≫3Kalm, Pehr≪3 /d/ Berättelse om et slags yrfä i Norra America, skogslöss kalladt; af ... /x/ [Account of a kind of winged insect in North America, called wood tick; by ...].
/g/	In: Kongl. Svenska Vetenska, Acad. Handl. 15: 19–31. /m/ 1754.
/q/	Note: For english translation with notes by Esther L. Larsen, see —— (4230).
/Z/	55, 169, 261, 7658, 10350.
/f/	≫3J.D.≪3 /d/ Linnaeus.
/a/	Ex: ≫3Swainson, William≪3 /c/ ≫1Taxidermy ...≪1 Pp. 249–253. /k/ London;
/m/	1840.
/q/	Note: Xerographic copy, courtesy Museum of Comparative Zoology, Harvard University
/Z/	126, 130.

Fig. 7. Entry formats for a journal or newspaper article and for an item by one author in a work by another.

Note the absence of type 1 delimiters, usually unnecessary since alphabetic sorting commences with the beginning of the title (ignoring leading articles). The short form of such a title is arbitrarily restricted to the first seven words (followed by an ellipsis if longer than seven words). For a few dissertations published as articles, type 1 delimiters are used as with book titles.

Titles of periodicals are cited in conformance with abbreviations adopted by the Hunt Institute a decade ago. The shorter abbreviations often used within some language areas may be adequate for those circumscriptions, but in the larger context of all periodical titles in the world's past and present biological and medical literature, in a great variety of languages, they often fail to specify titles unambiguously.

The entry format for articles allows the same freedom in use of Notes as does that for books. The /Z/ element for index heading numbers is also used.

A special format was devised to accommodate a work by one author published in that by another (Fig. 7). Bibliographically, such a work contained in a book by another is treated as if it were an article in a journal; thus the computer treats if as an independent item, isolating in other elements the author and title of the work in which it appears. In such an entry we distinguish an article *in* the book (indicating that the article is to be found only within that book, which itself is in this Collection), from one that is *ex* (or from) the book (thus reporting that the article exists separately from its occurrence in that book itself). When such an item has been obtained from an external source, the location of the original is given.

Throughout this Collection, items difficult to find are represented by photocopies, thus increasing its comprehensiveness and its utility to scholars. Identity of an item as a reproduction is so reported in the Catalogue.

IV. *Data-processing and Catalouge production*

This Catalogue is said to be computer-produced. The statement is only partly correct, however, for the front-matter, the Preface, the Introduction, and the first appendix (accounts of the pupils of Linnaeus) require no electronic data-processing and are set directly by linotype. All the rest—Catalogue proper, two indices, and Appendices II–XII—is processed by computer, from initial data entry through "typesetting". The data actually entered into the computer include the full content of each primary Catalogue entry, each hand generated cross-reference, and each of the 8 000+subject index headings. Other cross-references, the full short-title index, the eleven appendices, and the subject index reference citations are all generated by the computer from the data elements of primary entries.

After individual entries or index headings are prepared or edited, the data for each are added to or updated in the computer file. This is done randomly entry by entry, without regard for numerical or alphabetical order; all entries are sorted later in the mainframe computer.

Three computers and associated peripheral devices are used in Pittsburgh to process the data and, ultimately, to produce the final print file on magnetic tape for computer typesetting. Initially, the data are fed into a minicomputer (DEC model PDP-11/04) owned by the Hunt Institute. This minicomputer stores the records on what are known as diskettes or "floppy discs" (thin flexible discs covered with a magnetic material, and about the size of a 45-rpm phonograph record). Each disc has a capacity for about 250 Catalogue entries and associated cross-references, or about 440 subject index headings. Forty-five discs accommodate the Catalogue proper; another 18 are required for the index headings. Data are recorded on the discs via CRT editing terminals (BME model Super Bee 2). Each terminal includes a keyboard and cathode ray tube screen (similar to those seen in airports) on which material appears for visual inspection as it is typed in by the operator or recalled from the disc for editing.

The console operator may "call up" any record on a disc by use of its sequence number. Its content then appears on the screen, and corrections, deletions, or aditions can be made to any element. By insertion of the appropriate disc into the unit, this may be done for any entry at any time.

The disc drive accommodates two discs at a time: one on which the data are recorded, the other a systems disc that stores the programs used to control the computer. These programs are written in ASSEMBLER, a machine-specific code or language one level above the binary code in which the computer actually operates.

When data of all Catalogue entries, including the hand-generated cross-references, and of all index headings, are on their respective suites of discs, the disc files are transferred by a direct or "hard" wire from the minicomputer to a larger computer (also a DEC unit, model PDP-11/45) at the University's computer center. Special programs, one running in each computer simultaneously, were written to do this. The 11/45 serves simply as an intermediate storage unit, holding on two disc packs all that was on the 63 floppy discs.

One of the University's mainframe computers (IBM model 360/67) is used for all the text processing work. The DEC equipment requires that material be coded in a format known as octal—in 8-bit "words". The IBM equipment, however, accepts only material coded in hexadecimal format—in 16-bit "words". Among other manipulations, the files are translated from octal to hexadecimal when they are transferred to the IBM unit.

Once in the IBM 360, the separate diskette files are concatenated to build master Catalogue and index heading files. These are then reviewed systematically by machine to check for certain types of errors (e.g., duplicate entry numbers), correct these, and make any standard changes desired throughout the content of the files.

For the Catalogue proper, additional cross-references are then generated by machine from the primary entries according to the following protocols:

(a) From entries for works published only under pseudonyms or initials, so cited in element /b/ or /f/, but for which that author's real name has been determined, cited in square brackets in element /a/ or /e/, and under which the entry is listed. The computer generates a cross-reference under the pseudonym or initials, with the short-title of the item and its Strandell number.

(b) From entries having two or more authors (recognized by the presence of the ampersand [&] in the author element). The computer generates a cross-reference under the name of the second author (and one under each successive author name, when present), with the short-title of the item and its Strandell number.

Sequence numbers for all cross-references are assigned in series distinct from that used for primary entries, thus permitting the computer to distinguish readily a cross-reference from a primary entry. Among the cross-references, those machine-generated are numbered in a series separate from that used for hand-generated ones, thus allowing their easy distinction during processing.

When making the tape file for computer typesetting, the numbers of all cross-references are suppressed; in the published Catalogue, only the primary entries will have Strandell numbers.

For the machine-generation of Catalogue cross-references, and for most subsequent major manipulations of the data in the IBM 360, a very powerful, flexible, generalized text-processing program is used. This program, written in Assembler, is in effect a software "system", as that term is used in the world of computers. It has its own, specialized, high-level (very English-like, strongly mnemonic, highly integrative) command language. In all major functional and contextual features, this program or system is analogous to such familiar systems/languages as BASIC, FORTRAN and COBOL. It is not a one-job program; rather, it can be used to perform any given job of text-processing, working with any number of input and output files, each such file in any of four standardized formats depending upon its purpose. To use this master program, a file of sequential instructions written in the command language (this file is actually a program in itself) is entered into the IBM 360 via a keyboard terminal, paper tape, card deck, or any other standard input mode. The master program is then run. First, it is called from storage into memory, along with the separate file of commands, and a portion of it called the *compiler* translates that command file into machine code, meanwhile checking for certain errors of format or logic in it. Once the command file has been compiled without error, the other major portion of the master program, the *executor,* is run. This actually performs the task specified in the command file, executing that series of operations by translating those now-coded instructions into sequences of unitary commands to the overall operating system of the IBM 360.

The next major task in producing the Catalogue proper is to sort all the entries and cross-references. First, all entries having an /X/ element are searched out, extracted from the master file, and held aside. The rest of the entries are then sorted by author, title and date, after which those with /X/ elements are inserted at the locations specified therein.

An editing printout is then produced. Unlike ordinary computer printouts, for which only capital letters are available this one is printed from an expanded, custom-made line-printer font (carried on what is termed a *print train,* which resembles, a bicycle chain with two brass type characters on the outside of each link, the chain being contained and running in a continuous race about a flattened ellipse). This font prints not only capital and lower case letters, but also almost all diacritical and punctuation marks used in languages employing the roman alphabet.

The editors make changes as required on this printout. The set of diskettes originally generated at the Institute are available to receive all corrections, deletions, and additions indicated on the editing printout. At the same time, new entries may be added or existing ones delated. The same is true for hand-generated cross-references. Once all such changes have been made using the minicomputer and editing terminals, the updated diskette files are transmitted to the IBM 360, where they form a new master file that replaces the existing one.

The most difficult and complex part of the entire production is the computer generation of appendices and indices, and of them compiling the Subject Index is most taxing of programming ingenuity and computer capability.

Appendix I (Pupils of Linnaeus) is printed from linotype composition.

Production of Appendices II through VI requires, for each, searching the entire master file of Catalogue entries for those possessing the element that contains data relevant to that appendix. These data, along with those required from other elements, are then extracted from each such entry. Whenever such data include names of authors and/or titles, the programs condense author names and suppress names and titles when repeated sequentially in the appendix. These machine-generated appendices are summarized as follows:

II. Respondents of dissertations. Based on element /j/ [the respondent's name, plus vital dates]; references under each by author of dissertation [the *praeses*], its publication date, and Strandell number.

Each occurrence of a given dissertation in the Catalogue (as with successive editions or in translations) is cited separately.

III. Authors of introductions or forewords, in works by other authors. Based on element /M/; references under each by inclusive author, short-title, place and date of publication, and Strandell number.

IV. Editors of works written by others (e.g., posthumous publications, later editions, or translations). Based on element /G/; references under each essentially as for Appendix III.

V. Illustrators and artists of portraits—primarily of Linnaeus. Based on element /z/; references under each by Strandell number of entry where the likeness is reproduced.

VI. Biographical studies. Based on element /E/ [name of biographee]; references under each by author, publication date, and Strandell number.

Appendices VII through XII are finding lists relating citations in selected references to the Strandell numbers of entries for those same items. The sequence numbers in these works are cited frequently in the literature (even in sales catalogues). From these lists one may locate quickly this Catalogue's entry for the same item.

For each of these lists the computer searches the master file for entries containing the pertinent element, extracting from each the reference citation and associating that with the Strandell number of the entry. These pairs of associated citations are formatted in sets of parallel columns, listed in ascending order by reference citation (the computer adding identifying heads for the columns).

The reference works thus accounted in each appendix are:

VII. [Soulsby, B. H.]—*A catalogue of works of Linnaeus*, ed. 2 (London, 1933). Based on the /o/ element.

VIII. Lindell, E. W.—*Bibliotheca Linnaeana.* (Wäxjö, 1932). Based on the /p/ element.

IX. Rudolph, G. A. and Williams, E.—*Linnaeana* (Manhattan, Kansas, 1970). Based on the /W/ element.

X. Pritzel, G.—*Thesaurus literaturae* botanicae, ed. 1 (Leipzig, [1847]-1815). Based on the /L/ element.

XI. Same ed. 2 (Leipzig, 1871–[1877]). Note: each of these two editions has its own independent series of sequence numbers; a given work that is listed in both editions will have a different entry number in each. Based on the /B/ element.

XII. Tullberg, T.—*Linnéporträtt* (Stockholm, 1907); and the continuation of the same series from: Beskow, I. T.—*Linnéporträtt Supplement* (Uppsala, 1967). Tullberg references are to portraits of Linnaeus, in all media. Here these citations are equated to Strandell numbers of entries in which those likenesses are reproduced. Based on the /T/ element.

Two indices are supplied. One is an entirely computer-generated short-title index for books and other independently published items treated in the Catalogue. These entries are arranged alphabetically, each consisting of short-title, place and date of publication, and Strandell number of that entry in the Catalogue. Duplicate titles by the same author (different editions) are listed in ascending chronological order.

The second index is an analytical subject index. This is synthesized from two basic files of data: one, a list of nearly 10 000 hand-generated headings (topical entries), under which references to relevant Catalogue entries may be sought; and two, a file of the corresponding sets of references, entirely computer-generated.

The list of heading is open-ended, new headings being added as compilation and editing of the Catalogue entries proceeded. Each heading is assigned a unique sequence number—in a series wholly apart from that for Catalogue entry numbers. Periodically, as the number of headings increased, and as existing ones were changed editorially for various reasons, it was necessary to generate updated alphabetically and numerically storted printouts to be sued in conjunction with editing the Catalogue entries. Three sets of these printouts were produced during the course of Catalogue compilation.

Most primary entries in the Catalogue contain /Z/ elements, to accommodate the relevant index heading number(s). The number of headings assigned to a given entry varies with the need, from one to as many as fifty or more.

The index headings are constructed according to a standard format designed to allow a hierarchical format when published. Each heading may comprise up to four hierarchical segments (each a separate *field,* for purposes of sorting and suppression). For example:

[field 1] Linnaeus (example only—never actually used by itself, but always with at least a second field segment—for Linnaeus there are more than 3 000 of these)

[fields 1–2] Linnaeus, works by (example only—also never used as such)

[fields 1–3] Linnaeus, works by—*Species plantarum* (ed. 1, 1753)

[fields 1–4] Linnaeus, works by—*Species plantarum* (ed. 1, 1753)—nomenclature of
Linnaeus, works by—*Species plantarum* (ed. 1, 1753)—studies of
Linnaeus, works by—*Species plantarum* (ed. 1, 1753)—works cited in

When the full subject index (headings plus references) is output for printing (using the master text-handling program), the heading numbers are suppressed, as are any first through third heading fields which are identical to the respective fields of the immediately preceding heading (except at the top of a new page). Previous to merging the files of headings and references during this formatting and outputting for print, the headings are sorted alphabetically on the basis of the hierarchical fields.

For each full heading, its place in the overall alphabetical sequence is determined by treating its constituent fields separately and sequentially as sorting keys. By sorting and then suppressing on the same basis, the printed product is indistinguishable from a hierarchical subject index prepared in the traditional way.

The suppression and sorting programs applied to the example headings above would generate successive headings in the printed index as follows:

Linnaeus, works by
  Species plantarum (ed. 1, 1753)
    facsimile eds. of
    nomenclature of
    studies of
    works cited in

The set of references under any given heading is rendered in one of four formats, as follows:

Format 1. Verbalized, under headings relating to certain of Linnaeus' works. Presence of his name in these headings eliminates the need for it in the references, each of which consists of short-title, place and date of publication, and Strandell number of that Catalogue entry. Examples of such headings are:

Linnaeus, botanical works by
  medical works by
  orations (addresses) by

Format 2. Non-verbalized (Strandell number only), under a few headings for Linnaeus topics known to be represented by a large number of Catalogue entries. Examples of such headings are:

Linnaeus, biographical accounts of (1 800+references) portraits of (1 000+ references)

To simply list more than 1 000 Strandell numbers under a heading would seriously impair the usefulness of the index. The solution adopted was to list the references in each of these sets by chronological subsets, as follows:

pre-1753	1820–1839	1879–1899	1930–1939
1753–1777	1840–1856	1900–1906	1940–1956
1778	1857	1907	1957
1779–1799	1858–1877	1908–1919	1958–1969
1800–1819	1878	1920–1929	1970–1978

Format 3. Non-verbalized (Strandell numbers only), under all other headings where the number of references does not exceed 10.

Format 4. Verbalized, under all other headings where the number of references exceeds 10. Each reference consists of author name, short title, place and date of publication, and Strandell number of that Catalogue entry.

To create the file of references that are to be merged with the file of headings by the master program, a sequence of single-purpose programs (written in FORTRAN language) is used to: search the master file of Catalogue entries for all occurrences of each index heading number in the /Z/ element; extract for each such occurrence the Strandell number and other data needed for the index reference to it; sort all these heading number/Strandell number associations (more than 75 000!) into sets by heading number; determine the relevant reference format type for each heading number (if not already known *a priori*—Formats 1 and 2); construct the references as appropriate under each heading; and sort the references under each heading either numerically or alphabetically, as relevant.

In addition to producing printouts for editing the index headings file, it is necessary of course to produce one of the full Subject Index—headings plus the machine-generated references—in order to verify finally all constituent data and their proper coordination. Among other things, this review of the full Subject Index serves as an additional editorial check of the Catalogue entries. It is there, in the master file of Catalogue entries, and not in the Subject Index itself, that any changes, additions or deletions called for as a result of editing the index references are made. So, too, does editing interim printouts of the Title Index and of Appendices II–XII contribute to editorial refinement of the Catalogue proper, from whose entries all those data are derived.

Thus, interim editing printouts of all of the various computer-processed portions of the work provide for intensive review and correction of the basic data as they are accumulated. When the master files of Catalogue entries and index headings are complete and have been fully verified from final check printouts, each portion of the full Catalogue—Catalogue proper, indices and appendices—is then output for the computer typesetter—formatted, set and paged sequentially according to the organizational scheme of the publication.

BIRGER STRANDELL

Research on Linnaeus Today from the Collector's Point of View

When I received the kind invitation to participate in this symposium, I concluded that the members would want my views, as a Linnaean collector, on the subject. The title of my paper was thus made clear. The presentation is, of necessity, both subjective and personal.

Over the years, indeed, over the centuries, book-collectors have been both damned and praised and misunderstood as often as appreciated. Allow me to digress for a moment to present and refute the negative views before proceeding to the positive benefits that collecting has brought to literature, science, and the arts.

Detractors of book-collecting view a collector as a strange person, one who is, to use a popular cliché, a negative achiever, whose efforts are valueless to his fellow man, and as one who, by some odd instinct, acquires, amasses, and stores a collection—of paintings, stamps, coins, books, manuscripts or other objects—and who does so primarily to inflate his own ego. True, there are such collectors, who are only book-collectors and not bibliophiles at all. Regardless of how complete may be the resultant collection, the enrichment of its owner is largely pecuniary and not at all intellectual. If the collection is of books, the only gain may have been to bring together those that had been widely separated. They will, one hopes, include the rare as well as the common and thus these rare books may be preserved for future scholarly use.

Intolerance of the ill-informed collector can be traced back for nearly 2000 years, when the Greek author Lucian (*c.* 125–185) made fun of "the foolish book-collector", whom he exposed with great scorn. In Sweden, two distinguished authors, Carl Gustaf Leopold (in the eighteenth century) and Sigfrid Siwertz (in the twentieth) bitterly criticized the book-collector.

Leopold (1756–1829) wrote a *causerie* in his *Lärdomshistoria* (History of Science) (1790) which is supposed to have reference to an extraordinary and prominent collector named Samuel Älf (1727–99), of Linköping, known as "one of the most prominent poets of his time, as one of our most renowned deans, and a man of respectable personality" (*Biografiskt lexicon öfver namnkunnige svenska män,* Bd. 23, p. 209, Örebro 1856). This did not prevent Leopold from attacking Älf—because he was a collector!

More recently, Siwertz (1882–1970) in his *All världens berättare* (Short Stories by Authors from All over the World) (Stockholm 1942) poked fun at the book-collector and bibliophile, "the book epicurean", as he called him, "who notices the paper quality, binding, gilt edges, typography, illustrations" and who "speaks about books as Brillat Savarin spoke about patridge stew and curd cake". Moreover, he held that "there is something senile and hopeless in the way people let themselves be hypnotized by original editions, off-prints and rarities". He recommended that "those who devote their time to such inferior labour should, once and for all, change their objective and collect snuff-boxes instead".

My countryman, J. Viktor Johansson, a well-known book-collector and bibliophile, wrote in his book *Försvar för boksamlaren* (In Defence of the Book-collector) (Stockholm 1958) that it surprised him that "an author could grouse about people who want to possess a work by him or his colleagues and who would bind them in *de luxe* bindings and consider them as delicacies". This seemed to him to be no more odd than that an artist should attack as a bad habit the hanging of a painting on a wall or that an actor should be offended by people attending the theatre at all time.

There are those who ridicule the collector who collects books in languages he cannot read such as Latin, Japanese or Chinese. But who insists that a gun-collector be a hunter, a soldier or a murderer?

Some critics aver that a collector's only merit is that, on his death, his collections can be sold and dispersed, so that other collectors may then fill gaps in their collections: collections again to be sold, on their deaths, to enrich other collections, and so on.

Again, there is validity in these criticisms, but they are only a small part of the whole truth. While there are mere collectors of books, as there are drones in a beehive, let us remember too that there are bibliophiles, lovers of books, the workers in that same beehive. Fortunately, and I believe this is true, the bibliophiles far outnumber the pedestrian collectors. The bibliophile is one who knows the books that he or she possesses, knows about the authors of the works collected, about the artists who illustrated them, and the people who produced them as typographic examples of a particular time or from a given place of origin. Let there be no mistake about it, the book-collector who increases his own level of scholarship also enriches the culture of his time and is thus able to contribute to a better knowledge of the literature in which he specializes, be it the literature of the arts, of letters or of the sciences.

The contributions of the true bibliophile are many. Knowing well the literature of his own field, he is often the first to recognize an item not previously included in current bibliographies on the subject. When that discovery is shared through publication, others benefit proportionately. The expertise of the collector may well enable him to identify the author of an anonymous work.

The experienced collector becomes a keen observer of minutia, but, more important, he must recognize the significance of what he sees. Of itself, this may lead to the discovery of rarities, of works made more valuable by the revelation of new evidence of prior ownership, and thus add to the provenance of the particular copy. Gradually, the collector acquires a flair by which he discovers items or important facts that others before him have passed over. Let me give you some examples from my own experience in the last few years.

At a book auction in Stockholm early in 1971, I acquired a German edition of Linnaeus's colleague Nils Rosén von Rosenstein's *Textbook on Paediatrics,* printed in 1766. Nobody seemed to have observed that the work was printed in Hamburg. When I had the book in my hands, it was easy to see that it was quite different from the first German edition of this work, which was printed in Gotha and Göttingen the same year (1766). In fact, it is a copy of a very rare pirated edition, of which no other copy has been found in the great public libraries in Sweden or in catalogues from the largest and best-known libraries of the world. Up to now, the only other copy of this edition has been found in Göttingen.

Early in 1974, I discovered a variant of Linnaeus's important dissertation *Demonstrationes Plantarum* (Höjer, Uppsala 1753), of which almost the whole of the title page was reprinted, probably after the thesis had been publicly defended. My copy still seems to be unique. I have published both these discoveries in detail (1, 2, 3).

Not long ago (1975), the original drawing of the floral vignette reproduced on the front cover of all issues of *Svenska Linnésällskapets Årsskrift* (Yearbook of the Swedish Linnaeus Society) was offered for sale at a

Stockholm book auction, together with the book-plate of Elof Förberg. The compiler of that catalogue had no knowledge of the current use of that decorative floral design, nor did he know that Förberg was a founder of Svenska Linnésällskapet or that the Society possessed his very fine Linnaeus collection. The text in the catalogue was written in accordance with his knowledge. None of the knowledgeable persons in Uppsala or Stockholm bid for the items. It was, however, my good fortune to get these two original drawings. On Friday this week, I shall have the pleasure of presenting them to our Society at Uppsala, placing them where they will be of the greatest significance.

Neither the vignette nor the book-plate was signed. But from annotations on the drawings, written by the artists, we learn that the vignette drawing was by the well-known Swedish artist Olle Hjortzberg (1872–1959), who was a professor at the Swedish Academy of Art. That of the book-plate is by another well-known Swedish artist, David Ljungdahl (1870–1940), who was also a professor of art. Certainly the collection of ephemera such as these items also adds to our knowledge an appreciation of additional aspects of Linnaeana.

While speaking about details, I am sure that nobody here has seen the extremely rare, original vignette which Linnaeus withdrew from p. 1 of his *Wästgöta-Resa* (Stockholm 1747) and which, as far as I know, exists in only three copies (and not in Linnaeus's copy). If you would like to study the details of this vignette, I can tell that the printer, Lars Salvius, found it advisable to use the cancelled vignette in other works by Linnaeus—his dissertations *Odores Medicamentorum* (Wåhlin, Stockholm 1752, p. 1) and *Noxa Insectorum* (Baeckner, Stockholm 1752, p. 1), which are easier to acquire.

Recently, I discovered a discreetly written annotation "Exemplar Auctoris", on the title-page of a copy of Linnaeus's *Systema Naturae* (first edition, 1735). I also recognized at once that it was in Linnaeus's own hand; *ergo,* this copy, which for more than 120 years has belonged to the Swedish Society of Medical Sciences in Stockholm and has very often been examined by Linnaean scholars, was suddenly identified for the first time as Linnaeus's own copy of that great work!

At the time when I made this discovery, I also noticed that the coloured copy laid in it of Ehret's engraved plate, illustrative of the 24 classes of Linnaeus's plants, was of the extremely rare first edition of that engraving, of which only two copies were previously known: one is in the Waller Collection at the University of Uppsala Library and the other is laid in Hans Sloane's copy of *Systema Naturae,* now at the British Museum. When the Swedish publishing house Rediviva produced in facsimile the above-mentioned Linnaean copy of *Systema Naturae,* this beautiful Ehret plate was included, in full colour and without reduction in size. Thus, the accidental discovery by a collector led in part to the making available of two rare items to fellow collectors and to institutions throughout the world. In my foreword (4) and in another paper (5), I have given a detailed account of these two discoveries.

All great public libraries owe a part of their greatness to the efforts and interests of private collectors. In many instances, entire and very substantial collections have been received *en bloc* from a private collection; in others no more than a single, long-wanted item has been received—an item that some collector has been wise enough to acquire and preserve, and later to deposit where it would best serve the interests of others. Without the collector, neither of these accessions might have happened. And what would our art galleries look like, if there had not been any art-collectors?

Every collector who is a true bibliophile becomes a specialist in the literature of a selected subject. To be most effective, the collector should also make the decisions as to the ultimate disposition of his collection. Moreover, the selection of its final repository—assuming that he does not opt for the auctioneer's block—will surely be his own greatest contribution to future research, especially when the collection is one that approaches to completeness in its subject field. Because of the importance to others of such a collection, it becomes essential that it should be kept together as a unit and not dispersed. This was the attitude taken by me and my family when a decision had to be made about the disposition of our collection of Linnaeana.

The story of how this collection ultimately became a part of the Hunt Botanical Library (HBL) at Carnegie-Mellon University in Pittsburgh has been recounted in my book *Vägen till Linné* (The Way to Linnaeus) (Stockholm 1974) and in my paper "The Linnaean Collection" in the *Proceedings of the Linnaean Symposium* published in *Taxon* (25: 3–8, 1976). A very significant condition in the agreement that our collection should go to Pittsburgh was that it would be properly housed, maintained and kept up to date and that it would be preserved for the future as a unit and would be available to all who need to consult it.

Prior to 1968, when the transfer was made, the largest Linnaean collection in America was that at the Kansas State University, whose holdings are reported in Rudolph and Williams's catalogue *Linnaeana* (Manhattan, Kansas 1970), an assemblage augmented by the rich collection at the sister institution, the University of Kansas, at Lawrence. Yale University's renowned collection of Scandinavian literature includes many Linnaean items but does not pretend to be exceptionally strong in the medical and natural sciences. Thus, despite excellence of individual items in these three American collections, America continued to lack anything approaching the magnitude of the Linnaean collection now at the Hunt Botanical Library in Pittsburgh. The transfer of our collection to America has unquestionably stimulated in that country an interest in Linnaeus and in Linnaean research.

In this connection—passing by other points of comparison—one cannot help thinking back to the acquisition by Sir James Edward Smith of Linnaeus's own natural-history collections and library of books and manuscripts, and its significance to Linnaeus's reputation in Great Britain and the English-speaking world.

Of the several catalogues of Linnaeana, two stand out above all others: J. M. Hulth's *Bibiliographia Linnaeana* (Uppsala 1907) and the British Museum of Natural History's *A Catalogue of the Works of Linnaeus* (London 1933); the latter is the work of Basil H. Soulsby. Both Hulth and Soulsby were eminent librarians and bibliophiles, made priceless contribution to Linnaean research, and, in an extraordinary way, facilitated immensely the work of scholars over the world. Almost daily, I have cause to turn to each of these works, there to find in a moment details and particulars about some item or other—details that are the result of years of investigation on the part of the authors. In recent years, I have been occupied with another work—the production of a new catalogue of Linnaeana—and this brings me to yet another substantial kind of contribution that may be made by a book-collector.

Since the time when our collection went to the Hunt Botanical Library, George Lawrence and I have worked assidously to produce a new, up-to-date, and annotated catalogue of Linnaeana, based on our collection and other acquisitions of Linnaeana at the HBL. The visits made between Sweden and America have been many. The acquisition of desiderata has been continuous and considerable. The search for and incorporation of pertinent biobibliographical data have seemingly been endless.

For the first time ever, so far as we know, a highly complex bibliography, replete with appendices and analytical indices, will have bee produced by a computer—even to the first photo-typesetting. Of course, every item of information, every name, data or other fact used by the computer, was brought forward and fed into it by us. The utilization of this process, however, has enabled us to achieve remarkable results. But, let me assure you, the frustrations encountered and the technical difficulties beyond our control have at times been almost unendurable! These difficulties, wholly external to our work, have caused delays which we never contemplated. Even so recently as last January, we expected that the completed, printed and bound catalogue would be here on display, for your examination today. Although part of our manuscript has already reached the printer in Uppsala, we know that the catalogue will not be available until next autumn. Today we can show you only a dummy.

A report on how this catalogue has been produced will be given by George Lawrence and Robert Kiger in their paper on "Linnaeus and the Computer" at the symposium in Uppsala on Friday. In our opinion, this catalogue may, in itself, be considered to be the product of a book-collector's efforts and is another exemple of "Research on Linnaeus Today".

Before I finish I would now like to say a few words about our catalogue.

The catalogue

The scope of the collection reported in this catalogue goes beyond works by or on Linnaeus. There are a number of works by or about his pupils, quite apart from the dissertations for disputations at which he was the *praeses*. There are works that were edited by Linnaeus but written by such pupils as Hasselquist *(Iter Palestinum,* Stockholm 1757) and Löfling *(Iter Hispanicum,* Stockholm 1758), both in current editions in foreign languages. There are also other works published by pupils, even after Linnaeus's death.

In his works on plants and animals, Linnaeus cited scores of titles by earlier authors, works which have to be consulted today when making critical studies of Linnaeus's writings. My predecessor Lindell had collected a number of these items and added others by colleagues of Linnaeus at Uppsala. I continued to add other volumes within this framework.

The literature of Linnaeana is dependent on other Swedish scientific works of the period. Linnaeus himself made references to many of them. Non-Swedish scholars need to know of and to have access to such items. Some of them are treated in this catalogue—mostly from the periodicals of the Royal Swedish Academy of Sciences. Others of Linnaeus's time, with a similar coverage but not strictly Linnaeana, are in the collection.

Some people's curiosity may be piqued to find here a work by the Swedish historian Olaus Verelius (1618–82), included only because this copy once belonged to Kilian Stobaeus, Linnaeus's eminent teacher at the University of Lund (1727–8), who inscribed his autograph on the title-page. Since no other autograph of Stobaeus was known to exist at the Hunt Institute, this copy was included among the acquisitions of 1968.

One part of those acquisitions was a collection of more than 6 000 newspaper cuttings about Linnaeana, without doubt the largest outside Sweden. From among them, I have selected for this catalogue record those whose contents are especially pertinent, including those by such leading Swedish Linnaean scholars as Felix Bryk (born in Vienna but educated in Poland and Germany), Carl Forsstrand, Telemak Fredbärj, Robert Fries, Knut Hagberg, Hans Krook, Sten Lindroth, Sten Selander, Rutger Sernander, Carl Skottsberg, and Arvid Hj. Uggla. In so doing, full tributes and more complete records are given to these authors.

To these, I have added many articles published in the press by prominent authors and journalists, especially those pertaining to Linnaean celebrations. Such accounts are more informative in content than are the formal papers published later in scientific periodicals. Valuable also to students of Linnaeana are the reviews of books and journal accounts on the subject. A selection of these is also included, many written by our best-informed scholars.

I also deemed it advisable to add a selection of newspaper reports on travels in Linnaeus's footsteps. Generally, they give reliable information about the preservation of or the changes that have occurred since Linnaeus's time in the topography, the fauna or the flora of a place or a region.

In so far as they were available to me, I have included cuttings of Linnaeana from abroad, which are often difficult to obtain. Some are from other Scandinavian countries, others from newspapers in Germany, the Netherlands, England, Italy, America, and other countries. In 1938, for example, I went every night for a fortnight to the central railway station in Stockholm to get a copy of *The Times*, expecting to find articles reporting the celebration of the 150th anniversary of the founding of the Linnean Society of London. Thus, I acquired not only the reports of events and the editorials, but also the subsequent letters to the editor and the responses elicited.

I am quite sure that this selection of cuttings could have been made more objectively, perhaps more generously on the whole, perhaps more rigidly as regards the scholarship of each item. But it does present a kind of record that is so often lacking in such collections. Its bibliographic importance is above challenge.

Our ambition has been to produce a catalogue that will facilitate research on Linnaeus. We have therefore tried to include information of biographic and bibliographic interest as far as possible. The effort to obtain such information has often demanded time-consuming research work which has not always been successful.

The reader will find that many entries are annotated, more or less. He will also find frequently occurring cross-references, which will facilitate the use of the catalogue.

I am sure that the reader will accept the fact that we have added to the collection—and th the catalogue—a limited number of works in Xerox copies or photocopies, instead of leaving them out or mentioning them merely as "wanting", which was the way in the days before the Xerox process was introduced (in Soulsby, for example). In this way, a scholar can read and study the contents of a work, even if he cannot get information about the binding, paper quality, and other details. Our acceptance of a work in a Xerox copy or photocopy does not mean that we have less ambition to acquire an original copy of the work.

In the catalogue, we have always given the corresponding number in Soulsby and the page number in Hulth, which has no item numbers. In this way, the reader will locate many Linnaean items, now included for the first time in Linnaean bibliography.

In an appendix, the pupils of Linnaeus are reported, 278 in all. Each of them is provided with a short biography. Thus, the reader can form his own idea of their eligibility or otherwise for the title of "pupil of Linnaeus", an honour even then prestigious and much sought after.

The extensive work which has been done on the index we hope will be appreciated by the readers.

To summarize what I have said, surely it is clear that the book-collector is not in need of defence. He can very often look back on his achievement with satisfaction.

It is also clear that the book-collector contributes to research in many ways. The knowledge and experience acquired enables him to investigate and to solve questions previously unanswered. He recognizes that items previously passed over deserve studies in depth and reports the contributions long buried in them.

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WILHELM ODELBERG

Some landmarks in the history of Linnaeus's Hammarby

What is it that leads us to go on pilgrimages to the places where famous men and women dwelt and worked, or to museums which have been specially established to present the life and achievements of such people through displays of original objects or reproductions? Unquestionably the reason is in some cases to be found in a national cult. Sometimes, people who have played a prominent part in the history of their country have shrines devoted to their memory. In the USA there is e.g. Mount Vernon, George Washington's beautiful home, in Britain Horatio Nelson's flagship the Victory.

In Sweden one may point to Selma Lagerlöf's Mårbacka, the manor house in Värmland which was her parental home and which the famous authoress managed to buy back when her books brought her financial success. She became popular among children in many countries through her Nils Holgersson's Wonderful Journey, a book which has perhaps done more than any other work of fiction to make Sweden known abroad. The latest museum established in Sweden to honour the memory of a single person is August Strindberg's Blue Tower as he called the apartment house in Stockholm in which he spent the final years of his life. A competitor for fame, with Strindberg is Hans Christian Andersen, whose memory is preserved in the H. C. Andersen museum at Odense in Denmark. His *Eventyr* or Fairy Tales have of course long had an acknowledged place in world literature. Andersen's travelling trunk and other relics attract visitors to Odense from all corners of the world.

Norwadays translation is as a rule needed if literature is to make an impact beyond the boundaries of its own country. Music and art can be enjoyed without translation. There are also one-artist museums. To take some examples from this part of the world, in Norway there are in Oslo the Munck museum and—though it is not a museum in the ordinary sense—the park devoted to Vigeland's sculptures. In Sweden the homes in Stockholm of the sculptors Carl Milles and Carl Eldh have become museums devoted to their works. In the world of music, we find in Norway Edvard Grieg's Troldhaugen outside Bergen and in Finland the Sibelius museum at Åbo (Turku).

If art and music are international in their impact, science is still more so. What, then, is the situation regarding memorials to the men and women who have become famous in the domain of science? That local interest is not always a reliable foundation to build upon, is shown by an experience I had some years ago in the Swedish town of Köping. It was there that the 18th-century chemist Carl Wilhelm Scheele spent his last years and it was there that he made his epoch-making discoveries of, among other things, oxygen. I asked whether anything had been done about Scheele's house there. "Why certainly", came the proud answer, "some years ago we pulled it down to make room for our splendid new post office."

Museums devoted to single scientists are comparative rarities. In the rebuilt Old City of Warsaw there is a museum dedicated to the memory of Marie SklodowskaCurie; in Leningrad Dimitri Mendeleyev's laboratory is preserved as a museum; and in London there is the museum opened at the Royal Institution in memory of the chemist Michael Faraday. Some days ago a part of the Swedish Linnaeus Society visited Charles Darwin's home in Kent. The museum in Stockholm devoted to Jacob Berzelius, the grand old man of Swedish chemistry, world famous for his work on chemical formulae and atomic weights, was established as long as eighty years ago. Some of our symposium saw it yesterday.

What, then, has Sweden done to preserve its memories of Linnaeus? The natural regret that Linnaeus's herbarium is not preserved in his own country, is more than balanced by the knowledge that his collections are so well cared for by the Linnean Society and that they provide Swedish researchers with welcome opportunities of visiting London. There is, however, a good deal to be done on our own soil. On 25th January this year there was submitted to the Swedish Parliament a private members' bill bearing the names of representatives of the Conservative, Centre, Liberal and Social Democratic parties. This bill is written in a language which contrasts vividly with the bureaucratic Swedish which from time immemorable members of Parliament have had to put up with. I propose to quote some of the passages in the bill.

"Sweden was for long on the outskirts of civilization. Abroad this cold country was felt to have an exotic interest. Here people had to struggle for survival and they seemed for natural reasons to be marked out by destiny mostly for warlike occupations. Since the Middle Ages Swedish students had gone to the Continent in order to lubricate their mental machinery and in the hope of bringing about a Swedish spiritual re-armament in course of time. It was not until the 18th century that the current turned. Then foreigners came here to acquire knowledge. The light came from Uppsala. The torch-bearer was Linnaeus. Sweden entered a warmer spiritual climate, a new epoch.

It is surprising that the study of nature and living things in the outside world should derive inspiration from events occurring right up in the north of Europe. It sounds paradoxical, but sometimes Linnaeus ran counter to nature's own dictates. Nevertheless he achieved a peaceful victory over nature, climate and cultural backwardness. His compatriots followed him out into the summer meadows. This is the reason for the great pride with which Swedes have nurtured the memory of Linnaeus, and this will be expressed on a broad front this year, when two centuries have passed since the death of the Swede who ranks highest of all in international reputation.

The places where Linnaeus lived and worked have been cared for by the Swedish Linnaeus Society, established in 1917, to the best of its ability having regard to the resources available. Fortunate circumstances have made it possible to preserve a great deal: the Linnaeus Garden and Linnaeus's house in Uppsala and his country retreat at Hammarby still exist, as also do parts of the contents of the two residences: and we have detailed information on what was cultivated in these places. The Swedish Linnaeus Society restored the Garden at Uppsala to its original state in 1920 and did the same for Linnaeus's dwelling house there a few decades later, while Hammarby has been preserved as a cultural memorial since the end of the last century.

These places are unique in their kind in Sweden. The Garden is much more than a display of beautiful flowers. Arranged according to Linnaeus's sexual system, it is a scientific cultural memorial to a way of thought which for a long period dominated in Sweden and the whole of the West. The museum and Hammarby are not only the homes of a celebrated professor but also authentic examples of settings in which people lived and dwelt in 18th-century Sweden. Hammarby with its surroundings represents a Sweden which has a cherished place in our hearts.

But Linnaeus's house, Linnaeus's Garden and Hammarby are not only Swedish memorials. We have not the right to think only of ourselves. We have a responsibility on behalf of the world in general.

It is sad to see what is happening to the Linnaeus memorials we have. The Garden is struggling with steeply rising costs, which the Swedish Linnaeus Society cannot meet for even one year longer. At Hammarby the ravages of decay and rot will be disastrous unless the needed resources for restoration are made available in time. The Society has made representations to the authorities concerned, including the city of Uppsala, the University of Uppsala and the Swedish Government. There have been negotiations. The questions of responsibility are still not entirely settled."

The private members' bill mentioned ended in a request that the Government should as soon as possible allocate funds for the rescuing of Hammarby and to establish a Linnaeus Foundation for the long-term care of everything connected with Linnaeus's memory. Let us hope.

Linnaeus said of himself during his time at Uppsala that he was "neither poor nor rich". He was a cautious man and as a rule handed over the management of the family finances to his wife, whom some have thought to be money-minded to an exaggerated degree. Like other Uppsala professors Linnaeus acquired and farmed a few acres of land outside the city's octroi limits. In December 1758 he wrote to a friend in Stockholm: "Now, my dear friend, I am really down in the dumps. I have always been as much afraid of debt as I am of serpents but now I run the risk of ending up in a debtors' prison. This I had never expected. With my little children in mind I bought a small estate at Uppsala last autumn for only 40 000 daler. It was a bold stroke but I had to put myself in debt for 20 000 daler. The anchor has been raised, I have to sail. It remains to be seen whether I will reach harbour."

It was the two properties of Hammarby and Sävja, situated in the parish of Danmark that Linnaeus had bought. In March of the following year he purchased from the celebrated philologist professor Johan Ihre the farm of Edeby which adjoined Hammarby. He obtained a loan of 40 000 daler from the university.

The purchases of these properties placed Linnaeus into a considerably more precarious economic situation than he had formerly been accustomed to. At this period he frequently suffered from bad health. He had premonitions of death and at times he felt great apprehension about the fate of his wife and children if he should die. As we all know, Linnaeus had nearly twenty years left to enjoy his Hammarby, the home which he loved above all others.

Hammarby's first owner known to us by name lived during the first half of the 14th century. The man from whom Linnaeus bought Hammarby, Anders Schönberg, master of the royal hunt, was a person of note. It was he who arranged King Frederick I's bear and elk hunts. Schönberg seems to have lived in a small one-storeyed wooden house with a superstructure in the middle. This is the present west wing. It suggests that he was a man of simple habits and few pretensions. It was in this building that Linnaeus and his family lived during their first few years at Hammarby. In 1762 the present main building was erected, possibly on foundations which were considerably older. It was a comparatively large two-storeyed house, simply but pleasantly fitted up. The most impressive rooms were the two on the first floor that were used by Linnaeus himself. Here the walls were papered with drawings of plants from exotic parts of the world. On a large erratic boulder behind the main building he arranged for an inscription to be carved in runic characters with the text: "The knight Carl Linné bought Hammarby and Säfia in 1758."

Through the purchase of these homesteads Linnaeus had acquired a convenient and pleasant home where he could live whenever he was not obliged to be in Uppsala. During the 18th century Uppsala was an unhealthy town, frequently revaged by epidemics—dysentery and scurvy, were veritable plagues. In April 1766 fire razed nearly a third of the town to the ground, spurring on Linnaeus in his plans to erect new buildings at Hammarby. Above all he was anxious to have a safe home for his irreplaceable collections. In 1769 the museum building erected on the bedrock in the grounds was ready to house Linnaeus's herbaria, stuffed animals, shells, insects, and minerals and he was always ready to show these to visitors. By present standards this museum building is almost ludicrously small, but to Linnaeus it was a source of pleasure and pride. It was there that he worked during the summer and it was there that he had meetings with his assistants. If the weather was fine, he might move out his famous lecture chair—it still exists—to the courtyard or the lawn. There he sat astride the chair, the desk before him, being piled high with books and notes. His pupils then seated themselves on wooden benches or squatted on the ground.

Under Linnaeus's direction many changes were made in the estate. There had long been a garden at Hammarby but it had become wild and overgrown. Linnaeus put the garden in order and filled it with rare plants. He also arranged a special square surrounded by trees, which his grandchildren called "Grandfather's arbour". Here the table was laid for dinner on fine summer days—here Linnaeus sat and smoke his pipe. The arbour was Linnaeus's favourite spot and he admonished his family to see that the grove was always well cared for after his death. If the trees should die others were to be planted in their place. Below the museum the traces of a stone enclosure can be seen. Here Linnaeus mainly planted specimens that he had been given by Empress Catherine of Russia. Linnaeus gave this plot the name Siberia.

Many foreigners came from far and near to visit Linnaeus and to see his celebrated collections. Among these visitors was the wealthy Frederick Calvert, Lord Baltimore, a member of the celebrated dynasty which provided hereditary proprietors of Maryland until the American Revolution. According to tradition Lord Baltimore came to Hammarby in a huge carriage which he had brought from England. It was so large that all the gateposts on the road had to be removed. Linnaeus asked Lord Baltimore if he intended to stay in Stockholm and seek audience with the King. Baltimore answered that he had come to Sweden to meet Linnaeus. He was *not* concerned to do anything else. He had not even bothered to meet his own King. And then he drove off to return to his own country.

After Linnaeus's death Hammarby was inherited by his widow Sara Moraea, who lived there until she died. Through the daughter of their youngest daughter Sophia, Hammarby passed to the Ridderbjelke family, in whose possession the property remained for three generations. As early as 1844 proposals were made that the nation should purchase Hammarby with its effects in order to protect for all time this monument to Sweden's most renowned scientist. At the time these efforts had no success, but the matter was raised again in 1878, that is to say exactly a hundred years ago. A Committee was set up to report on the matter and in the following year both chambers of the *Riksdag* decided without a division to appropriate an amount of 30 000 kronor in order to purchase the Hammarby property together with its buildings, garden, grounds and effects. It is difficult to say exactly what this sum would represent in terms of the present value of money but nevertheless it can be said that it was a considerable amount that the Government made available. The other Linnaeus properties were bought at the same time by the University of Uppsala.

After the purchase of the Hammarby property various works were carried out, partly for the preservation of the buildings, partly with the aim of restoring as much as possible to the condition in which it was in Linnaeus's time. For this purpose those responsible had access to pictures from earlier times and could be guided by various reliable traditions.

With regard to the plantation the principle was followed that no plant should be allowed unless it could be shown that during Linnaeus's time it was cultivated at Hammarby or in other gardens in Uppland. As they are now, the grounds certainly give a good idea of how the place looked when Linnaeus lived here. The descendants of a number of herbs which he planted form a luxuriant carpet in the grounds, e.g. Aquilegia, Myrrhis, Mercurialis perennis, Tulipa silvestris, Lilium martagon, Epimedium alpinum, Crepis sibirica, Asarum europaeum, Corydalis nobilis, Campanula latifolia, Galanthus nivalis, Leucoium vernum.

Indoors, too, there are many objects which recall Hammarby's famous owner. In the main building the visitor can see furniture, portraits and other objects that at one time belonged to Linnaeus. In the diningroom there stand the original clumsily made dining table and simple yellow painted sideboard. The same clock as in Linnaeus's days marks the passage of the hours. In a room on the first floor is the bed in which Linnaeus is said to have died. Also on view are his big, strange-looking inkpot as well as his walking sticks for weekdays and holy days. Pieces of Chinese porcelain decorated with linnea tendrils are on display. In the 1880's the Linnean Society of London presented to the Royal Swedish Academy of Sciences about 300 works of a non-scientific nature, which had belonged to Linnaeus. In its turn the Academy in 1903 handed over these books to Hammarby to form part of the museum's collections.

As I have already mentioned, the care and preservation of Hammarby throughout the years have presented considerable problems, especially in such a varying climate as prevails in Uppland. It has proved that both books and textiles have suffered considerably. For the time being the collection of books is kept in the University Library at Uppsala and most of the textiles are at present in the care of the Museum of National Antiquities in Stockholm. It is our hope that Linnaeus's Hammarby will one day be a worthy memorial, as it was intended to be from the beginning, both with regard to the interior of the house and the surroundings.

In conclusion, I should like to quote some lines written by Thore

Magnus Fries in his classical and hitherto scarcely surpassed monograph on Linnaeus:

"Hammarby imbues the visitor with emotions of humility and respect. One feels irresistibly that here one is treading on classic soil and it is with a certain surprise that one reflects that it was from this inconspicuous spot in the North that once light was spread over the wide field of nature research, that it was to this place that men in search of knowledge came from all parts of the world to hear from the master's lips words of wisdom, which would give them light and guidance during coming days. Hammarby is a place of pilgrimage for natural scientists. Here scholars with world reputations have been seen to bare their heads humbly, to enter with almost religious respect into the simple dwelling. It is with joy and emotion that one considers what a treasure this is for our cultural history. Precisely because of its unpretentiousness, Linnaeus's Hammarby with its rich memories speaks a language more powerful, more uplifting and challenging than if it were a magnificent palace filled to overflowing with earthly treasures."

CARL LINNAEUS 1778–1978

Bicentenary Symposium: Research on Linnaeus— Progress and Prospects

The Linnean Society of London

Monday, 22 May

Chairman: The President of The Linnean Society of London, Dr P. Humphrey Greenwood.

— *Opening remarks* by the President of The Linnean Society of London and the President of The Swedish Linnaeus Society.

— Professor W. T. Stearn, F.L.S. Linnean Society of London: *Linnaeus, the man and his work.*

— Professor J. L. Larson: *Linnaeus and his nominalist critics.*

— Professor J. L. Heller: *On Linnaean trivial names.*

— Mr A. Wheeler: *The sources of Linnaeus' knowledge of fishes.*

— Dr M. G. Fitton, F.L.S. and M. C. Day, Dept. of Entomology, British Museum (Natural History): *The importance of the Linnaean insect collection.*

— Mr P. W. James, F.L.S. Dept. of Botany, British Museum (Natural History): *The Linnaean Collection of Lichens.*

Tuesday, 23 May

Chairman: The President of The Swedish Linnaeus Society, Professor C.-J. Clemedson.

— Professor P. C. C. Garnham: *Linnaeus' thesis accepted for the M.D. degree of the University of Harderwijk.*

— Professor H. Goerke: *Johann Christian Schreber and the Materia Medica of Linnaeus.*

— Dr C.-O. von Sydow: *Linnaeus and his German colleague J. G. Gmelin.*

— Dr P. Smit: *The zoological dissertations of Linnaeus.*

— Mr J. F. Shillito: *Linnaeus—Zoology in the last years.*

— Dr G. Broberg: *Linnaeus and Genesis.*

— Dr B. Strandell: *Research on Linnaeus today—from a collector's point of view.*

Uppsala University

Friday, 26 May

Opening ceremony in the Linnaean Garden.
Welcome addresses by Professor T. Segerstedt, Rector of Uppsala University, Professor F. Wickman, President of the Royal Swedish Academy of Science, and Professor C.-J. Clemedson, President of the Swedish Linnaeus Society.

Chairman: Professor T. Segerstedt.
— Professor W. T. Stearn: *Linnaeus, the man and his work.*
— Professor Sten Lindroth: *Linnaeus in his European context.*

Chairman: Dr F. H. Perring, Botanical Secretary of the Linnean Society of London.
— Professor K.-G. Hildebrand: *The economic background. Sweden in the 18th Century.*
— Professor G. Eriksson: *The botanical success of Linnaeus. The aspect of organization and publicity.*

Chairman: Professor J.-A. Nannfeldt, Vice President of the Swedish Linnaeus Society.
— Dr B. Strandell: *Linnéforskning av idag—ur en samlares synvinkel.*
— Dr G. Lawrence: *Linnaeus and the computer.*
— Professor J. L. Larson: *An alternative science: Linnaean natural history in Germany, 1770–1790.*

Royal Academy of Sciences, Stockholm

Saturday, 27 May

Chairman: Dr P. Humphrey Greenwood, President of the Linnean Society of London.
— Professor H. Goerke: *Linnaeus' German pupils and their significance.*
— Dr G. Broberg: *Linnaeus and Genesis.*
— Mr A. Wheeler: *The sources of Linnaeus' knowledge of fishes.*
— Dr M. G. Fitton: *The importance of the Linnaean insect collection.*
— Dr P. W. James: *The Linnaean collection of Lichens.*

Chairman: Professor R. Granit, Stockholm.
— Dr C.-O. von Sydow: *Linné och hans tyska kollega J. G. Gmelin.*
— Professor J. F. Heller: *Bibliotheca zoologica Linnaeana.*
— Dr P. Smit: *The zoological dissertations of Linnaeus.*
— Professor P. Sourander, *Linnaeus and neurology.*
— Professor E. Bobrov: *Publications by and on Linnaeus in Russia and the Soviet Union* (not delivered).

Linnaeus' Hammarby (outside Uppsala)

Sunday, 28 May

Spring meeting of the Swedish Linnaeus Society.

Chairman: Professor C.-J. Clemedson, President of the Society. *Address of welcome*. Awarding of medals.

— Dr W. Odelberg: *Some events in the history of Linnaeus' Hammarby*.

— Dr A. J. Boerman: *Linnaeus and the scientific relations between Holland and Sweden*.

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