EDITORIAL

POLYPHYLY AND THE CAMBRIAN EXPLOSION

Perhaps the most compelling feature of the fossil record is the sudden appearance of a wide diversity of fossils at and near the base of the Phanerozoic sediments. This sudden appearance is called the Cambrian Explosion, and has been the subject of much comment and analysis.

First appearances of phyla and classes of metazoans (multicellular animals) are not distributed evenly throughout the geologic column, but are largely clustered at the lower end of the Phanerozoic, predominantly from the uppermost Precambrian to the Ordovician, peaking in the Cambrian.[1] *First appearances for orders also peak in the Cambrian and Ordovician, but are more broadly distributed. In contrast, first appearances of families, genera and species are relatively low in the Cambrian, and generally increase through the geologic column.*[2] *The increase is especially marked from the Cretaceous to the top of the column. This means that the Cambrian fossil record consists of a relatively small number of species with widely varying anatomical designs, or body plans. As one moves upward through the column, the fossil families, genera and species differ from level to level, but the higher taxonomic categories tend to remain the same. What does this mean?*

Most scientists read the geologic column as a record of history, in which the Phanerozoic portion extends over some 540 million years. Viewed from this perspective, the Cambrian Explosion is most easily explained as the result of a polyphyletic origin for life. But, oddly enough, the scientific community seems to resist this interpretation. The reason seems not to be scientific, but philosophical and historical.

According to standard evolutionary theory, all organisms derive from a single ancestral species. Darwin's famous book[3] *is noted for having only one illustration – the familiar monophyletic evolutionary tree, showing all living organisms linked to a single ancestor. The structure of this tree shows diversity first increasing at low taxonomic categories, eventually building to diversity at higher taxonomic categories. Evolutionarily speaking, this pattern* *seems inevitable — small changes add up, eventually producing new species, then new genera, families, orders, etc. Unfortunately for the theory, this description is the opposite of the actual pattern in the rocks. The greatest morphological differences appear in the lower Phanerozoic rocks, while the rest of the fossil record consists largely of variations of familiar themes.*

Molecular studies of living species impact the interpretation of the Cambrian Explosion. Several phyla are soft-bodied and/or microscopic, and absent or very rare as fossils. Viewed solely from the fossil record, these phyla might have originated much later in geologic history than the phyla that are found in the Cambrian sediments. But molecular phylogenies are interpreted as showing that the soft-bodied phyla are of similar age as those with a good fossil record.[4] Thus, the Cambrian Explosion includes not only those phyla with fossils in Cambrian sediments, but also the other phyla with poor fossil records.

If the Phanerozoic is to be read as a record of extended history, what does the Cambrian Explosion tell us? One possibility is that the fossil record is woefully inadequate to trace the origins of the higher taxa. But this explanation has some serious implications. How can the fossil record be trusted to tell us anything if it is so poor that we cannot trace even the major stages in the evolution of higher taxa? And what evidence is there that the fossil record is that poor? Is there anything beyond the presupposition of monophyly that suggests such an incomplete record?

No one would claim the fossil record is perfectly complete, but it does not seem to be bad enough to explain the Cambrian Explosion in terms of monophyly. Fossils of soft-bodied organisms are famously found in Cambrian Preservat-Lagerstätten such as the Burgess Shale and the Chengjiang locality in China. Fossil bacteria are reported from both Precambrian and Phanerozoic rocks. Why would depositional conditions favor preservation of bacteria in both Precambrian and Phanerozoic rocks, but soft-bodied multicellular organisms only in the Phanerozoic and uppermost Precambrian?[5] The fossil record is obviously incomplete, but there is no evidence it is so incomplete it would not preserve fossils of soft-bodied organisms for half their supposed geologic history.[6]

Perhaps polyphyly is an idea that deserves greater consideration by the scientific community. The idea has been mentioned a few times,[7] but does not seem to have been seriously discussed within the mainstream scientific community.

A counterargument against polyphyly is that biomolecular similarities indicate common ancestry and monophyly. For example, the genetic code and metabolic enzymes are similar in nearly all living organisms. However, there are significant differences in the details of the cellular processes in different groups of organisms.[8] Scientists have become so acutely aware of anomalies in molecular phylogenies that they have even considered abandoning attempts to reconstruct the root of the evolutionary tree, with the explanation that lateral gene transfer has confused the situation beyond recognition.[9] In addition, the origin of the genetic code has no plausible naturalistic explanation.[10] This may be a good time to make some changes in thinking.

Creation theory offers reasonable explanations for both the Cambrian Explosion and the origin and ubiquity of the genetic code. The taxonomic diversity seen in the Cambrian Explosion may be simply the result of preservation of various communities of marine organisms living on or near the floor of the sea. The basis for the association of the fossils is ecological rather than genealogical.[11] The absence of ancestors in the underlying strata is not due to a faulty fossil record, but reflects separate origins of the various groups. This proposition applies whether one reads the fossil record as extended history or as complex catastrophe.

Polyphyly implies that the genetic code has multiple independent origins, and is not the result of common ancestry. This suggests the concept of similarity by common design. Design may be the best explanation for the origin and ubiquity of the genetic code.[12] Common design seems eminently reasonable as an explanation of similar features in organisms that appear genealogically unlinked.

Is the fact that an idea is associated with creation theory sufficient reason to exclude the idea from consideration in science? It would be unfortunate if prejudice against a competing theory were so intense that an idea is rejected merely because it is part of that competing theory, even though it might be the best available explanation. Polyphyly is an important tenet of creation theory. In *this case at least, creation theory appears to provide the explanation that is most in accordance with the evidence from nature.*

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ENDNOTES

1. Erwin DH, Valentine JW, Sepkoski JJ. 1987. A comparative study of diversification events: the early Paleozoic versus the Mesozoic. Evolution 41:1177-1186.
2. Signor PW. 1994. Biodiversity in geological time. American Zoologist 34:23-32.
3. Darwin C. 1958. The origin of species. 6th edition, 1872. NY: Mentor Books. The diagram is found in Chapter 4; page number varies according to the publisher.
4. Ayala FJ, Rzhetsky R, Ayala FJ. 1998. Origin of the metazoan phyla: molecular clocks confirm paleontological estimates. Proceedings of the National Academy of Sciences (USA) 95:606-611.
5. Assuming the Ediacaran fauna are truly multicellular.
6. Foote, M., J.J. Sepkoski. 1999. Absolute measures of the completeness of the fossil record. Nature 398:415-417. See also the reference in Endnote 4.
7. Polyphyly has been suggested for life in general in: Schwabe C, Warr GW. 1984. A polyphyletic view of evolution: the genetic potential hypothesis. Perspectives in Biology and Medicine 27:465-485. Polyphyly has also been suggested for invertebrate phyla in: Willmer P. 1990. Invertebrate relationships. NY: Cambridge University Press, p 359. Such suggestions are much more rare than one would expect, given the state of the evidence.
8. Fox GE, Stackebrandt E, Hespell RB, Gibson J, Maniloff G, + 14 other authors. 1980. The phylogeny of prokaryotes. Science 209:457-463.
9. Doolittle WF. 1999. Phylogenetic classification and the universal tree. Science 284:2124-2128.
10. Di Guilio M. 1997. On the origin of the genetic code. Journal of Theoretical Biology 187:573-581. Many attempts have been made, for example: Alberti S. 1999. Evolution of the genetic code, protein synthesis and nucleic acid replication. Cellular and Molecular Life Sciences 56:85-93.
11. This does not imply denial of variation, or even speciation, among the Cambrian fossil groups, but emphasizes that the overall pattern of the fossils is not genealogical, but is related to ecology.
12. Design is not being proposed, but seems an obvious possibility. See, for example: Freeland SJ, Hurst LD. 1998. The genetic code is one in a million. Journal of Molecular Evolution 47:238-248.