Supplemental Material for Chapter 5, "Neo-Darwinian School"

Evolution: Bottom-up or Top-down?

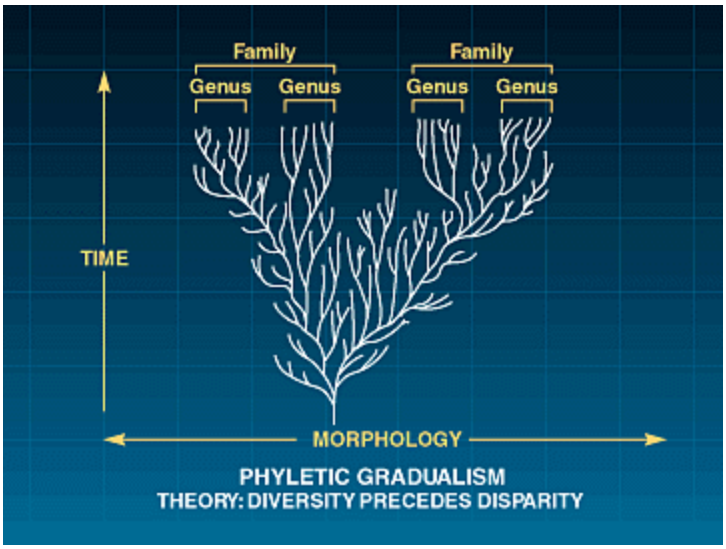
Version 1.0

A global problem for evolution, closely related to the problem of the fossil record and the Cambrian Explosion, is that of the nature of evolution: is it top-down (designed) or bottom-up (completely random)? This is obviously an important point in today's environment, where any talk of "design" raises hackles because of the implications it has for issues such as the purity of science, the nature of reality, and not least, the philosophical and religious inferences (positive and negative) so often drawn from evolution.

The problem is not difficult to understand. As discussed in the book, evolution understood in the Darwinian and Neo-Darwinian theories is based squarely on the notion of phyletic gradualism: emergence of new species and higher taxa by the slow accumulation of beneficial genetic changes that improve and change the phenotype. These changes accumulate until they are so great that a new species, genus, or other taxon is born. Phyletic gradualism is the antithesis of the "hopeful monster" or "saltation" model of evolution, whereby large changes occur at one fell swoop.

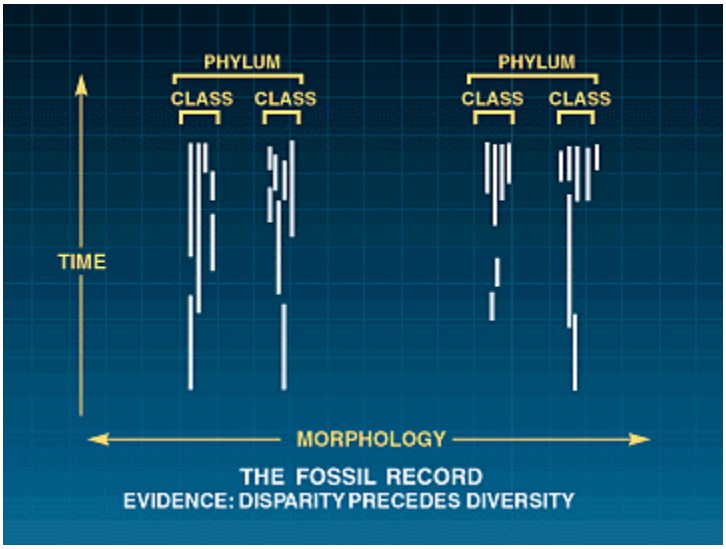
A consequence of the phyletic gradualism paradigm is the emergence of *diversity* before *disparity*. Diversity, in this context, refers to the origination and existence of many different species. Disparity refers to differences in architecture, i.e., phyla. In practice, this means that higher taxa should emerge later. The idea can be readily understood from Figures 1 and 2.[1] Figure 1 shows what should be seen under the Darwinian theory. Multiple higher taxa, such as genus and family, only appear after a long period of time (the original organism giving rise to the tree shown belonged to a phylum, order, class, family, genus and species, but there was only one). Multiple phyla, under this paradigm, would emerge last, after the greatest time, and cannot be illustrated in the figure due to the long time scale involved. Figure 2 shows what is actually seen. The phyla (disparity) are multiple before the lower taxa (diversity). This is exactly the *opposite* of what was expected. Indeed, virtually all phyla appeared in the Cambrian period, as shown in Figure 3, which illustrates the Cambrian Explosion (about 530-520 MYA).*

* The Cambrian Explosion refers to a relatively brief time in the Earth's history, about 10 million years, during which nearly all phyla emerged.



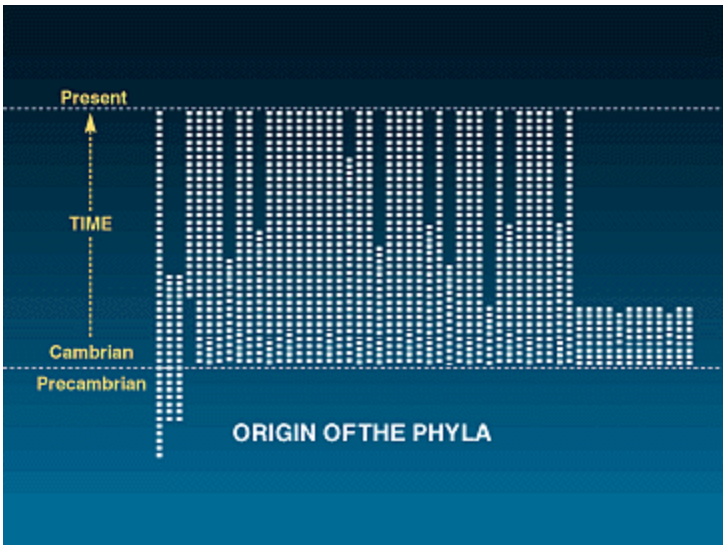
Source: Battson, n.d.

Figure 1. The emergence of higher taxa according to the phyletic gradualism paradigm of Darwin and neo-Darwinism.



Source: Battson, n.d.

Figure 2. The emergence of higher taxa as seen in the fossil record.



Source: Battson, n.d.

Figure 3. Origin of the phyla as seen in the fossil record (Cambrian Explosion).

Writing in the journal *Evolution*, Valentine and Sepkoski note:

> The fossil record suggests that the major pulse of diversification of phyla occurs before that of classes, classes before that of orders, and orders before families. This is not to say that each higher taxon originated before species (each phylum, class, or order contained at least one species, genus, family, etc. upon appearance), but the higher taxa do not seem to have diverged through an accumulation of lower taxa.[2]

This, of course, is a direct contradiction of the course of development as predicted by the Darwinian and neo-Darwinian theories.

The problem can perhaps be made still clearer if we plot diversity against disparity, and consider the patterns expected under Darwinism and neo-Darwinism (gradual increase in both), and the observed fossil record. A gradual increase in both, which is the logical consequence of the evolution pattern shown in Figure 1, leads to a more or less linear pattern, starting at the origin. But a rapid divergence of phyla, before a proportionately large diversity in species, leads to an affine pattern, sloping to the left, as the number of phyla has decreased over time. Figure 4 shows the result in schematic fashion.[*] In this figure, the diversity and disparity are given as percentages of the maximum values they have assumed. As the figure shows, there is a serious problem.[†]

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[*] Because this figure does not explicitly show time, Punctuated Equilibrium would look the same as Darwinian and neo-Darwinian evolution, and so is not separately illustrated.

[†] S. C. Morris (1998) has suggested that disparity has been increasing over time since the Cambrian period, but in spurts. This would resolve the problem, but unfortunately he does not indicate how he proposes to measure disparity if not at the phylum level. Nor does he give any empirical data to back up his claims.

The only way that the fossil record can be made to accord with the schema predicted by Neo-Darwinism is if there was an extremely rapid diversification in the early Cambrian period, such that all phyla were formed almost immediately, as illustrated in Figure 5. Unfortunately no evidence exists to suggest that this was the case, and as the phyla are pushed further back in the Cambrian, the problem becomes more acute since the available time for the hypothetical diversification shrinks. Nor does it resolve the problem just indicated of how the higher taxa diverged without an accumulation of lower taxa. Such rapid diversification does, however, alleviate one very serious problem, namely, how such different architectures could originate at all. *If they each originated in an extremely simple form, then the problem of generating them is much less onerous than if a highly developed architecture has to be transformed into a completely different architecture.*

This is the famous problem of the "Cambrian explosion", or "Biology's Big Bang", and deserves some additional consideration. The amount of time for the development of the very large number of phyla we have discussed, believed to be 100 or more, perhaps even hundreds,[3] is now estimated to be as small as a few million years,[4,5] with an upper limit of 10-15 million. The time estimated to produce a new species is estimated to be on the order of a tens of thousands to perhaps a few million years. Therefore to generate higher taxa by the species->genus->order….method would require hundreds or thousands of these steps, corresponding to millions or hundreds of millions of years for each. So there is not enough time to generate all of the phyla, unless we assume (without justification) that species formed much faster then. And there is another problem. The phyletic gradualism hypothesis is able to explain nicely the commonality of genes in, say, insects and humans: humans arose much later, and inherited the genes from their ancestors going all the way back to a hypothetical common ancestor. The rapid emergence of phyla observed in the Cambrian explosion does not allow anywhere near enough time for this sharing to occur. The problem is widely acknowledged, but there is no widely accepted resolution. Most speculation centers on the idea that there must have been organisms along the developmental path further back in the Cambrian period that have not been preserved, or at any rate, have not yet been found. Recent Chinese finds through this explanation into doubt, however.

As discussed in connection with the Cambrian Explosion in another essay, one explanatory route that needs to be explored is that of considering how a new phylum would look when it first made its appearance in the form of a new species (organism). It would look much like its immediate predecessors, which is to say, it would not seem to be a radically different architecture. But because all architectures at that early stage would be fairly simple, changes could occur rather more easily that would ultimately yield vastly different organisms. The extent to which this would resolve all the problems posed by the diversity-disparity issue is not known.

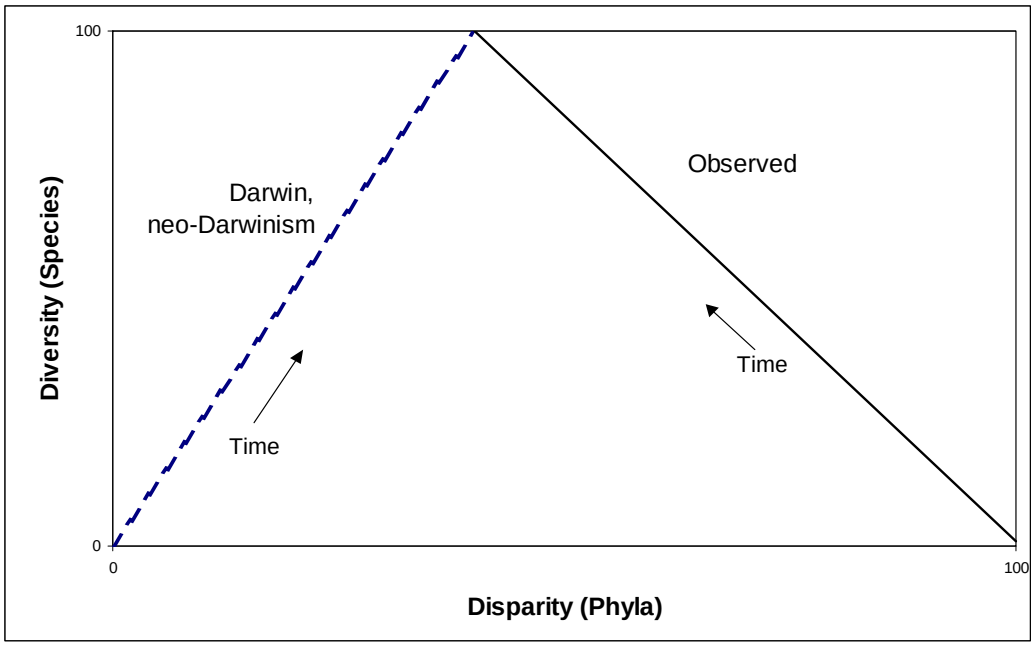
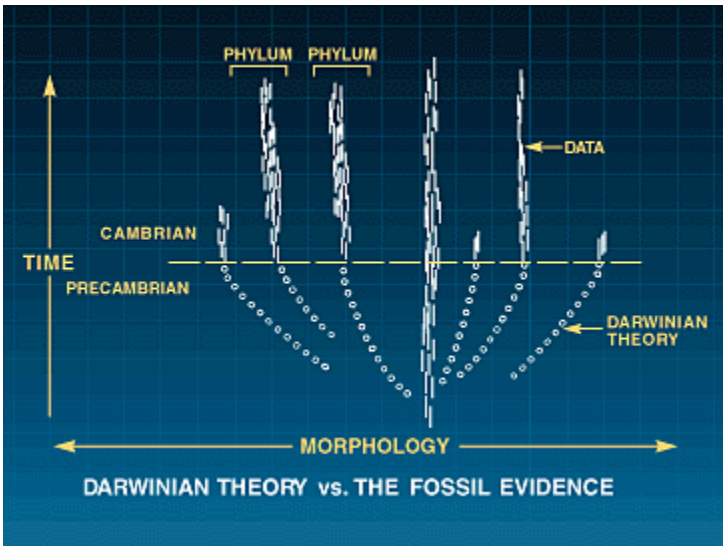


Figure 4. Disparity vs. Diversity for the Fossil Record, Theory vs. Observed.



Source: Battson.

Figure 5. Diversification needed to bring fossil record into agreement with Darwinian paradigm of evolutionary development.

[1] Figures 5-3, 5-4, and 5-5 come from Art Battson, "On The Origin of Stasis", http://id-www.ucsb.edu/fscf/library/battson/stasis/.

[2] Erwin, D., Valentine, J., and Sepkoski, J. “A Comparative Study of Diversification Events”, *Evolution* **41:** 1183 (1988).

[3] Morris, Conway, p. 208.

[4] Kerr, R. (1993), “Evolution's Big Bang Gets Even More Explosive,” *Science*, **261**: 1274 (3 September 1993).

[5] Bowring, S.A., Grotzinger, J.P., Isachsen, C.E., Knoll, A.H., Pelechaty, S.M., Kolosov, P., “Calibrating Rates of Early Cambrian Evolution,” *Science*, **261**: 1293-1298 (3 September 1993).