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Trees of history in systematics and philology

Abstract – «The Natural System» is the name given to the underlying arrangement present in the diversity of life. Unlike a classification, which is made up of classes and members, a system or arrangement is an integrated whole made up of connected parts. In the pre-evolutionary period a variety of forms were proposed for the Natural System, including maps, circles, stars, and abstract multidimensional objects. The trees sketched by Darwin in the 1830s should probably be considered the first genuine evolutionary diagrams of the Natural System – the first genuine evolutionary trees. Darwin refined his image of the Natural System in the well-known evolutionary tree published in the *Origin of Species,* where he also carefully distinguished between arrangements and classifications. Following the publication of the *Origin,* there was a great burst of evolutionary tree building, but interest in trees declined substantially after 1900, only to be revived in recent years with the development of cladistic analysis.

While evolutionary trees are modern diagrams of the Natural System, they are at the same time instances of another broad class of diagrams that may be called «trees of history»: branching diagrams of genealogical descent and change. During the same years that Darwin was sketching his first evolutionary trees, the earliest examples of two other trees of history also appeared: the first trees of language evolution and of manuscript genealogy. Though these were apparently independent of evolutionary trees in their origin, the similarities among all these trees of history, and among the historical processes that underlie them, were soon recognized. Darwin compared biological evolution and language evolution several times in the *Origin of Species,* and both Ernst Haeckel and the linguist August Schleicher made similar comparisons. Both linguists and stemmaticists (students of manuscript descent) understood the principle of apomorphy – the principle that only shared innovations provide evidence of common ancestry – more clearly than did systematists, and if there had been more cross-fertilization among these fields the cladistic revolution in systematics might well have taken place in the nineteenth century.

Although historical linguists and stemmaticists have in some respects had sounder theory than have systematists, at least until recently, they have also had the practical problem of very large amounts of data, a problem not often faced by systematists until the advent of molecular sequencing. The opportunity now exists for systematists to contribute to the theory and practice of linguistics and stemmatics, their sister disciplines in historical reconstruction, through application of our commonly used computer programs for tree estimation. Preliminary results from the application of numerical cladistic analysis to a large stemmatic data set have been very encouraging, and have already generated much discussion in the stemmatics community.

Introduction

In a series of influential papers beginning in the 1960s, Michael Ghiselin challenged a view common among philosophers of science that species, the basic unit of systematics, are best thought of ontologically as natural classes (Ghiselin, 1966, 1974, 1984, 1987). Rather than seeing species as classes of organisms, Ghiselin argued that they should in fact be regarded as complex, historical individuals: singular things which have particular spatial and temporal distributions, and which have individual organisms as their *parts* rather than as their members. Although this view of the ontological status of species was initially rejected by many philosophers, it has since come to be widely accepted (Hull, 1975, 1978; O'Hara, 1988b).

Although Ghiselin was primarily concerned with the ontological status of species in these papers, it was implicit in his position that higher taxa must also be individuals in a certain sense (Ghiselin 1984: 85), individuals made up of species which are their parts, just as any whole human body is made up of individual organs. In this paper I have two aims. The first aim, following Griffiths (1974), de Queiroz (1988), and my own earlier work (1993), is to develop the notion that higher taxa are ontological individuals or *systems,* as Ghiselin had implied, and to demonstrate that reflective systematists have long regarded them as such. My second aim is to show that evolutionary trees, our modern representations of the single Natural System, are also examples of another class of historical representations which may be called «trees of history». As such they can be profitably studied, from both theoretical and practical perspectives, in conjuntion with other trees of history such as genealogical diagrams of language evolution and of manuscript descent. By putting evolutionary trees in the context of other trees of history we will be better able to see the many similarities that tie together the entire range of the historical sciences.

Higher taxa as systems rather than classes

The ontological status of higher taxa has attracted some attention in the recent systematic literature, and Ghiselin's distinction between classes and individuals is often expressed in this literature as a distinction between *classifications* on the one hand, and *systems* or *arrangements* on the other (Griffiths, 1974; Ax, 1987; de Queiroz, 1988; Minelli, 1993; O'Hara, 1993). A classification is a collection of classes each of which contains elements or members. The only important relationship among the elements of a classification is the relationship of inclusion: class A may contain class B, or it may be contained within class B, or it may be independent of class B entirely. In contrast to a classification, a system is an integrated, connected whole that is not made up of classes, but is instead made up connected parts. In a system there are many more relationships among the parts than simple inclusion. There are, for example, positional relationships: parts are not simply components of larger parts, they may also be to the left or right, to the north or south, earlier or later, above or below other parts within the system.

We can understand the distinction between classifications and systems more clearly if we contrast a map (as a system) with a geographical classification. It would be possible to construct a classification of places in Europe, with «Europe» as the largest class, including Italy, France, Germany, Spain, England, Ireland, and so on. Included under the heading «Italy» in this classification would be Milan, Rome, Bologna, Venice, and Naples; under the heading «England» would be London, Cambridge, Liverpool, Oxford, and Sussex; and so on. But if this classification of places is all we know of geography, then we do not know a great deal. We do not know whether Rome is north or south or east or west of Milan; we do not know whether Oxford is north or south or east or west of London. This is because the classification expresses only relationships of *inclusion*. We may contrast a geographical classification of this sort with a geographical map, which is an integrated whole: a system. A map of Europe will communicate not only relationships of *inclusion* – that Milan and Rome are both within Italy – but also *positional* relationships in geographical space: Milan is north of Rome, and Oxford is west of London.

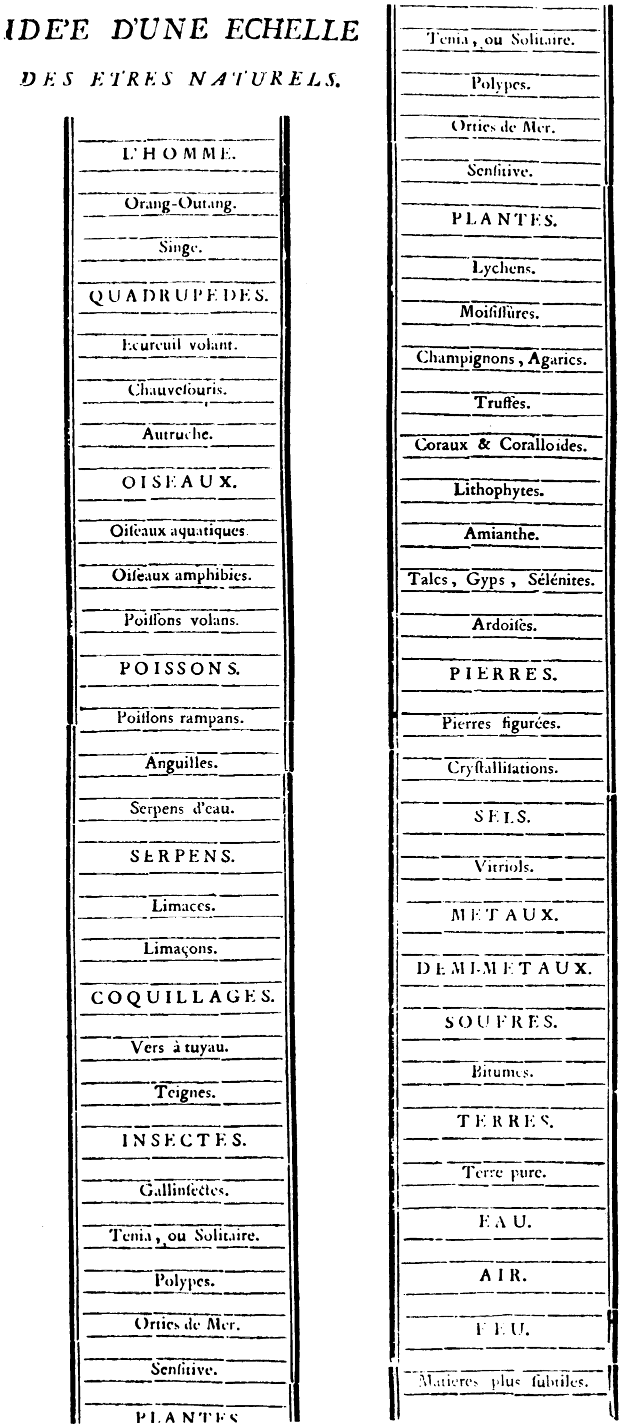

Fig. 1 - The Scala Naturae or Chain of Being, from Bonnet (1745). Bonnet's original figure is a single folding column. This Chain of Being cannot be reduced to a classification without loss of information, because it represents a system of relationships more complex than simple inclusion.

The distinction between classifications and systems or map-like arrangements is important because classification, as a distinct intellectual activity, has been overemphasized by many writers on systematics and its history. Many systematists of the past, especially the reflective ones, did not see themselves as constructing classifications, but rather as reconstructing a large particular object they called the Natural System (O'Hara, 1993), and for these workers the Natural System was a rich and multi-faceted idea, far more complex than any classification could possibly be. Consider, for example, one of the earliest images of the Natural System: the image of the Scala Naturae or Chain of Being (Lovejoy, 1936). Figure 1 shows an eighteenth-century representation of the Chain of Being, drawn by the entomologist Charles Bonnet in 1745. The information conveyed in this systematic arrangement cannot be reduced to a simple classification without loss of information, because the arrangement depicts not only relationships of inclusion but also positional relationships along the chain: «Oiseaux» does indeed contain many taxa which are not enumerated, but in addition Oiseaux is *above* Poissons and *below* Quadrupedes.

As the diversity of life became better known in the late eighteenth and early nineteenth centuries, systematists came to realize that the Chain of Being was an inadequate representation of the Natural System, and a great variety of more complex representations were developed and put forward (Stevens, 1982, 1984; Barsanti, 1988; O'Hara, 1988a, 1991). The quinarian school of systematists led by William Sharpe Macleay (1819-21) and William Swainson (1836-37), for example, argued that the Natural System is held together by interlocking relationships of affinity and analogy, and that these relationships displayed numerical regularity. Arguing against the quinarians, Hugh Strickland (1841) and Alfred Russel Wallace (1856) represented the Natural System as an irregular map-like entity (Fig. 2) held together by affinities only, affinities that in Strickland's view could sometimes be circular or loop-like.

With the acceptance of the principle of common descent, the notion of the Natural System was converted from a system of ideal affinities to one of physical genealogy (Darwin, 1859: 485). Almost as soon as he became convinced of the truth of the theory of descent, Darwin began to sketch evolutionary trees in his notebooks (Darwin, 1987: 177-180), and the only diagram in the *Origin of Species* itself is Dar-

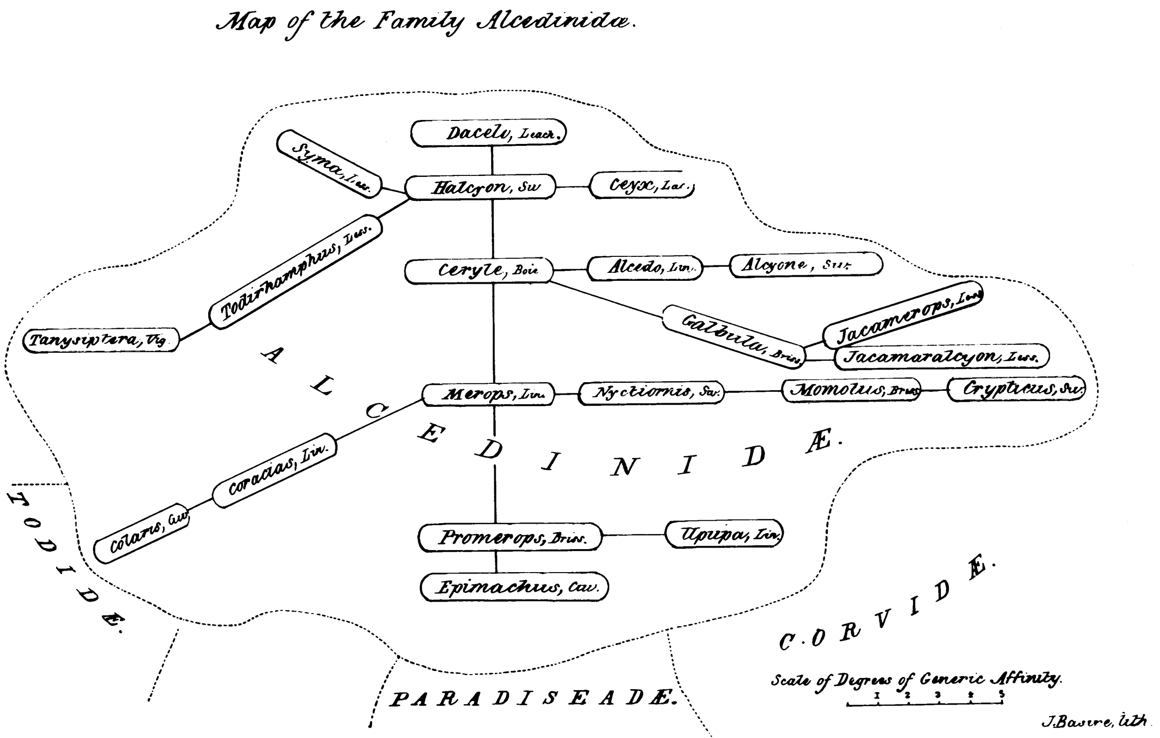

Fig. 2 - «Map of the Family Alcedinidae», from Strickland (1841). Relationships of affinity connect each genus, and a «Scale of Degrees of Generic Affinity» appears in the lower right corner. Although none are shown here, Strickland believed it was possible for chains of affinity to double back on themselves, forming a loop.

win's well-known representation of an evolutionary tree. Very soon after the publication of the *Origin,* evolutionary trees began to appear in the general systematic literature, and their history between 1859 and 1900 is very complex. The elaborate phylogenies of Ernst Haeckel are among the best known (Oppenheimer, 1987), but many other authors drew trees also (Figs. 3 and 4) and there was much discussion of the methods of phylogenetic reconstruction (Reif, 1983; Stevens, 1984; O'Hara, 1988a, 1991; Craw, 1992; Darwin, 1993: 379-380). It became clear to some systematists at this time, for example, that only shared innovations could count as evidence of common ancestry, and that shared retentions (today called ancestral character states or plesiomorphies) were

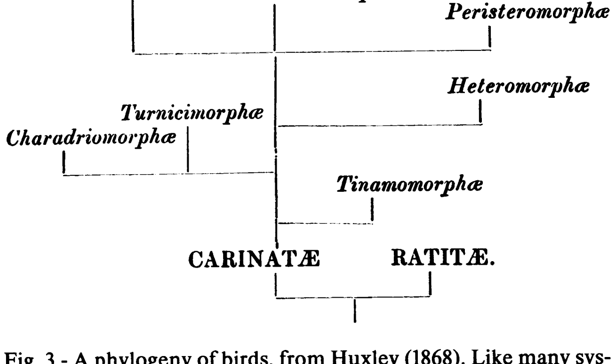

Fig. 3 - A phylogeny of birds, from Huxley (1868). Like many systematists of his time, Huxley published tree diagrams but did not explain in detail the procedure he followed in constructing them.

phylogenetically uninformative (Mitchell, 1901; O'Hara, 1988a; Craw, 1992).

Around 1900, however, interest in phylogenetic reconstruction began to flag, and as «biologists focused ever more intently on problems of organic function they transferred their allegiance from the ideal of historical explanation, the critical support for all who had studied organic form and transformation, to the promise extended by the experimental investigation of vital processes» (Coleman, 1977: 160). This shift in interest was not universal (Craw, 1992), but it was widespread (Allen, 1975; Zuckerman, 1976; Coleman, 1977; O'Hara, 1988a, 1991). Historical approaches were denigrated as «speculative» (T. H. Morgan in Mayr, 1982: 542) for much of the century, and it was not until the widespread acceptance of cladistic analysis, beginning in the 1970s, that phylogenetic reconstruction attained prominence again.

Trees of history

Let us now consider evolutionary trees in their other intellectual context, as examples not only of diagrams of the Natural System, but also as «trees of history». During the very decades when Lamarck was offering his first speculations on the transformation of species and Lyell was laying the foundations of modern historical geology, scholars in the field of comparative philology were sketching the outlines of a new historical science of language and literature. Although the development of philology in the late 1700s and early 1800s was complex (Pederson, 1931; Aarsleff, 1967; Burrow, 1967), modern-day linguistic historians often point to a statement made by the

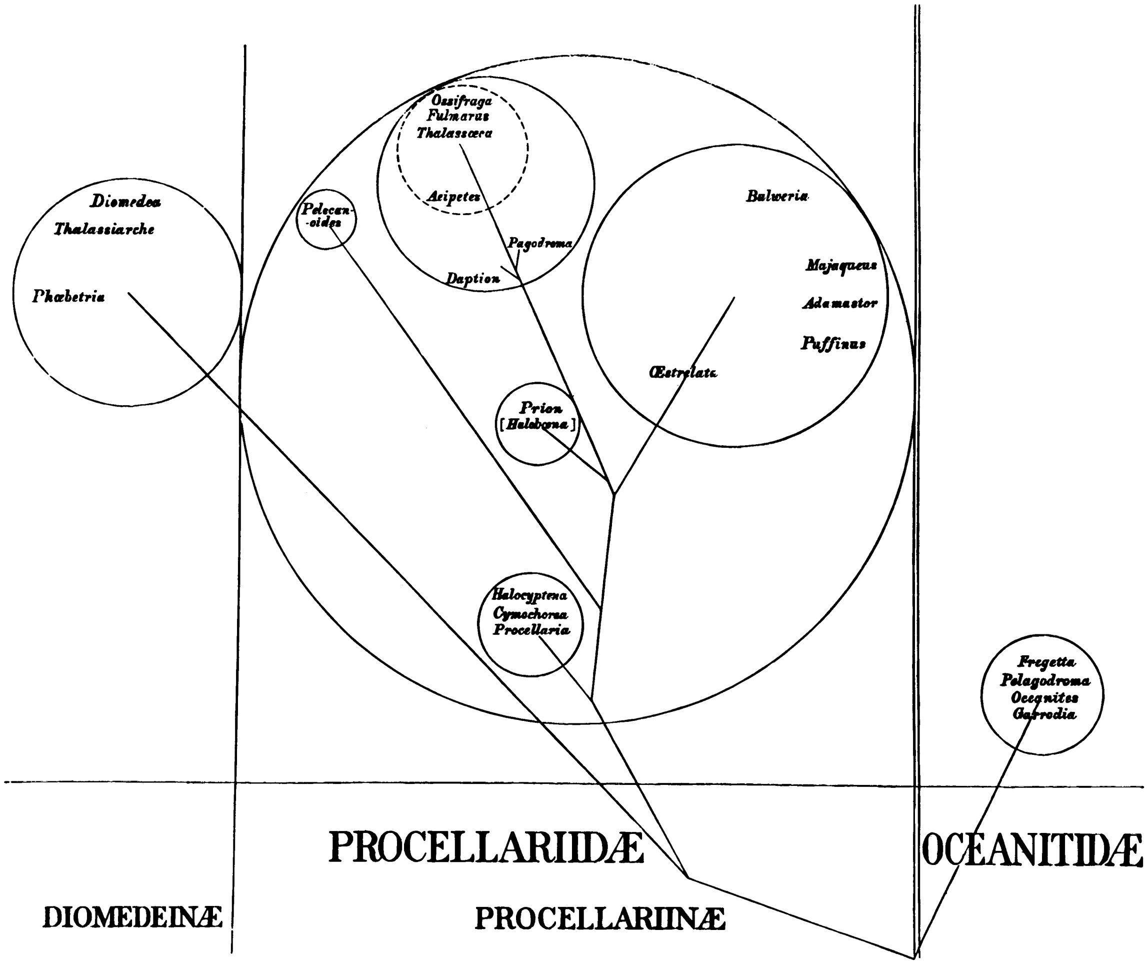

Fig. 4 - The evolution of the tubinarial birds, from Forbes (1882). The meaning of the circles and the positions of the genera are not explained in Forbes's text.

English jurist Sir William Jones as the traditional starting point of their discipline. Jones was one of the first Europeans to learn Sanskrit, the classical language of India, and he noticed a number of striking similarities between Sanskrit on the one hand, and Greek and Latin on the other. He concluded that these similarities were much too remarkable to have arisen by chance, and that no philologist could examine all three languages – Latin, Greek, and Sanskrit – «without believing them to have sprung from some common source, which, perhaps, no longer exists» (Jones, 1786). The historical study of this family of languages, which came to be called Indo-European and which stretches from Ireland to India, continued at great speed in the early 1800s. The first genuine tree diagram of the history of Indo-European (and of any family of languages) was apparently published around 1800 (Auroux, 1990), but linguistic trees of history didn't really become widespread until the 1850s, even though the concept of historical families of languages had been clear for some time by then. František Čelakovský, a professor of philology at Prague, published a genealogical diagram of the Slavic languages in 1850 (Fig. 5; Priestly, 1975), but it was the German philologist August Schleicher – who had spent time in Prague and may been influenced there by Čelakovský (Holm, 1972) – who finally popularized the use of tree diagrams in historical linguistics through his widely-read publications (Hoenigswald, 1975; Stewart, 1976; Koerner, 1982, 1987; Priestly, 1985).

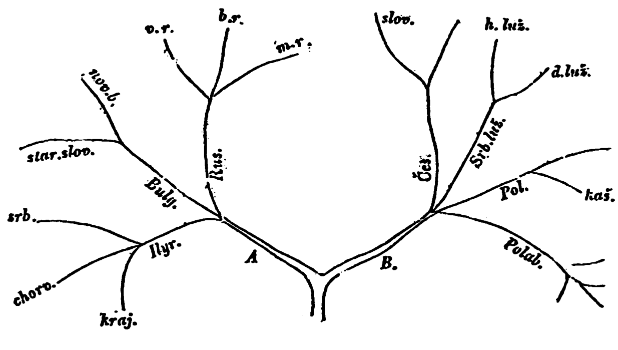

Fig. 5 - A family tree of the Slavic languages by František Čelakovský, published posthumously in 1853. Čelakovský's work may well have influenced August Schleicher, whose own genealogical diagrams have often been regarded as the first trees of language evolution (Priestly, 1985).

The historical study of languages was only one of the tasks of comparative philologists, however; the other was the study of the history of written texts. Most works of ancient literature do not exist today in copies written by the authors themselves – rather, they are known from copies of the originals, and copies of those copies, often made over a period of hundreds of years and with varying degrees of care. Philologists who specialize in the study of texts are faced with a very specific problem: given ten or twenty or a hundred copies of the same text, all of which differ at different points, how can we determine the exact words of the lost original? The answer is that we can determine the original of the text by reconstructing the tree – or as manuscript scholars call it, the *stemma* – of the copies that now exist. The idea of an ancestral text represented today only by its varying descendants had been clear to manuscript scholars for a long time, but as was the case in systematics and linguistics, the first actual illustrations of manuscript stemmata do not appear until the early 1800s. The first published stemma appears to have been that of Carl Johan Schlyter (Holm, 1972), and it appears in 1827, fully formed like Athena from the head of Zeus. Schlyter and his collaborator Hans Collin had been commissioned by the King of Sweden to research the history of medieval Swedish law, and they made an exceptionally comprehensive study of all the medieval legal documents then known. Many of these documents were multiple copies of original texts that had been lost, and in one such case, in order to «make the relationship all the clearer between the codexes now described», wrote Schlyter, «containing in whole or in part the text of the Västergötland Law..., we have attempted to present their affinities, as far as we could determine them from mutual agreements and differences, in a kind of family-tree» (Fig. 6; Collin & Schlyter, 1827, translated by Holm, 1972: 51-52). Very shortly after Schlyter's tree was published, a series of other manuscript stemmata appeared in rapid succession. Carl Zumpt published a genealogy of the known copies of Cicero's *Verrine Orations* in 1831, and Zumpt's stemma was followed by stemmata drawn by Friedrich Ritschl in 1832, and by J. N. Madvig in 1833. Holm (1972) has reproduced all of these along with several other early stemmata.

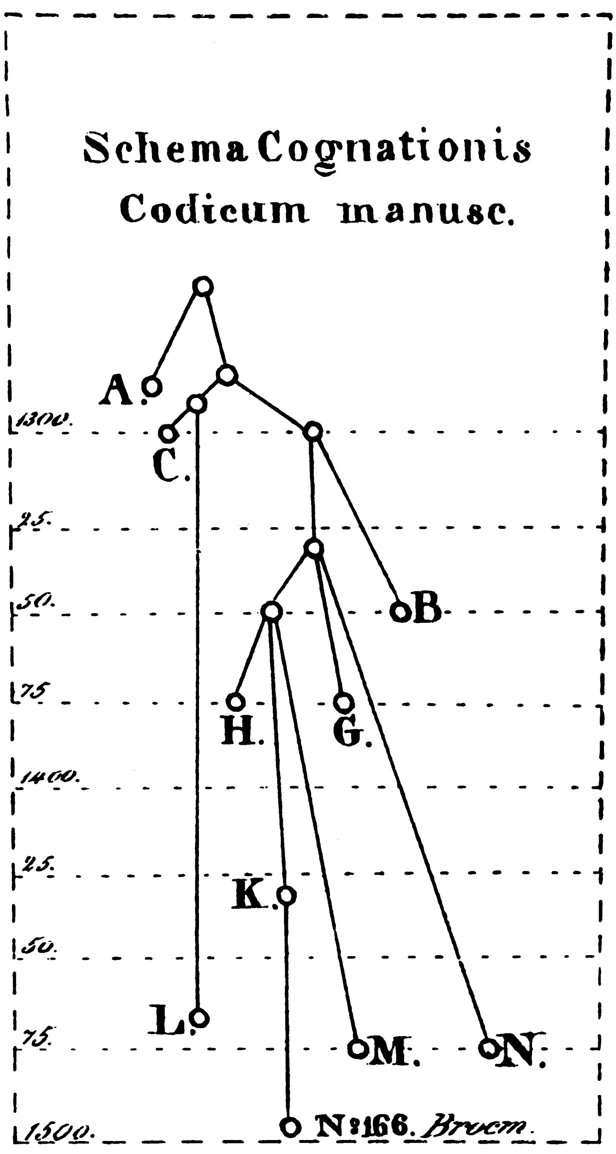

Fig. 6 - A stemma of several copies of the Västgöta Law, drawn by Carl Johan Schlyter (Collin & Schlyter, 1827). The vertical axis represents absolute time, the interval between each dotted line being fifty years. The similarity of this diagram to Darwin's evolutionary tree in the *Origin of Species* is striking, but apparently coincidental.

As we saw in the case of systematics, after the publication of the *Origin of Species* there was a great burst of tree-making, and much discussion of phylogenetic theory. This same period – the late 1800s – was similarly a golden age of historical philology. Linguistic and textual scholars did an extraordinary amount of work reconstructing the details of the evolutionary history of the Indo-European languages during these years (Pederson, 1931; Morpurgo Davies, 1975; Hoenigswald, 1990), and establishing the original texts of Classical and Medieval authors through the reconstruction of manuscript stemmata (Timpanaro, 1981; Reynolds, 1983). It did not escape notice at the time that the goals of the new natural historians and the goals of the new historical philologists were similar in many respects (Hoenigswald & Wiener, 1987; Hoenigswald, 1990). August Schleicher, for example, published on *Die Darwinsche Theorie und die Sprachwissenschaft* (Schleicher, 1863), and his work caught the attention of Ernst Haeckel as well (Maher, 1966; Koerner, 1981, 1983). And like the systematists, the philologists interested in tree reconstruction quickly recognized that only shared innovations could be used as evidence of common ancestry (Hoenigswald, 1990).

In another remarkable parallel to systematics, however, interest in many of these large-scale problems of historical philology began to wane around the turn of the twentieth century. Many manuscript scholars came to believe that horizontal transmission of readings between manuscripts – called «contamination» in stemmatics – was so widespread that any hope of reconstructing true stemmata was in vain. And linguists began to distinguish between what they called diachronic or historical studies of language on the one hand, synchronic or structural studies of language on the other, and began to regard synchronic, structural linguistics as the most «scientific» approach to their field. Much of linguistics since 1900 has been profoundly ahistorical, almost completely turning its back on the achievements of the nineteenth century (Haas, 1966; Anttila, 1989).

But systematics has re-historicized itself in the last thirty years, and there is reason to hope that the same thing may happen in linguistics and textual studies as well, and it may happen with some cross-disciplinary help from systematics. Some valuable interdisciplinary forays have been made in recent years (Hoenigswald & Wiener, 1987; Flight, 1988; Lee, 1989) and these hold much promise. A collaboration I began in 1991 with a textual scholar who is interested in the application of computers to stemmatics has also generated much interest, and our application of cladistic analysis to the history of manuscript traditions has met with considerable success (Fig. 7; Robinson & O'Hara, 1992, in press; O'Hara & Robinson, 1993).

Conclusion

One of the first scholars to study the interrelationships of the historical sciences was the polymathic British philosopher William Whewell, who was born just two hundred years ago, in 1794. Whewell coined the term «palaetiology» for these sciences, and offered geology, philology, and archeology as examples. Had Whewell become an evolutionist he surely would have included the historical science of systematics in the group as well. The palaetiological sciences, Whewell realized, cut across many conventional disciplinary boundaries, including even the boundary between science and the humanities. And yet all of these sciences «are connected by this bond; – that they all endeavour to ascend to a past state, by considering what is the present state of things, and what are the causes of change» (1847: 638). The reconstruction of trees of history is one of the common themes of the palaetiological sciences, but they share many other themes as well, such as the principle of uniformitarianism, which has been applied not only in geology but also in linguistics (Johnes, 1843; Christy, 1983; Naumann, et al., 1992). Whewell's term «palaetiology» never attained the currency he had hoped it would during his lifetime, but in our own day, as the ahistorical tenor of the mid-twentieth century recedes into the past, the term may be due for a revival. Not since the nineteenth century have Whewell's insights rung so true:

As we may look back towards the first condition of our planet, we may in like manner turn our thoughts towards the first condition of the solar system, and try whether we can discern any traces of an order of things antecedent to that which is now established; and if we find, as some great mathematicians have conceived, indications of an earlier state in which the planets were not yet gathered into their present forms, we have, in pursuit of this train of research, a palaetiological portion of Astronomy. Again, as we may inquire how languages, and how man, have been diffused over the earth's surface from place to place, we may make the like inquiry with regard to the races of plants and animals, founding our inferences upon the existing geographical distribution of the animal and vegetable kingdoms: and thus the Geography of Plants and of Animals also becomes a portion of Palaetiology. Again, as we can in some measure trace the progress of Arts from nation to nation and from age to age, we can also pursue a similar investigation with respect to the progress of Mythology, of Poetry, of Government, of Law... It is not an arbitrary and useless proceeding to construct such a Class of sciences. For wide and various as their subjects are, it will be found that they have all certain principles, maxims, and rules of procedure in common; and thus may reflect light upon each other by being treated together (Whewell, 1847: 639-640).

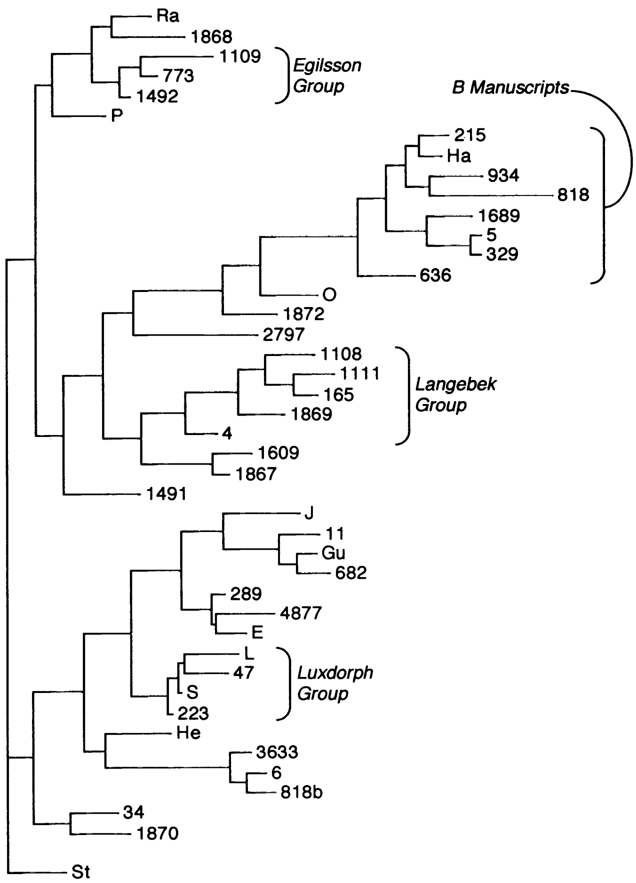

Fig. 7 - A stemma of the Old Norse narrative *Svipdagsmál*, from Robinson & O'Hara (1993, in press). This stemma was produced with the cladistic analysis software PAUP (Swofford, 1991), and it is very similar to the stemma produced by Robinson alone using traditional non-cladistic means (Robinson, 1991). This tree was generated much more quickly, however, thereby allowing the textual scholar more time for critical study and analysis of the result.

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