ARTICLES

PUNC EQ CREATION STYLE

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WHAT THIS ARTICLE IS ABOUT

Punctuated equilibria ("punc eq" or PE) was originally proposed as an attempt to offer an alternative evolutionary view to the classical Darwinian theory of speciation as a slow, gradual process. PE theory includes both a two-pronged claim about the fossil record of a species — stasis and abrupt appearance — and a historical scenario and/or mechanism to explain that claim. Although the mechanism is often very difficult to test, the claim about the fossil record of species is rather easily testable, being both falsifiable and potentially verifiable.

Not a single species has been found with a fossil record which definitely violates the claim of stasis and abrupt appearance. The organisms with fossil records the closest to violating stasis and abrupt appearance are unicellular organisms, and are primarily found in the Cenozoic portion of the stratigraphic column. Existing evolutionary theory, even that invoked in PE theory mechanisms, cannot explain why unicellular organisms should be the only organisms to violate the first two claims (stasis and abrupt appearance) of PE theory.

A stratigraphic mechanism for the claim of punctuated equilibria is here suggested. Species which experience instantaneous burial would be expected to display stasis and abrupt appearance in the resultant sediments. As the length of time actually represented by the sedimentary record increases, exceptions to stasis and abrupt appearance would be expected — beginning with short-lived, catastrophe-tolerant species. Since possible exceptions to stasis and abrupt appearance are found only among species with generation times of less than a year, there is no evidence that the sediments in which any species is preserved must have taken any more than a year to be deposited. The fact that exceptions to stasis and abrupt appearance may occur in the Cenozoic sediments, but not in the older sediments, is consistent with the idea that the pre-Cenozoic was deposited in the flood, and that a significant portion of the Cenozoic may be post-flood.

INTRODUCTION

Dating from only 1972 (Eldredge & Gould 1972), punctuated equilibria is a rather young theory of science. As with new ideas in other arenas of human thought, such as clothing design, computer improvement, and the rebellion of the next generation's youth, few novel ideas of science become popular. New ideas and those who hold them often encounter a plethora of competitive ideas and an abundance of misunderstanding. Punctuated equilibria is no exception. Over the last seventeen years a number of valid variations, as well as invalid understandings, of punctuated equilibria theory have surfaced. This paper seeks first of all to clear up the confusion about what punctuated equilibria truly is, and what it is not. The second purpose of this paper is to propose a punctuated equilibria mechanism which is consistent with a young-earth creation model.

PUNC EQ — WHAT IT IS, AND WHAT IT IS NOT

Clarifications of PE Theory

Punctuated equilibria (fondly known as "punc eq," and hereafter referred to as PE) theories are all composed of two claims. The first claim is merely a paleontological observation, or what Stephen Jay Gould calls the "geometry" of PE. As will be elaborated below, this claim is that: 1) transitional forms are lacking between species, and 2) a species morphology does not change substantially throughout its range in the fossil record. Because, with minor variations, it is a common element in all PE theories, the paleontological observation may just as well be considered punctuated equilibria *sensu stricto*. The second claim of each PE theory is a mechanism proposed to explain the paleontological observation — usually a speciation mechanism to account for the lack of transitional forms between species. The variety of these mechanisms accounts for a vast majority of the variations upon PE theory that exist. Since PE theories differ predominantly in their second claims, it may be said that PE *sensu lato* is a statement of the paleontological observation along with a mechanism for its explanation.

A further clarification is that PE theories are proposed to deal with species, and *should* be applied exclusively to species — or, in some cases, subspecies and/or varieties. This claim will be argued more fully in subsequent sections of this paper. "Stasis," when used to describe the fossil record of higher taxa, has a very different and much more abstract meaning than when it is used to describe the fossil record of a species (see under "The claim of stasis," below). The difference in meaning renders it very difficult, if not impossible, to test the claim of stasis in higher taxonomic groups. The abrupt appearance of higher taxa would also be defined differently from the abrupt appearance of species (see under “The claim of abrupt appearance”, below). With regard to mechanisms of origin, higher taxa, may have arisen by different means than component species. As a result, it may well be inappropriate to apply PE mechanisms — which are designed to account for the origin of species — to the origin of higher taxa. PE theory should not be applied to the fossil record of genera, families, orders, classes, phyla, or any other taxonomic unit higher than the species.

The Claim of Stasis

The paleontological observation of punctuated equilibria (or PE *sensu stricto*) is itself composed of two claims about the fossil record of species — that species predominantly show both stasis and abrupt appearance. The claim of stasis is that the range of morphological variation exhibited by populations of a given species does not change over the duration of the stratigraphic range of a species. Thus no substantial change in morphology occurs between the stratigraphically lowest population and the stratigraphically highest population — nor, in fact, between any other two populations between. This particular claim is verifiable and potentially falsifiable from the known fossil record. In fact, it is extremely likely that, if incorrect, this claim would be very quickly and profoundly falsified, even if the fossil record were very incomplete. It should theoretically take only two stratigraphically distinct populations of a species to indicate that a population had changed substantially.

Once again, to elaborate upon an earlier clarification, the claim of paleontological stasis is to be applied only to species. A higher taxon is defined as a region of morphological space which includes at least the morphologies of all component species. If higher taxa are real and have true boundaries in morphological space (which is the claim of many creationists), then there is unrecognized, unrealized, and perhaps even unrealizable morphological space within each higher taxon. This means that it is very improbable that any definition based upon realized morphology reflects the true nature of the higher taxon.

Let us say, for the sake of argument, that a particular higher taxon is real and that its true boundaries have never changed through time. Let us further postulate that there was a time in the history of that higher taxon when it was represented by only a single species (i.e., a single morphology). Let us further speculate that at some later point in time the higher taxon is represented by more than a single species (i.e., more than a single morphology). Regardless of how the new species came about, the empirical morphological evidence alone would lead us to the incorrect conclusion that the higher taxon's morphological range has, at the very least, become broader. Suppose further that the original species was neither represented at the later time period nor was its morphology within the region of morphological space bounded by the species that were alive. In this case the higher taxon's morphology has not only appeared to become broader, but it has also changed. To arrive at any other conclusion would not be viable. If one simply defined the higher taxon as the morphological space which includes all component species, living and dead, then it would be impossible to falsify the hypothesis of morphological stasis of a higher taxon. Such a concept would be useless to us in determining whether stasis occurs in higher taxa.

If we are to define higher taxa as exhibiting stasis, then non-paleontological and perhaps even non-morphological evidence will have to be employed. Thus, the PE claim of paleontological stasis of species should not be applied to taxonomic groups above the level of the species. If we wish to study the "stasis" of higher groups it will be advisable to carefully define new descriptors, such as "paleontological stasis", "species stasis," "familial stasis," etc.

The Claim of Abrupt Appearance

The second claim of the paleontological observation of PE is abrupt appearance. It is, in fact, unfortunate that this claim should be labeled "abrupt appearance," for the label itself implies that its definition is tautologous. Abrupt appearance would most logically mean that a species appears abruptly in the stratigraphic record in the oldest sediments where that species is identified. If this were its definition, abrupt appearance would be a tautology — a true statement but without explanatory power. This, however, is *not* the definition of abrupt appearance. Rather, abrupt appearance is the claim that the oldest identifiable population of a species is not preceded by any transitional series or even transitional form from another species in the fossil record. Stated another way, abrupt appearance is the claim that there are no inter-specific transitional forms in the fossil record. As with stasis, this claim is verifiable and potentially falsifiable for the known fossil record. Considering the number of species in the fossil record (approximately a quarter million, according to Raup & Stanley 1978, p 3), it seems that if it were false, it is likely that this claim would be falsified.

Also like stasis, abrupt appearance should not be applied above the level of the species. Although PE theory maintains that there are few if any inter-specific transitional forms, it does not deny the possibility that a species can act as a transitional form between two higher groups. For example, it might be argued that although there are no inter-specific transitional forms leading to or away from *Archaeopteryx*, *Archaeopteryx* itself can be considered a transitional form between reptiles and birds. It might also be argued that although there are no inter-specific transitional forms connecting any pair of species in the human series, or the horse series, or the elephant series, etc., the various species in each of these cases can be understood to be intermediate species. Thus although there may be no inter-specific transitional forms leading up to a higher taxon, there may well be transitional species leading up to a higher taxon. This would mean that although the fossil record of a higher taxon is exhibiting abrupt appearance on the species level, it is not truly exhibiting abrupt appearance. Abrupt appearance of higher taxa has a different meaning than abrupt appearance of species.

The Original Mechanism for Abrupt Appearance

The variety among PE theories largely arises from the variety of mechanisms that have been proposed to explain the two paleontological claims outlined above. The original formulation of PE theory was that of Niles Eldredge and Stephen Jay Gould in 1972. According to its formulators, PE theory came primarily from prevailing biological theory and not from paleontology (nor, as some have intimated, from the claims of creationists that transitional forms do not exist in the fossil record) (Eldredge 1971; Eldredge & Gould 1972).

For nearly a century after Darwin most evolutionary biologists were of the opinion that speciation occurs through a phyletic transformation of large species populations over very long periods of time. By 1950, however, advances in genetics and population biology had left little hope for this type of speciation mechanism. Stabilizing selection in large populations seemed to prohibit rather than allow change to occur. As a result of this, many alternative mechanisms were proposed to explain the origin of species.

By the time Eldredge and Gould went through graduate school, the peripheral isolate theory of allopatric speciation of Ernst Mayr (1963, 1971) was the most popular and oft-advocated biological theory of speciation. According to this theory species actually arise in small populations isolated from and peripheral to the main population(s) of a species. In these peripheral isolates high selection pressure, genetic drift, and the founder effect combine to (theoretically) allow speciation in only a thousand generations or so.

If, as Eldredge and Gould reasoned, this is how species actually arise, it should be possible to specify what the paleontological prediction of such a theory would be. If this was the speciation mechanism, the transitional populations would be small in terms of occupied area. They would also exist over a time period of only thousands to tens of thousands of years. Accordingly, if the fossil record in fact records 3.5 billion years of earth history, the likelihood would be extremely low that a transitional population would ever be located in the fossil record. Furthermore, if large population sizes tend to prohibit morphological change via stabilizing selection, species should exhibit stasis during most or all of their existence. It is important to note that PE as originally defined by Eldredge and Gould was born out of the second claim — the mechanism of Mayr's peripheral isolate theory of allopatric speciation. The paleontological observation was a prediction from that mechanism.

It is also worthy of note that Eldredge and Gould do *expect* exceptions to the universality of abrupt appearance. In those rare occurrences where the transitional populations are found in sediments of sufficient resolution, inter-specific transitional forms are expected to be seen. Since the mean stratigraphic resolution is considered to vary inversely with age, the rarity of exceptions might be expected to increase with the age of sediment. In their original paper Eldredge and Gould (1972) also suggest that PE may not apply to all organisms. Mayr's peripheral isolate mechanism was proposed to account for the origin of sexual species. Most sexual organisms would be expected to follow predictions of PE theory. Since speciation mechanisms are largely unknown among asexual organisms, Eldredge and Gould considered it possible that the fossil record of asexual organisms might not follow the predictions of PE theory. PE theory as originally formulated would predict that the number of exceptions to stasis and abrupt appearance would be small, but would increase in frequency with decreasing age, and perhaps be more frequent among asexual organisms.

Other Mechanisms for Abrupt Appearance

The peripheral isolate mechanism proposed for the original PE theory is not the only mechanism which has been invoked to explain abrupt appearance. If speciation always occurred by means of macromutation, then abrupt appearance without any exceptions would be the paleontological prediction. Thus another PE theory *sensu lato* would be one with a macromutation mechanism. If, on the other hand, speciation occurred by means of large-scale morphological changes caused by mutations in developmental regulatory genes, once again abrupt appearance without any exceptions would be the paleontological prediction. A third PE theory *sensu lato* would then be one which included speciation by means of the mechanism of regulatory gene mutation. A fourth PE theory *sensu lato* might include a speciation mechanism which accounts for a large change in adult morphology by means of small, non-regulatory-gene changes in the ontogeny of an organism. A fifth theory might include any combination of the four speciation mechanisms mentioned above.

It is important to note that Goldschmidt (1940) proposed that higher taxa (e.g., phyla) may well have arisen by means of the third and/or fourth mechanisms above — namely by means of small changes (regulatory or not) occurring in ontogeny which effect large changes in adult morphology. Although Goldschmidt's "hopeful monster" mechanism *can* be used as a mechanism to account for the paleontological observation of PE theory, it is *not* usually so used. It is generally appealed to in order to account for the origin of higher taxa, and *not* the origin of species.

Strictly speaking, since the origin of a higher taxon occurs with the origin of a new species, a mechanism for the origin of higher taxa can also be seen as a speciation mechanism. However, some evolutionary biologists feel that higher taxa do not simply originate by means of the usual speciation mechanism, or even a scaled-up version of it. It is thought that higher taxa originate only rarely, and by a mechanism of a very different nature from the normal mode of speciation. Goldschmidt's "hopeful monster" mechanism is of a very different nature from the traditional speciation mechanism, and it is thought to have occurred only very rarely, if ever, and primarily in the origin of higher taxa. His "hopeful monster" theory is *not* to be equated with punctuated equilibria, as the two are not the same.

Mechanisms for Stasis

Besides there being a number of speciation mechanisms to account for the observation of abrupt appearance, there are several mechanisms to account for the observation of stasis. As mentioned above, one suggestion is that large population size may swamp out change and account for stasis. Another possibility is that since the fossil record preserves only a small number of the morphological characters of an organism (e.g., primarily the hard parts of organisms), the organism may actually be changing radically — just not in the characters observed. Yet another possibility is that environments persist through time, producing no net change in selection pressure. An additional possibility is that there is some unknown mechanism of "homeostasis" which prevents organismal change. Any one or more of these mechanisms can be combined with a speciation mechanism to make up a PE theory *sensu lato*.

HOW PE *SENSU STRICTO* FARES AGAINST THE DATA

The paleontological observation of PE theory (i.e., PE theory *sensu stricto*) has fared rather well in the light of the data of the last seventeen years. The best exception to the claim of paleontological stasis in the fossil record of which I am aware is the Permian foraminifer *Lepidolina multiseptata* (Ozawa 1975, Gould & Eldredge 1977). Other possible claims exist among the Cenozoic fossil records of unicellular organisms, but are insufficiently documented to be conclusive (Lazarus 1983).

To the claim of no inter-specific transitional forms there are also suggested exceptions (Kellogg 1975; Williamson 1981; Malmgren, Berggren & Lohmann 1983; and Arnold 1983). Gould and Eldredge (1977), however, feel that Kellogg (1975) did not provide sufficient evidence to exclude the possibility of the change being non-genomic (i.e., non-heritable) and ecophenotypic: (i.e., environmentally determined) in character. Similar arguments could be directed against Ozawa (1975) if the time period covered (Middle to Upper Permian) was collapsed into a period within the year of a global flood. Williamson's (1981) study did not demonstrate stasis in the case of any of his thirteen "new species." Furthermore, the changes he identified happened simultaneously in large populations of widely different organisms (sexual through hermaphroditic; infaunal through epifaunal, etc.). Once again, then, it is possible that Williamson's data record ecophenotypic, and not genotypic, change (Mayr 1982, Boucot 1982). Both Arnold (1983) and Malmgren et al. (1983) looked at only a single core of sediment, so did not control for the possibility that a climatic change may have forced the replacement of one species with another more tolerant of the new climate. As Malmgren et al. (1983) admit, there is a gradual change in ocean temperature across the interval sampled, and their own study does not exclude the possibility that a species may have migrated across the area as a result of climatic change.

Although there are no *bona fide* exceptions to the paleontological observation of punctuated equilibria, the best cases seem to come from foraminifera in the Upper Cenozoic. Although Eldredge and Gould (1972) felt that asexual organisms may not follow PE theory, most asexual organisms do (e.g., parthenogenic freshwater snails; Williamson 1981). There is nothing in current evolutionary theory — PE mechanisms included

— which should predict that the exceptions to PE theory should come specifically from foraminifera, and not other asexual organisms. Yet, because some researchers think that forams show gradual change, it has been suggested that unicellular (asexual?) organisms evolve by means of a very different evolutionary mode than multicellular organisms. They, in fact, are appealing to information that is not yet known — to be forthcoming, so it is hoped.

AN ALTERNATIVE MECHANISM FOR PUNC EQ

Conventional Geology and PE Theory

All the PE theory mechanisms that have been proposed to date are biologic in nature, and most are evolutionary. They do not exhaust the possibilities. It is also possible to consider a stratigraphic mechanism for the paleontological observation of punctuated equilibria.

Let us consider such a possibility by first of all by asking what variety of theories might be invoked to explain the rock record on earth. There are a large number of potential theories — in fact, there is theoretically an infinite number. Let us simplify the situation and place all the possible theories onto a one-dimensional “spectrum of theories for the origin of the earth’s rocks.” At one end of such a spectrum might be the theory that the rate at which existing rocks were formed has been constant throughout the entire history of the earth. At the other end of such a spectrum might be the theory that all the earth’s current rocks were formed in one event of zero duration (e.g., creation) or of very short duration (e.g., a single, very short-lived catastrophe). Since rocks are forming today and at varying rates, neither of these end-point theories accurately accounts for the origin of all the rocks on the earth. The true theory for the origin of the earth’s rocks lies somewhere between these two extremes. It is up to geologists to determine where on that spectrum of possibilities the theory lies which can best account for all the earth’s rocks.

Consider for a moment the uniform-rate theory at the one end of the spectrum. This theory would more or less characterize Charles Lyell’s theory for the origin of the earth’s rocks. Modern geologic theory has modified Lyell’s theory of uniformity to allow for many local catastrophes and varying rates through time, but is still located close to the uniform rate end of the spectrum. If this theory correctly characterizes the manner in which the earth’s rocks were formed, the fossil record is to be interpreted from bottom to top as a sampling from the earth’s biota through time. Each sample is in essence a snapshot of a particular moment in the history of the earth. Though some of the successive snapshots are closer together in time than others, the fossil record would be analogous to a motion picture of the history of life on earth — each frame being a snapshot of a very brief moment in time. Consequently, any change in morphology up the geologic column would be interpreted as reflecting a change with time — in other words, as evolution. Since this idea of what Stephen Jay Gould calls "deep time" is the conventional understanding of the stratigraphic column, it is understandable that any mechanism to explain vertical changes in the fossils in the stratigraphic column would be inherently biologic and evolutionary in nature.

Geologic Catastrophe and PE Theory

Let us now consider, however, the theory on the opposite end of the spectrum — that all the earth's rocks originated in a single event of very short duration. If the earth's rocks originated by means of such a catastrophe, the fossil record represents a snapshot of the earth's biota at a moment in time. Changes in fossil morphology between levels would not then reflect changes in biology through time. There would be no need to invoke evolutionary mechanisms to explain any vertical changes in organismal morphology. What then would we expect to see in the fossil record with respect to stasis and inter-specific transitional forms? Since each species would be sampled at only a moment in time, species should predominantly show stasis in the fossil record.

Exceptions to species stasis would occur in one or more of three ways. Firstly, the processes operating during the catastrophe may have sorted the organisms into a vertical gradient of morphology. Such an explanation might be proposed if a laboratory simulation of the depositional processes of the catastrophe sorted individuals of a given species in a manner reflective of their stratigraphic distribution. Secondly, a vertical morphology gradient may be reflective of an original geographic, latitudinal, or altitudinal gradient of morphology. This might be substantiated if a similar morphology gradient exists in living populations of the species of concern and/or related species. Thirdly, a vertical morphology gradient may be the result of an actual morphological transition during the course of the catastrophe. This could occur only in an organism which is resistant to the conditions of such a catastrophe and has a generation time substantially shorter than the duration of the catastrophe.

A catastrophe would produce a fossil record predominated by a lack of inter-specific transitional forms. As in the case of stasis, exceptions might occur in one or more of three ways. Firstly, a lineage could show inter-specific intermediates by an inter-specific morphology landing by chance in a stratigraphically intermediate position. This is a very unlikely event, and the more intermediates are found, the lesser is the likelihood that such a scenario actually occurred. Secondly, a fossil record which shows two species vertically separated by a zone of inter-specific transitional forms may be reflecting a pre-catastrophe morphology gradient. If this were the case, the fossils representing the inter-specific transitional forms should be found in a select geographic region, somewhat reflective of the original hybrid zone (or zone of intermediates). Thirdly, an apparent change in morphology up section may reflect an actual speciation event. Once again, this could occur only in an organism which is resistant to the conditions of such a catastrophe and has a generation time substantially shorter than the duration of the catastrophe. The rarity of exceptions to PE *sensu stricto* indicates that a model of catastrophic deposition of the earth's rocks could be invoked as a mechanism to account for the paleontological observation of PE theory.

As one moved across the spectrum from the single-catastrophe at the one end, theories would be encountered which would introduce more time into the formation of the earth's rocks. It is possible to posit that there was a single catastrophe with the remainder of the earth's history uniform, or that there were several catastrophes with uniformity between, or that there were catastrophes of increasing length. As one moved across the spectrum in this way, one would expect that true examples of biological change will manifest themselves with greater and greater frequency. When the periods of uniformity are short, the only biological change that could possibly be seen would be in those organisms with short generation times. Only when the periods of uniformity were long enough could organisms with long generation times show intra- and inter-specific evolution.

Creation Geology and PE Theory

Biblically based models of earth history are varied. There are in fact too many of them to permit consideration of each of them here. An outline of one creation model will be presented with its corresponding paleontological prediction. This model begins with the creation of the earth's oldest rocks in something less than 24 hours on Day 1 of the creation week. On Day 3, there may well have been another geologic catastrophe of less than 24-hour duration. Then, for over 1600 years, until the global catastrophe of the flood, there was a period of apparent uniformity of geologic processes at something near current rates. The initial stages of the flood may well have eroded away and thus destroyed all evidence of this antediluvian geology. It may have even destroyed some or all of the effects of the Day-3 catastrophe.

After the flood there may have been a series of catastrophes — perhaps decreasing in geographic extent, magnitude, and duration as time passed. Each pair of successive catastrophes was probably separated by a period of uniform geologic sedimentation, again with rates similar to today. Once again, however, the evidence for the periods of "normal" activity may have usually been destroyed by subsequent catastrophe. This particular model would understand the lower portion of the rock record as the product of one or two catastrophes. Only the uppermost part of the post-flood rock record would have any significant amount of evidence of a uniform rate of rock formation.

This model lies towards the catastrophe endpoint of the spectrum of theories for the origin of the earth's rocks. Such a model would predict a fossil record which predominantly shows stasis and abrupt appearance. Since the flood was on the order of a year in length, exceptions to PE *sensu stricto* in the flood sediments would most likely be sediment-suspension-resistant, marine organisms with generation times on the order of a month or less. In the post-flood sediments, exceptions to PE *sensu stricto* (if they occur at all) should increase in frequency vertically. Exceptions, once again, would most likely be short-lived, marine organisms which are resistant to suspended sediment.

CONCLUSION

"Punc Eq Creation Style" (PECS) is a punctuated equilibria theory *sensu lato*. It is composed of two primary claims: that stasis and abrupt appearance predominate in the fossil record of species, and that the stasis and abrupt appearance can be accounted for in a catastrophic flood model. All other PE theories explain the paleontological observations of stasis and abrupt appearance of species. Most PE theories also explain why the proposed exceptions tend to be in the Upper Cenozoic. PECS, however, goes even further. It not only predicts the stasis and abrupt appearance of species, but it also predicts that exceptions, if they occur, will be found more often than not in the Upper Cenozoic among the marine, suspension-resistant organisms with short generation times (e.g., foraminifera). Because of its greater explanatory power, PECS theory is superior to other PE theories.

Much research needs to be done in this particular area. Currently, in spite of a number of claims to the contrary, there are no completely satisfactory exceptions to the universality of PE *sensu stricto*. Although no PE theory, including PECS, requires the existence of exceptions, valid exceptions will make it possible to choose from among the various PE theories. Alone among PE theories, PECS predicts that exceptions will tend to be marine, sediment-suspension-resistant organisms with short-generation times (one month or less in flood sediments). Searches for exceptions and evaluation of claims for exceptions will be important in determining the validity of the PECS model.

Exceptions to stasis and abrupt appearance which are the result of true morphological change through time should also aid us in differentiating between flood and post-flood sediments. It is in post-flood sediments where substantially more exceptions should be found. The identification of pre-flood/flood and flood/post-flood boundaries will be extremely important in the elaboration of better flood models. The evidence to date from possible PE exceptions suggests that at least the Neogene (Upper Tertiary) may be post-flood. PE exceptions may also aid in determining the mode, tempo, and number of post-flood catastrophes. Inferred generation times may allow for an estimate of duration of both catastrophes and inter-catastrophe periods. Organismal resistance to conditions experienced during catastrophes may allow us to infer what type of catastrophe actually occurred.

Exceptions to stasis and abrupt appearance which are not due to actual changes in morphology may also provide valuable information about the mode of deposition as well as original biogeography. Exceptions to stasis which are due to sorting will indicate the importance and manner of sorting which occurred during any one depositional period. It may well be, for example, that Cope's Law (that a lineage tends to increase in body size up the stratigraphic column) is the result of such preferential sorting. Exceptions to a lack of inter-specific transitional forms which are due to the chance occurrence of an intermediate morphology in intermediate stratigraphic position will indicate the possible importance of randomness in the production of apparent pattern in the fossil record. The more that is known about the effects of sorting and randomness in catastrophic events, the closer we will be to understanding what happened during the flood. Exceptions to stasis and/or abrupt appearance, on the other hand, which are reflections of original biogeography, will aid us immensely in the understanding of paleo-biogeography, which in turn will help us to understand paleoclimates and paleobiology.

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REFERENCES

Arnold AJ. 1983. Phyletic evolution in the *Globorotalia crassaformis* (Galoway and Willer) lineage: a preliminary report. Paleobiology 9:390-397.

Boucot AJ. 1982. Ecophenotypic or genotypic? Nature 296:609-610.

Eldredge N. 1971. The allopatric model and phylogeny in Paleozoic invertebrates. Evolution 25:156-157.

Eldredge N, Gould SJ. 1972. Punctuated equilibria: an alternative to phyletic gradualism. In: Schopf TJM, editor. Models in Paleobiology. San Francisco: Freeman, Cooper and Co., p 82-115.

Goldschmidt R. 1940. The material basis of evolution. New Haven, CT: Yale University Press.

Gould SJ. 1980. Return of the hopeful monster. In: Gould SJ. The Panda's Thumb. NY: W.W. Norton, p 186-193.

Gould SJ, Eldredge N. 1977. Punctuated equilibria: the tempo and mode of evolution reconsidered. Paleobiology 3:115-151.

Kellogg DE. 1975. The role of phyletic change in the evolution of *Pseudocubus vema* (Radiolaria). Paleobiology 1:359-370.

Lazarus D. 1983. Speciation in pelagic Protista and its study in the planktonic microfossil record: a review. Paleobiology 9:327-340.

Malmgren BA, Berggren WA, Lohmann GP. 1983. Evidence for punctuated gradualism in the Late Neogene *Globorotalia tumida* lineage of planktonic foraminifera. Paleobiology 9:377-389.

Mayr E. 1963. Animal species and evolution. Cambridge, MA: Harvard University Press.

Mayr E. 1971. Populations, species and evolution. Cambridge, MA: Harvard University Press.

Mayr E. 1982. Questions concerning speciation. Nature 296:609.

Ozawa T. 1975. Evolution of *Lepidolina multiseptata* (Permian foraminifer) in East Asia. Memoirs, Kyushu University Faculty of Science, Series D: Geology 23:117-164.

Raup DM, Stanley SM. 1978. Principles of paleontology. San Francisco: W. F. Freeman.

Williamson PG. 1981. Palaeontological documentation of speciation in Cenozoic molluscs from Turkana Basin. Nature 293:437-443.