ARBOR Ciencia, Pensamiento y Cultura
Vol. 189-763, septiembre-octubre 2013, a072 | ISSN-L: 0210-1963
doi: http://dx.doi.org/10.3989/arbor.2013.763n5009

LAS MUSAS DE DARWIN TRAS EL DIAGRAMA DE 1859

DARWIN'S MUSES BEHIND HIS 1859 DIAGRAM

Erica Torrens y Ana Barahona
Grupo de Estudios Sociales de la Ciencia, Facultad de Ciencias,
Universidad Nacional Autónoma de México
torrens@ciencias.unam.mx

Citation/Cómo citar este artículo: Torrens, E. y Barahona, A. (2013). "Darwin's muses behind his 1859 diagram". *Arbor*, 189 (763): a072. doi: http://dx.doi.org/10.3989/arbor.2013.763n5009

Recibido: 30 abril 2013. Aceptado: 29 julio 2013.

RESUMEN: En este artículo queremos mostrar mediante una revisión de algunos diagramas en forma de árbol, que el hecho de que Darwin escogiera la metáfora de un árbol para representar relaciones evolutivas entre los organismos no resulta enteramente sorpresivo, ya que la figura arbórea ya guardaba una posición importante en la tradición iconográfica europea. En la revisión de algunos usos del "árbol" para representar diferentes clases de relaciones en la época pre-darwiniana, queremos ilustrar dos cuestiones fundamentales. Una particularmente importante es que Darwin tuvo la brillantez de incorporar una variedad de símbolos y metáforas que ya estaban siendo usadas para representar diferentes aspectos del mundo vivo, en su propia teoría de la evolución, particularmente la metáfora general de la ramificación y re-ramificación. La otra es que cuando Darwin publicó *El Origen de las especies* en 1859, la gente ya estaba familiarizada con el tema del "árbol" para representar genealogías. Esto pudo haber sido importante para sentirse familiarizado con los diagramas evolutivos y para aceptarlos como entidades reales, también para asociarlos fuertemente con metáforas religiosas.

PALABRAS CLAVE: Árbol evolutivo; El árbol de la vida; Evolución; Darwin; Genealogía.

ABSTRACT: This article uses a review of a number of tree diagrams to highlight how the fact that Darwin was to choose the metaphor of a tree to describe evolutionary relationships between organisms should come as no great surprise, as the tree already occupied an important position in European iconography. In the review of some of the uses of a "tree" to represent different types of relationships in the pre-Darwinian age, we want to illustrate two basic issues. One particularly important issue is that Darwin had the insight of including various symbols and metaphors that were already being used to represent different aspects of the living world in his own theory of evolution, particularly the general metaphor of branching and rebranching. The other is that when Darwin published *On the Origin of Species* in 1859, people were already familiar with the idea of a tree to represent genealogy. This may have been an important factor in people's familiarity with evolutionary diagrams and also in strongly associating them with religious metaphors.

KEYWORDS: Evolutionary tree; The tree of life; Evolution; Darwin; Genealogy.

"Genealogy is the history of the symbolic, iconographic and rhetorical practices, the systems for recording and the techniques of culture through and in which the knowledge of families, races and species or of the succession of life within time is handed down." (Weigel, 2007, 1).

INTRODUCTION: TREES BEFORE *ON THE ORIGIN OF SPECIES*

Soon after his return from the voyage on the H.M.S. Beagle, Darwin was struck by the fact that a continuous evolutionary process is taking place in nature. Although the idea that all living beings are nature's productions and that the resulting biodiversity of the Earth has been produced over eons due to an inherent and indefinite mutability of species had been around before him, and many people already believed in some sort of transformation occurring in the organic world, at his return from travelling around the world he saw clearly that this was the case. He wondered about the driving force behind this transformation, about the nature of the entities that evolve and about the nature and speed of the changes. He came up with a plausible mechanism rather soon. After reading Thomas Malthus' essay in 1838, among other influential authors, he started developing the idea of Natural Selection and for many years he worked hard to gather large quantities of evidence to support his argument. Albeit in *On the Origin of Species* (1859) he explains the action of divergence by means of natural selection and states that "The accompanying diagram will aid us in understanding this rather perplexing subject" (Darwin, 1859, 116), he had made use of the image of a tree as soon as 1837 to materialize his ideas on species descent from a common ancestor.

The fact that Darwin chose the metaphor of a tree to represent evolutionary relationships between organisms is not entirely surprising since that figure holds an important position in European iconographic tradition.

A review of the pre-Darwinian use of 'trees', illustrates two fundamental notions. In the one hand, Darwin had the brilliance to incorporate a variety of symbols and metaphors already at use to represent different aspects of the living world, into his own theory of evolution. One particularly important was the general metaphor of branching and rebranching that had appeal to some before him to represent the order of species.

On the other hand, by the time Darwin published the *Origin* in 1859 people was familiar with the motif of a 'tree' to represent genealogy. Once the 'tree' turned into an icon of evolution in late nineteenth century, the representations of evolutionary trees for popular audiences normally included images to represent the groups of organisms depicted just like in religious and some other family-descent diagrams. This may have been important for people to feel a familiarity with evolutionary diagrams and to embrace them as real entities, but also to associate them strongly with religious metaphors higher vs. lower, good vs. bad, moral vs. reprehensible or complex vs. simpler, which interfered with purely evolutionary interpretations (see for example Gould, 1997).

THE TREE AS A SYMBOL OF MYSTICAL THOUGHT

The family tree is one of the oldest relationship diagrams. During the Middle Ages it was a powerful symbol for Jewish mystical thought; it had its roots in a mythical Biblical scene: the Fall of Man. The Old Testament mentions two trees, the tree of knowledge and the tree of life, the tree of knowledge was a medieval device used to "visualize the hierarchy of learning" (Hellström, 2012) and to depict logical divisions. The tree of knowledge is also considered to be the first 'family tree' not because it represented origin and descent *per se* but because having tasted the forbidden fruit involved the beginning of the origin of kinship relationships by starting the propagation of human kind (Weigel, 2007) (Fig. 1).

Figure 1. Medieval Scene, Berthold Furtmeyer: *Baum des Todes und des Lebens*, 1481 (depiction of both trees in a single one) (Cook, 1974, 44)

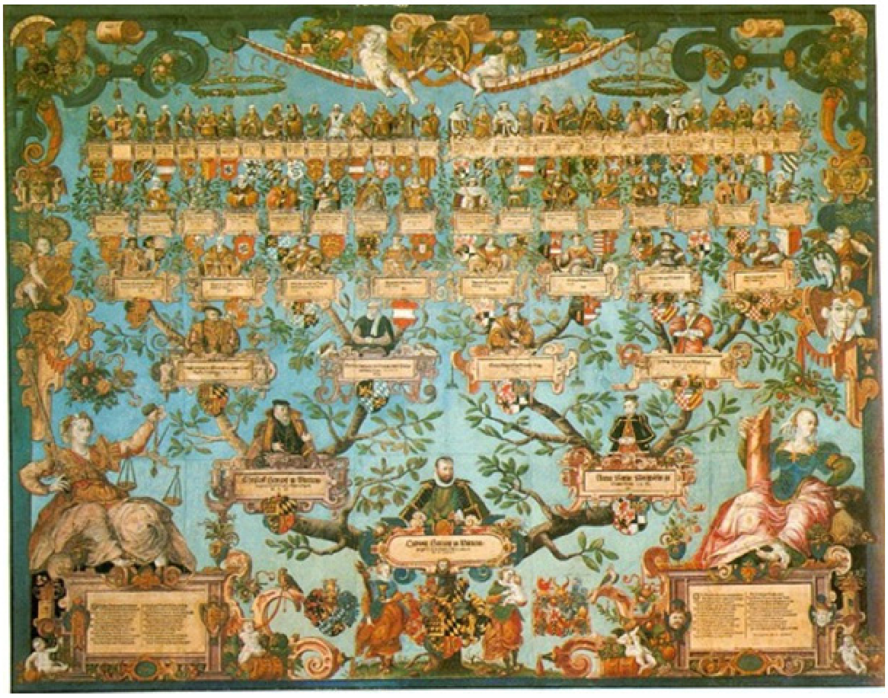
ARBOR Vol. 189-763, septiembre-octubre 2013, a072. ISSN-L: 0210-1963 doi: http://dx.doi.org/10.3989/arbor.2013.763n5009

The first western tree laid the groundwork for subsequent representations of origin and descent diagrams. From the ninth century the image of a tree in Christendom continued to be used to illustrate Jesus' descent and also other components of the Bible's sacred genealogy.

Even though Jesus' tree is quite different in meaning and purpose from subsequent trees, which is reflected in the fact that is Jesus himself often the 'tree', during the Middle Ages, it adopted several variants. Genealogical or family trees, dynastic or genealogical tables, pedigrees, scales and other soon appeared when the coexistence of genealogical tales such as epic poems emerged (Fig. 2).

However, the tree was also used to represent philosophical deduction systems and knowledge about different types of relationships (the medieval *arbores* which sprouted from the biblical Tree of Knowledge and that were hierarchical tables of the classical tradition, typically descending schemas of circles joined by lines (Hellström, 2011)). One of the favorite medieval diagrams was the *arbor porphyrianna* or Porphyry's Tree[1]. This image completely resembles a tree in the botanical sense. It has roots, a trunk, and six twigs on either side adorned by different sorts of leaves. It was used to represent the logical 'dichotomous division' proposed by Plato and inherited by Aristotle (Fig. 3).

Figure 2. Family tree of Herzog Ludwig I of Württemberg (1568-1593)



This diagram was widely used by the Scholastics for educational purposes to illustrate the logical division or dieresis of the supreme genus 'substance', which is indicated by a crown (Papavero, Llorente, and Bueno, 1994). Two more examples of medieval *arbores* are Ramon Llull's *Tree of Science* (1295-1296) and Paoplus Pergulensis's Tree of 1486 (Fig. 4).

PRE-DARWINIAN TREES OF SPECIES

It was not until the early nineteenth century when the representation of relationships between organisms as branched systems, even as trees albeit without an evolutionary meaning, except for Lamarck, emerged. One example is Augustin Augier who, in 1801, illustrated the relationship between the plants by means of a rich *Arbre botanique* (see Stevens, 1983) (Fig. 5). This is possibly the first representation of the natural system with this image. His tree was the result of an unsuccessful battle to fit plants into a single series:

> "I worked for a long time trying to fit families into a continuous series but I found great difficulty… finally I solved it by separating the branches in two and was successful at least at joining them at their bases. At that point I became convinced that plants form different series united at the base, a gradation as that of tree branches" (Augier, 1801, vi).

Figure 3. Porphyry's Tree (Baldwin, 1911, p. 714)

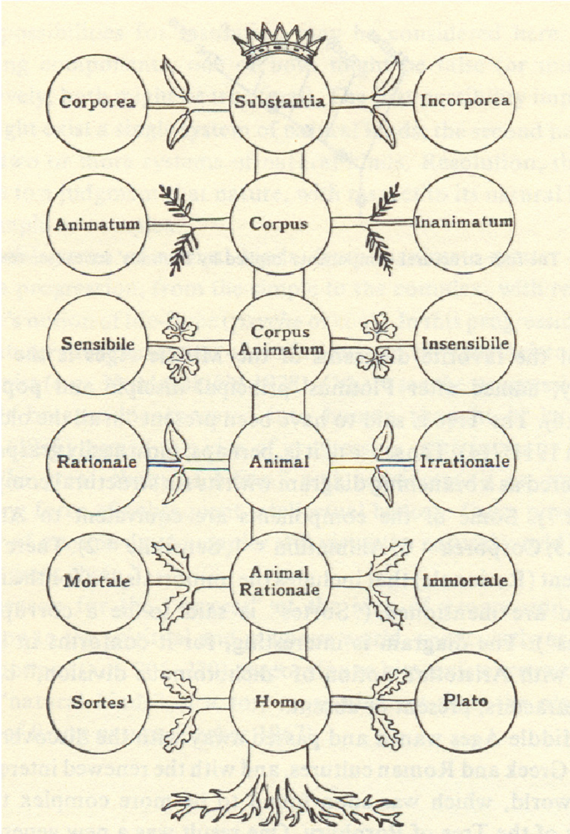
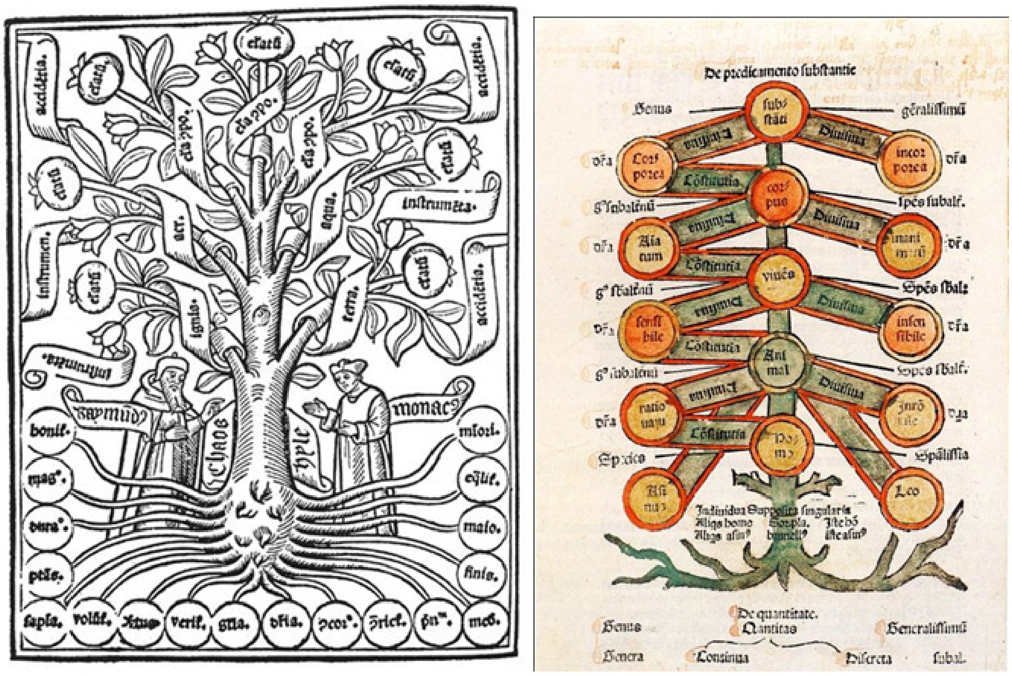


Figure 4. Left: "*Arbor scientiae*" (Tree of Science), Ramon Llull, 1295-1296. Right: Paoplus Pergulensis, 1486



He later notes:

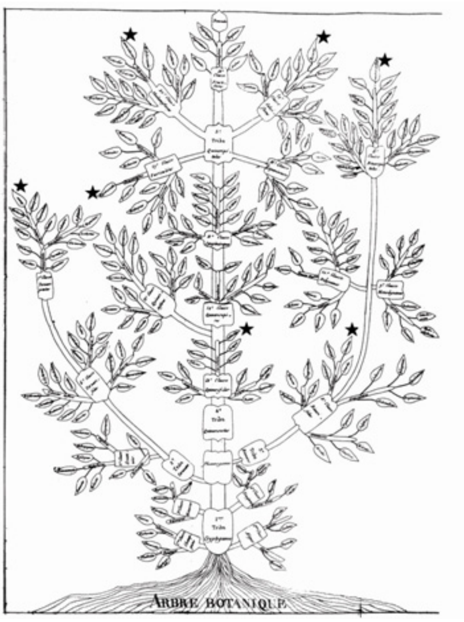
> "A shape such as a family tree seems to be the most appropriate to understand the order and gradation of the series of branches that form classes or families. This shape, which I call 'arbre botanique', shows the arrangements between different series of plants, although they are not joined to the trunk; [unlike] a family tree that shows the order by which the different branches of the same family stem from the trunk to which they owe their origin" (Augier, 1801, 2).

With this description it is understandable that, although Augier's creativity opened new horizons by proposing a tree to represent relationships between plants and dismissing the natural scale's linear notion, he never considered the possibility that his image represented lines of origin and descent and, therefore, the evolution of the organic world as family trees did. His tree still represents a continuous progression of forms committed with the notion of the Great Chain of Being[2]. The most imperfect such as mosses and fungi at the bottom and the most perfect at the top.

Augier also considered that the same representation could be achieved for the other two of nature's kingdoms (animals and minerals):

> "The order that I established among plants is also found in the three natural kingdoms and I think that it is a favorable precedent for it to be considered as natural. The three kingdoms form main series that start with the less perfect beings and culminate with the most perfect… Zoophytes join these three kingdoms; mammals are united to fish by whales and birds to quadrupeds by bats, etcetera" (Augier, 1801, viii).

Figure 5. Augustin Augier 1802 *Arbre Botanique*. Harvard University Herbaria (Stevens, 1983)

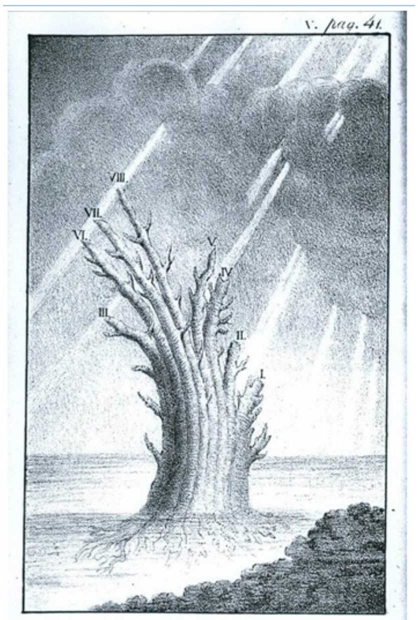


Another noteworthy example of the use of the tree metaphor is found in Peter Simon Pallas, who in 1766 proposed that the best representation for the gradation seen in animals would be a tree, although he never illustrated his ideas:

> "… The whole system of organic beings may well be represented by its resemblance to a tree, its roots immediately dividing into the most simple animals and plants, which remain adjacent as they move along the trunk. Animals and Vegetables; those at the head starting from Mollusca and moving toward Fish, with large side branches of Insects, there to Amphibians; Quadrupeds are found at the upper end of the tree, Birds truly grow to one side as a large lateral branch below Quadrupeds. At the same time this image shows that animals are neither continuous nor adjacent, but they stand as a lone tree. Its trunk is formed by the series of major genres which are adjacent and closely together; everywhere, genres grow like branches, though they never connect by lateral relations" (Pallas, 1776, 23-24).

However, some argue that Carl Edward von Eichwald's 1829 diagram is an interpretation of this description (Mikulinskii, 1972) (Fig. 6).

Figure 6. *Pre-evolutionary tree*, (Eichwald, 1829). As in the description by Pallas, the branches representing the main groups of animals are contiguous but independent of each other. This is a creationist tree since the branches arise 'independent' from the base to represent a separate origin for each lineage.



doi: http://dx.doi.org/10.3989/arbor.2013.763n5009

TREES IN PHILOLOGY

Trees were not only used by naturalists who experimented with new representations of the natural system. Another practice that used this pictorial metaphor as from the nineteenth century was philology. This practice originated with Sir William Jones's conclusion in 1786 that similarities between Sanskrit, Greek and Latin were too striking to believe that they were a coincidence. Therefore, "no philologist can examine these three languages without thinking that they emerged from a single source that may no longer exist" (Jones, 1786, 415-431).

However, although philology studied the common origin of Indo-European languages Sanskrit, Greek and Latin since the last decades of the eighteenth century, their genealogical representation in the form of trees became popular until the 1850s through the work of August Sleicher (1821-1868). The following two figures are an example of the use of family trees to represent the origin and relationships of languages at that time (Figs. 7 and 8).

Figure 7. Slavic languages family tree, Frantisek Celakovský, 1853 (O´Hara, 1996, 81-88)

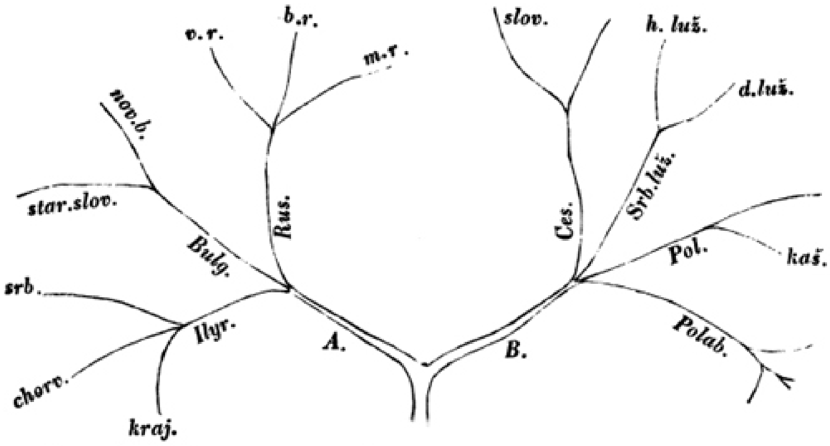
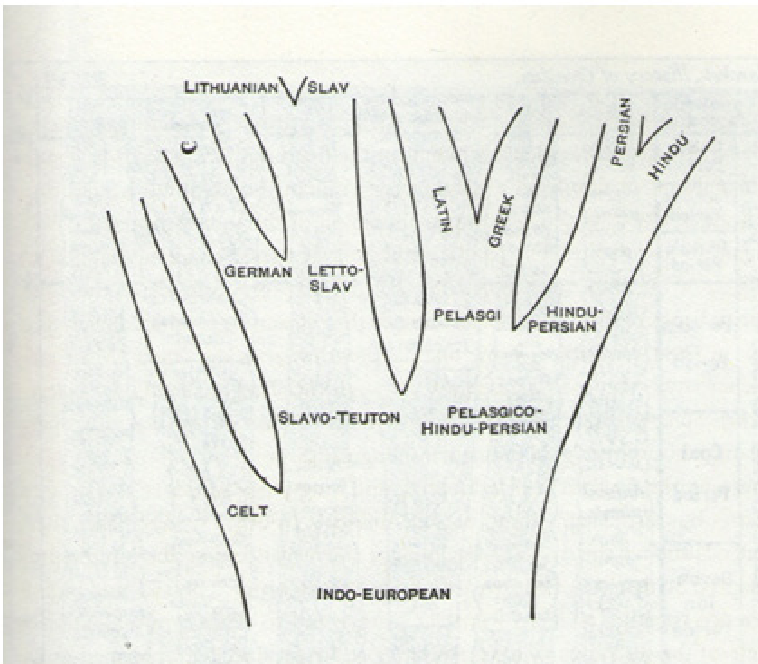


Figure 8. Linguistic genealogy, Schleicher, 1853 (Alter, 1999)



Sleicher was a linguist from the Arts Faculty at Jena University in Germany who became a very good friend and a fundamental influence to Ernst Haeckel, the German champion of evolutionism. Although his arboreal representations of the genealogy of various languages prior to the publication of the *Origin* might have influenced Darwin's own thoughts on commonality of descent, his profound impact on Darwin's Theory came a bit afterwards.

According to Richards (2008), Haeckel had convinced Sleicher to read Heinrich Bronn's translation of Darwin's *Origin* and soon after reading it he became aware that his own discipline could make the perfect complement to Darwinian Theory by giving concrete evidence to it. Sleicher wrote *Die Darwinsche Theorie und die Sprachwissenschaft* (Darwinian Theory and the science of language, 1863). There, he "proposed that languages provided the missing evidence to render the idea of historical transmutation a reality. Languages, he maintained, were natural, historical phenomena; and modern languages, it was perfectly obvious, had descended from early languages –linguistic fossils existed to demonstrate this descent. Hence we had ample evidence in language of the kind of evolutionary transitions that Darwin's theory could only project but not prove" (Richards, 2008, 125).

The above idea had a fundamental impact on human evolution theories of Haeckel, who has the credit of being one of the main, if not the chief popularizer of the theory of evolution and the evolutionary tree of the 19th century.

EMBRYOS AND BRANCHES

Branched or tree-shaped depictions are hierarchical by their very nature, since buds stem from branches, which stem from the trunk. Likewise, the most useful and concise classifications are also hierarchical. Thus, starting from the late eighteenth century, other types of branched diagrams emerged from the field of embryology, seeking to clarify the organization (and classification) of the organic world.

Because the subject of embryology and recapitulists metaphors that appeared in Germany mainly during the eighteenth and nineteenth centuries has been addressed extensively by various scholars (for example Gould, 1985; Richards, 1992). Following, the authors present in a succinct manner, some pictorial contributions of embryology, which probably influenced Darwin.

Among anatomists of late eighteenth century, mainly Germans, there was a widespread notion that embryos reflected a sequence of miniature adults of lower species, generally known as 'evolution' although some authors use it differently or with semantic equivalents, *i.e*. In English, *theory of development* was used as a synonym of *theory of evolution*. However, not all embryologists were in favor of this idea. Estonian embryologist Karl Ernst von Baer was opposed to that principle. Although he maintained that the classification of organisms could be achieved according to the characteristics of their embryonic development, Von Baer differed of the rest by stating that the principle governing the organization of organisms was their shape. For him, animal life manifested four key layouts of organic parts or archetypes, which were also evident in the early stages of embryonic development. This meant that all organisms started the same way from a general structure given by the archetype and acquired their distinctive traits as they developed.

This idea was introduced to Britain by Scots physician Martin Barry who, in 1837, wrote a report titled: *On the unity of structure in the animal kingdom* for the *Edinburgh New Philosophical Journal.* In this report, Barry explains the four Von Baer archetypes and the way to obtain a classification of animals based on their embryonic development. To achieve this, he used a series of novel branched diagrams whose branches stem from the same origin the most general archetype to diverge subsequently as organisms differentiate (Fig. 9). Barry called one of these diagrams the 'Tree of animal development' (Fig. 10).

The root of this 'tree of animal development', marked with the number 1, represents the archetype, which is morphologically similar in all animals. Vertebrates and invertebrates branch from that point of origin. "Barry diagrammatically sketches, without labels, the three main stems of the invertebrates, each coming directly off the germ; and his more elaborate depiction of three types of vertebrates also included elliptical representations of the branching of reptiles and birds. In the ascent of the branches, the nodes represented the more generalized classes, orders, families, and a genus, with the branch ends the more particularized species, varieties and individual characters" (Richards, 1992, 129).

These diagrams were published shortly before Darwin began writing in his notebook B (Voss, 2010, 93). Although there is no evidence that he was inspired by Barry to draw his branched diagram, he may have

Figure 9. One of Barry's diagrams in his 1837 essay: *On the unity of structure in the animal kingdom*. The diagram shows the single point of origin based on an archetypal shape (A) and the subsequent divergence in the structure of each group of organisms: B, fish; C, reptiles; D, birds and E, mammalians.

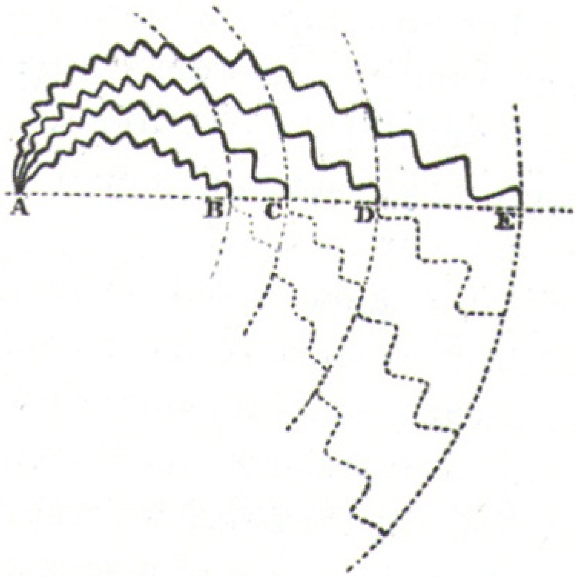
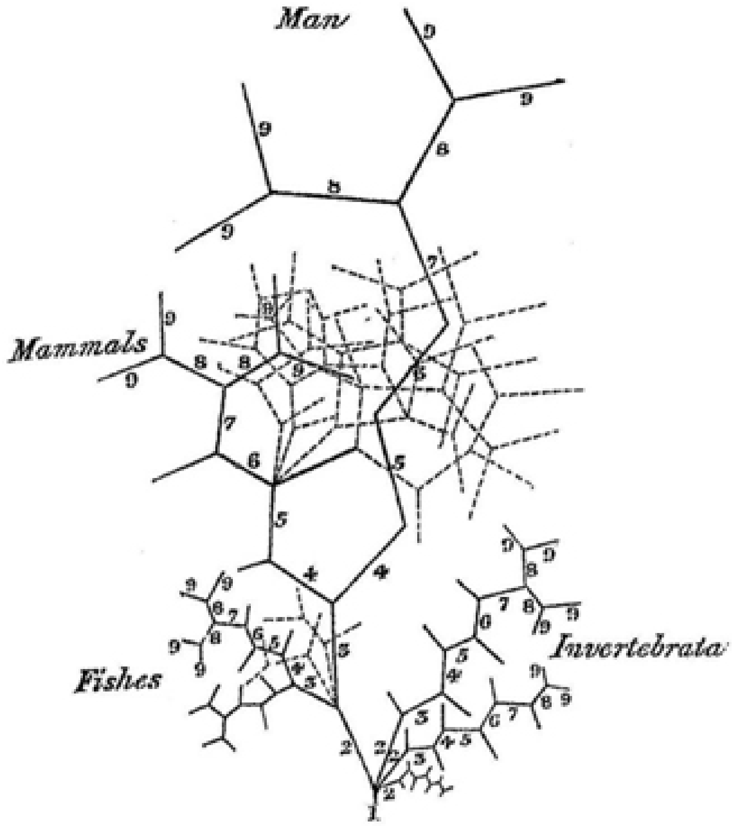


Figure 10. Martin Barry's 1837 'Tree of animal development', which shows Von Baer's conception of the four organization archetypes in the animal kingdom. All organisms start from the same point of origin and differentiate in structure as they advance in their embryonic development.



ARBOR Vol. 189-763, septiembre-octubre 2013, a072. ISSN-L: 0210-1963

doi: http://dx.doi.org/10.3989/arbor.2013.763n5009

looked at the ‘tree of animal development’ through the screen of his own ideas since both diagrams look remarkably alike. Both diagrams even feature a number 1 which means a simple monad at the root.

Shortly after the public appearance of Barry‘s diagrams, other branched diagrams inspired on them began to emerge. Although each author removed or added ideas to the original plot, all retained the single point of origin from which a main vertical branch symbolizing embryonic development shared by different groups of organisms arises and branches out at different points representing the divergence in structure of the different groups of organisms. Examples include the diagrams of William Carpenter, 1841 and Robert Chambers, 1844 (see Secord, 2000; Voss, 2010, 97-98).

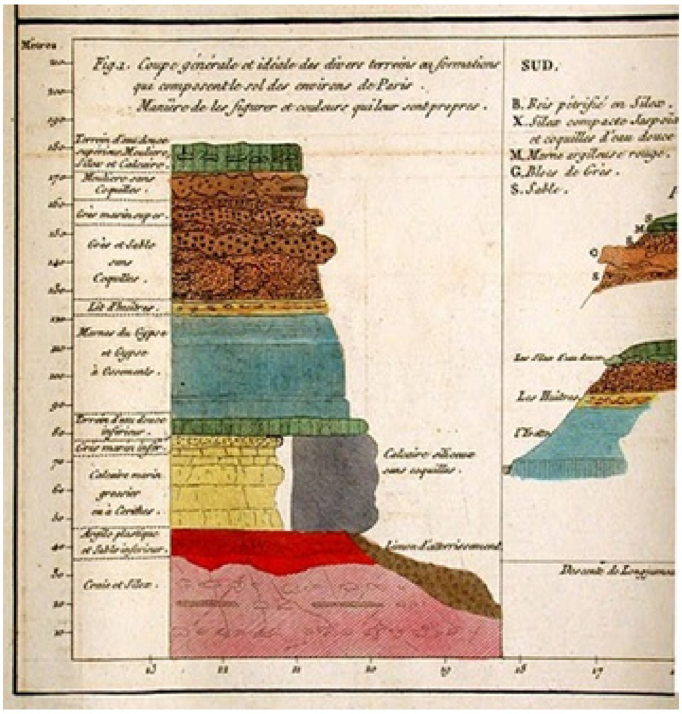
It can be said then that embryology contributed significantly to the already rich tradition of visual representation of organism classification, and revealed the need to consider different attributes of living beings in the pursuit of ‘natural order’.

STRATA AND FOSSILS: GEOLOGICAL DIAGRAMS

The first representations of the history of organisms originated from Geology (Voss, 2010, 102). From animal and plant fossils embedded in layers of rock, naturalists began to recreate, with increasing detail, the past history of our planet. In the early nineteenth century Cuvier established the phenomenon of extinction of living beings not only because he was among the first to recognize that some species ceased to exist, but also for giving an explanation based on natural causes and the fact that the deeper geological strata are the oldest. This meant that the current era had been preceded by other ages in which animals and plants different from the present had dominated Earth. The most different beings were those located in the oldest deposits and, although Cuvier never gave a specific age for our planet, he mentioned ‘thousands of centuries’ to refer to the Montmartre fossils (Young, 2007, 73).

As much the same time, William Smith in England and Alexandre Brongniart in France showed that every geological formation contained distinctive fossil species, through which the correct sequence of strata could be established. These ideas were captured by naturalists in depictions of rock cuts which enabled them to visualize the vast geological time and its corresponding space (indicated by different colors), together with the succession of flora and fauna (Fig. 11).

Figure 11. Stratigraphic profile; Cuvier and Brogniart, «*Essai inéralogique sur les environs de Paris*», 1808



doi: http://dx.doi.org/10.3989/arbor.2013.763n5009

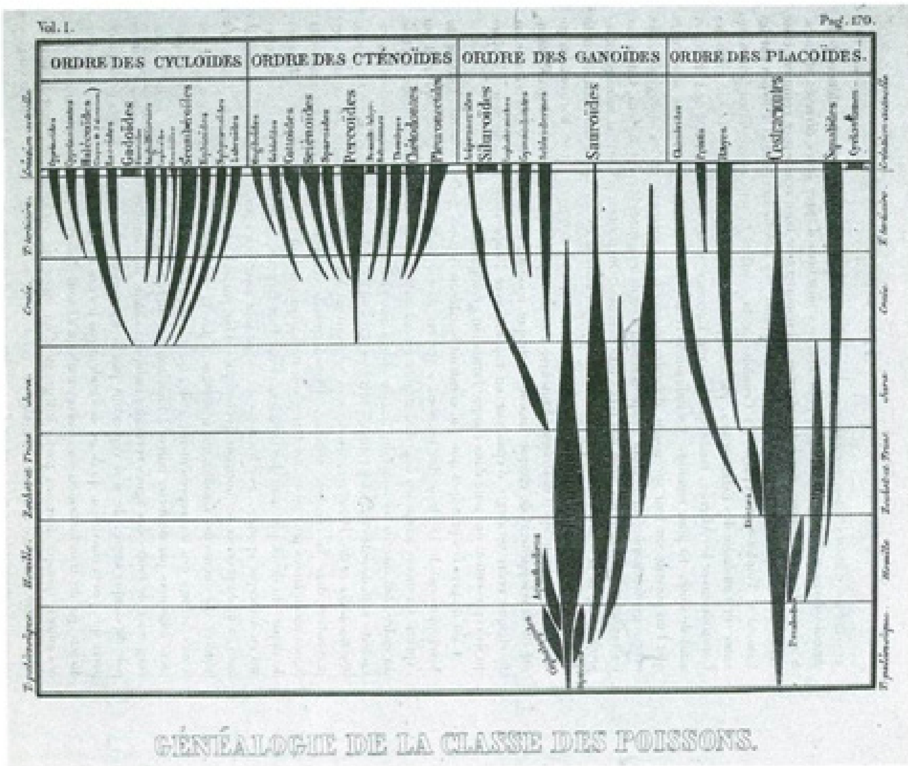
These 'geological maps' gave rise to the modern field of stratigraphy: a visual representation of Earth's past, with its unique way of symbolizing time, geological formations and inhabitants of every age (See Rudwick, 1972; 1985; 1992; 1997; 2004).

An interesting conclusion, derived from efforts to define the sequence of geological formations, emerged during the first half of the nineteenth century. By 1840, many formations called 'systems' such as the Cambrian, Silurian, Devonian and Carboniferous had already been designated, with their distinctive fossils that allowed to trace the history of life on Earth to its origin. In other words, the general 'map' of the fossil record was being built.

For naturalists, this knowledge established that the history of animal life involved a sequence of changes. Permian fossils showed that the 'Age of Mammals' had been preceded by an 'Age of Reptiles', which in turn had been preceded by an 'Age of Fishes' as made evident by the Devonian System. Before fish, Earth had blossomed with invertebrates during the Cambrian period and, prior to that, nothing; rocks showed nothing else. The important question then was to establish the meaning of those sharp transitions.

Louis Agassiz, Swiss naturalist and later founder of the Museum of Comparative Zoology at Harvard University, offered an explanation to this matter for which he built a pair of diagrams. Though of a creationist nature, these diagrams were later reprocessed in the light the theory of evolution. For Agassiz, it was clear that the apparent sequence of animal life on our planet was the result of a Creation Plan whose purpose was the progressive fitting of the Earth for the eventual appearance of human beings. His specialty as an ichthyologist led him to develop in 1833 the first record of the history of fish called *Génealogie de la classe des posissons* present in his work *Recherches sur les poissons fossiles*. According to Voss (2010, 104), following the geological visual practices emerging at that time, Agassiz placed the time scale on the vertical axis with the earliest time at the bottom. The novelty of this diagram however, is that, using shapes in the form of leaves, Agassiz included information on the relative abundance of each group, their point of origin and duration (Fig. 12).

Figure 12. Diagram; Agassiz, *Recherches sur les poissons fossiles*, 1833. Geological time periods that enable the establishment of the origin of fish groups are marked on the left. Agassiz displays the duration and relative abundance of each group using the thickness of lines that rise and either stop growing or reach the present time.



Although this appears to be an evolutionary diagram, no ‘leaf’ arises from another; they are separated to indicate the different moments of ‘Creation’ of each lineage. However, the way Agassiz managed to represent certain aspects of the history of organisms in such a significant way, eventually provoked that this diagram could easily be reinterpreted in light of the theory of evolution. It was just needed to assume that species in a geological period had originated the species of the next period in a line of descent. Today we can find similar diagrams in museums, books on evolution and textbooks (Fig. 13).

It is important to stress, that Agassiz was one of the great nineteenth century naturalists that defended creationism and polygenism (the idea that human varieties are of different lineages and indeed different species) in America. Thus, his diagrams are a fundamental rhetorical device for his theories, which in due time were antagonistic to Darwin’s. For example, the tableau that accompanies Agassiz opening sketch on “The provinces of the animal world and their relationship to the types of man” from Dr. Josiah C. Nott and George Gliddon’s “Types of Mankind” (1854) shows the idea that different human races are unrelated and that the different biogeographical faunas each had their own species of primordially created man placed “by the will of the Creator” (page 1 Xxvi) (Fig. 14).

Figure 13. Left: Evolutionary tree at the American Museum of Natural History, displaying the appearance and disappearance of species, as well as their relative abundance. Right. Portrayal of the evolutionary history of some lineages, at the Universum science museum in Mexico City.

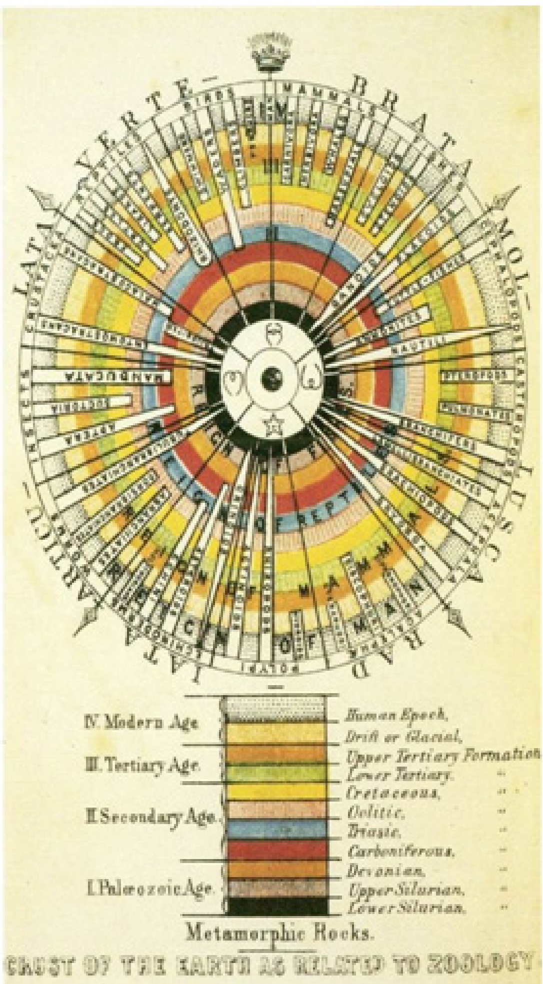
Figure 14. Tableau that accompanies Agassiz opening sketch on “The provinces of the animal world and their relationship to the types of man” from Dr. Josiah C. Nott and George Gliddon’s “Types of Mankind” (1854)

Although in *On the Origin of Species* Darwin never addressed the issue of human evolution, it was easy to detach the implications of his theory in the human realm. Its plot involved a branched commonality of descent to all plant and animal species, including human beings, so that all human races would have evolved from a common stock. Agassizs later disagreed with Darwin's views that all men were descended from the same ancestors and wrote an answer to this idea in his 1886 "Against the Transmutation Theory" from Methods of Study in Natural History, which begins with his restatement of his opposition to Darwin's work, materialism in general, and to the Darwinian theories that had already, he writes, become generally accepted[3].

Returning to Agassiz' geological diagrams, the second important diagram for our discussion was developed in 1848 as a frontispiece for his work *Principles of Zoology*. It once again shows the creative power of this character. A circle, the center of which represents the center of the Earth and the beginning of life history, is surrounded by another circle with symbols for the four *embranchements* of Cuvier's division of animals. From this circle, the different groups of animals begin to emerge in separate acts of creation, this time deliberately further apart than in the previous diagram to leave no doubt of his belief in the Divine Plan of the origin of animals (Fig. 15).

"Darwin had already taken the mental step required to turn Agassiz's fish classes into a theory of evolution in the form of a drawing" (Voss, 2010, 108). In 1850 he drew a sketch similar to Agassiz's frontispiece, including the geological scale but taking the points of origin to the center and connecting each of the groups to a single line of descent, specifying at the top of the diagram that "points mean [the appearance of] new forms" (see Voss, 2010, 109). This illustration remained a secret within Darwin's notes.

Figure 15. Back cover of Agassiz's 1848 *Principles of Zoology*



ARBOR Vol. 189-763, septiembre-octubre 2013, a072. ISSN-L: 0210-1963 doi: http://dx.doi.org/10.3989/arbor.2013.763n5009

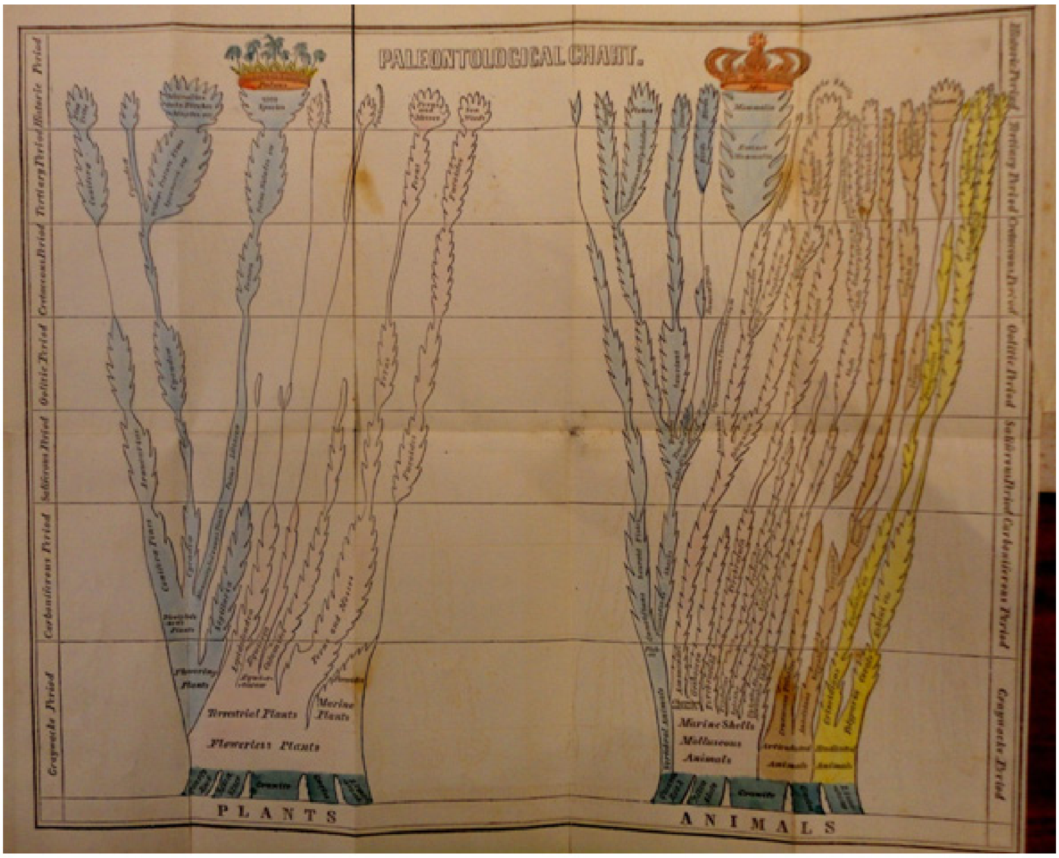
Later, in 1865, Tremaux also found this unusual notion of a circular tree to be useful. In this, as in Agassiz's groups, branches are projected outwards to all directions from a central point which represented the '*cellule primordiale'* (see Gould, 1997).

Another unusual diagram of paleontology is that of Edward Hitchcock, who in 1840 published the first edition of his book *Elementary Geology* with the following drawing as a frontispiece (Fig. 16).

This is one of the first attempts to illustrate paleontological knowledge using a tree diagram[4]. With it, Hitchcock intended to prove "the commencement, development, ramification and in some cases the extinction of the most important tribes (of Animals and Plants)" (Hitchock, 1840, 100). As on Agassiz's diagram, Hitchcock showed the relative abundance of different families by means of the thickness of branches and extinctions by branches that have stopped growing. And although it seems to be an evolutionary diagram because all branches arise from a single root, Hitchcock used different colors to show that branches were independent of each other, representing a separate origin for each lineage. He completed his zoological series "with MAN at their head, as the CROWN of the whole" (Hitchock, 1840, 100).

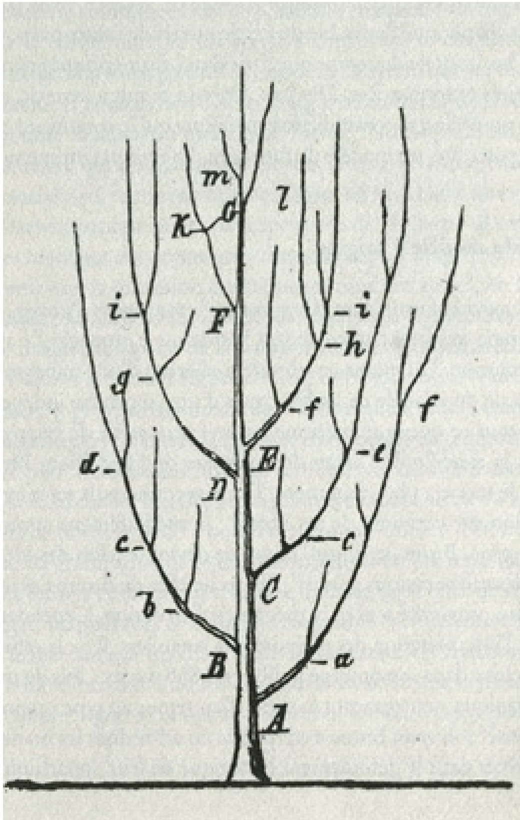
The last image we will mention in this review appeared just a year prior to the publication of *On the Origin of Species.* In 1858 the German geologist and paleontologist Heinrich Georg Bronn published a prize-winning essay about the history of life. He concluded as most of his contemporaries that the present condition of the natural world was due to gradual and progressive changes. These progressive changes were easily seen in the fossil record, where lower strata were dominated by invertebrates, followed in upper strata by fish, reptiles and lastly by mammals. Bronn explained that these changes in the zoological composition of the fossil record evidenced to main trends in the history of life: an increasing complexity of life forms and a continuous adaptation of organisms to their environments. These two trends produced a tree-like diagram of the history of life (fig. 17).

Figure 16. Edward Hitchcock's tree-shaped paleontological diagram, in the frontispiece of *Elementary Geology*, 1840



ARBOR Vol. 189-763, septiembre-octubre 2013, a072. ISSN-L: 0210-1963
doi: http://dx.doi.org/10.3989/arbor.2013.763n5009

Figure 17. Heinrich Georg Bronn's tree-like diagram published in *Untersuchungen über die Entwickelungs-Gesetze der organischen Welt* in 1858



Bronn depicted the principal and larger groups of animals invertebrates, fish, reptiles, birds, mammals and man by branches labeled A-G which sprang from a main stem. Distinct species of each group are represented by lowercase letters and the overall arrangement was made according to the particular representational mode of paleontology: organisms lower on the tree were found at deeper strata in paleontological deposits. However, even though it seems an evolutionary tree, for lack of evidence Bronn dismissed the idea of one species changing gradually into another.

CONCLUSIONS

As the previous, rather brief, sample of tree-like and branched diagrams shows, the use of the motif of a tree whether literal or metaphorical was a widespread practice in Europe since the early decades of the first millennium. The motif of a tree has been recurrent in diverse fields of human life. It can be found in mythology, genealogy, religion and science. "It takes its authority from repetition and conflation; metaphorical trees have appeared in similar but ever changing manifestations since antiquity" (Hellström, 2011, 10).

Thus, during the preparation of his figures to represent common ancestry and divergence, Darwin was deeply immersed in a "visual dimension of the scientific traditions he had inherited" (Donald, 2009, 3), which had already used a wide variety of representations for relations between organisms (to know more about the imagery around the problem of natural classification and the search for the Natural System see for example Nelson & Platnick, 1981; O'Hara, 1988, 1991; Barsanti, 1992; Papavero & Llorente, 1993-2004, Stevens, 1994, Ragan, 2009; Rieppel, 2010; Pietsch, 2012). Each of these representations involved theories about the organic world's order and a different symbology. In constructing a tool to visualize the process of evolution, Darwin borrowed some elements of this rich symbology to achieve the projection of species in time and to join them through genealogical relationships by means of a branching diagram. As a result, his sketch on Notebook B would become the famous and only image present in *On the*

ARBOR Vol. 189-763, septiembre-octubre 2013, a072. ISSN-L: 0210-1963

doi: http://dx.doi.org/10.3989/arbor.2013.763n5009

Origin of Species, published in 1859*;* which represents a new way of using the highly popular metaphor of branching and rebraching. Before Darwin, the representation of relationships between organisms through branching diagrams was inextricably linked to the notion of the Great Chain of Being or to the notion of a special creation, because no matter how complicated the diagram looked side branches were mere tangents of a trunk, a trunk that rises through a hierarchy of shapes, from the less to the most perfect. Even in Lamarck, the transformation of organisms involved an 'ascent' from monad to human.

That is a reason why Darwin's diagram is so important and retains its status as one of biology's most powerful pictorial symbols. Yet, by naming his evolutionary metaphor the great 'Tree of Life' after its biblical namesake, he gave way to the posterior development of graphic reinterpretations deeply entrenched with religious connotations. These have meddled with strictly scientific notions provoking confusions in the non-specialist.

ACKNOWLEDGMENTS

This paper was supported by the project Ciencia Básica 2012 SEP-CONACyT 178031 "La enseñanza de la evolución en el contexto de la historia y la filosofía de la ciencia en México". The authors also want to thank Mª. Alicia Villela González for her support in the edition of the manuscript.

NOTES

1 Porphyry (233-309dC) was a Neoplatonic philosopher whose work, Isagogue, or introduction to Aristotelian categories, became a reference in medieval logic texts.

2 The series are the oldest metaphors to represent the natural world order, followed by networks. Series represent a linear and hierarchical order of nature (reflecting the conception of fixity and immutability of species proper of the Plan of Creation) in the form of chains, cords, ladders and stairways. The most famous series is the Great Chain of Being (see Lovejoy, 1976). Series stopped riveting scholar attention by the mid Eighteenth century when the priory significant Great Chain of Being was "increasingly seen to be an inadequate description of the order in nature, and by about 1780 it had been largely abandoned" (Ragan, 2009).

3 "The series of papers collected in this volume may be considered as a complement ... to my '*Essay on classification*'....I have also wished to avail myself of this opportunity to enter my earnest protest against the transmutation theory, revived of late with so much ability, and so generally received. It is my belief that naturalists are chasing a phantom, in their search after some material gradation among created beings, by which the whole Animal Kingdom may have been derived by successive development from a single germ, or from a few germs. It would seem, from the frequency with which this notion is revived —ever returning upon us with hydra—headed tenacity of life, and presenting itself under a new form as soon as the preceding one has been exploded and set aside —that it has a certain fascination for the human mind—. This arises, perhaps, from the desire to explain the secret of our own existence; to have some simple and easy solution of the fact that we live... These chapters were first embodied in a course of lectures delivered at the Lowell Institute in Boston." (Preface, p. iii-vi.).

4 At the end of page 100 of his book, Hitchcock mentions that both his diagram and the principles on which it was based were previously used by professor Bronn in his diagram published in *Lethea Geognostica* de 1837-1838.

BIBLIOGRAPHY

Alter, S. G. (1999). *Darwinism and the linguistic image*. Baltimore: The Johns Hopkins University Press.

Augier, A (1801). *Essai d'une nouvelle Classification des Végétaux conforme à l'Ordre que la Nature paroit avoir suivi dans le Règne Végétal: d'ou Resulte une Méthode qui conduit à la Conaissance des Plantes & de leur Rapports naturels*. Lyon: Bruyset Ainé.

Barsanti, G. (1992). *La Scala, la mappa, l'albero. Immagini e classificazioni della natura fra sei e ottocent*. Florence: Sansoni.

Cook, R. (1974). *The Tree of Life. Image for the Cosmos*. New York.

Darwin, C. (1859). O*n the Origin of Species by means of Natural Selection.* London: Murray, (1st Ed.).

Donald D. (2009). In the introduction to the book *Endless Forms, Charles Darwin, Natural Science and the Visual Arts,* Diana Donald and Jane Munro (Eds.). New Haven: Yale University Press.

Eichwald, E. (1829). *Zoologia specialis quam expositis animalibus tum vivis, tum fossilibus potissimum Rossiae in universum, et Poloniae in species, in usum lectionum publicarum in Universitate Caesarea Vilnensi habendarum. Pars prior. Propaedeuticam zoologiae atque specialem Heterozoorum expositionem continens*. Vilnae: Josephus Zawadzki.

Gould, S. J. (1985). *Ontogeny and Phylogeny*. Belknap Press of Harvard University Press.

Gould, S. J. (1997). "Redrafting the Tree of Life". *Proceedings of the American Philosophical Society, 141* (1), 30-54.

Hellström, N. P. (2011). "The tree as evolutionary icon: TREE in the Natural History Museum". *Archives of natural history,* 38 (1), 1-17, p. 10, London.

Hitchcock, E. (1840). *Elementary Geology*, (1st ed.). Amherst: J. S. & C. Adams.

Jones, W. (1786). "The third anniversary discourse". *Asiatick Researches,* 1 pp. 415–431, *London*.

Lovejoy, A. O. (1976). *The Great Chain of Being: A Study of the History of an Idea*. Harvard University Press

Mikulinskii, S. R. (Ed.) (1972). "Istoriya Biologii s Drevneishiky Vremen do Nachala XX Veka [History of Biology from Ancient Times to the Beginning of the Twentieth Century]". Moscow: Nauka. In Ragan M. (2009), Trees and networks before and after Darwin, *Biology Direct*, 4, p. 43.

Nelson, G. and Platnick, N. (1981). *Systematics and Biogeography: claddistics and vicariance.* New York: Columbia University Press.

Nott, J. C. & Gliddon, G. (1854). *Types of Mankind.* Philadelphia: Lippincott, Grambo & Co.

O'Hara, R. J. (1988). "Diagrammatic classifications of birds, 1819–1901: views of the natural system in 19th-century British ornithology". In H. Ouellet (ed.), *Acta XIX Congressus Internationalis Ornithologici*. Ottawa: National Museum of Natural Sciences, pp. 2746–2759.

O'Hara, R. J. (1991). "Representations of the natural system in the nineteenth century". *Biology and Philosophy*, 6 (2), pp. 255–274.

O'Hara, R. J. (1996). "Trees of history in systematics and philology". *Memorie della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, 27 (1), pp. 81–88.

Pallas, P. S. (1766). *Elenchus zoophytorum sistens generum adumbrationes generaliores et specierum cognitarum succinctas descriptiones cum selectis auctorum synonymis*. Hagae-Comitum [The Hague]: Petrum van Cleef.

Papavero, N. and Llorente, J. (1993-2004). *Principia Taxonomica,* (9 volumes). México: UNAM.

Papavero, N.; Llorente, J. and Bueno, A. (1994). *Principia Taxonomica*, Vol. VIII. México: UNAM.

Pietsch, T. W. (2012). *Trees of Life: A visual history of evolution.* Baltimore: The Johns Hopkins University Press.

Ragan, M. A. (2009). "Trees and networks before and after Darwin". *Biology Direct*, 4, p. 43.

Richards, R. J. (1992). *The Meaning of Evolution: The Morphological Construction and Ideological Reconstruction of Darwin's Theory.* Chicago: University of Chicago Press.

Richards, R. J. (2008). *The tragic sense of life: Ernst Haeckel and the struggle over evolutionary thought*. Chicago: University of Chicago Press.

Rieppel, O. (2010). "The series, the network, and the tree: changing metaphors of order in nature". *Biology and Philosophy,* 25, pp. 475-496.

Rudwick, M. (1972). *The meaning of fossils. Episodes in the history of paleontology*. Nueva York: American Elsevier.

Rudwick, M. (1985). *The great Devonian controversy. The shaping of scientific knowledge among gentlemanly specialists*. Chicago: University of Chicago Press.

Rudwick, M. (1992). *Scenes from deep time. Early pictorial images of the prehistoric world*. Chicago: University of Chicago Press.

Rudwick, M. (1997). *Georges Cuvier, fossil bones and geological catastrophes. New translations and interpretations of the primary texts*. Chicago: University of Chicago Press.

Rudwick, M. (2004). *The new science of geology. Studies in the earth sciences in the age of revolution*. Burlington: Ashgate Publishing. *Variorum Collected Studies Series*, 789.

Secord, J. A. (2000). *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of Vestiges of the Natural History of Creation.* Chicago: The University of Chicago Press.

Stevens P. F. (1983). "Augustin Augier's 'Arbre Botanique' (1801), a Remarkable Early Botanical Representation of the Natural System". *Taxon*, Vol. 32, No. 2 (May, 1983), pp. 203-211.

Voss, J. (2010). *Darwin Pictures*. New Haven: Yale University Press.

Young, D. (2007). *The discovery of evolution*. Cambridge: Cambridge University Press.

Weigel, S. (2007). *Genealogy: On the iconography and rhetorics of an epistemological topos*. http://www.educ.fc.ul.pt/hyper/resources/sweigel/

ARBOR Vol. 189-763, septiembre-octubre 2013, a072. ISSN-L: 0210-1963 doi: http://dx.doi.org/10.3989/arbor.2013.763n5009