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The Rhetorical Construction of Eldredge and Gould's Article on the Theory of Punctuated Equilibria in 1972

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ABSTRACT – This article seeks to show how several rhetorical tools were used and, in fact, played a central role in the argumentation advanced by Niles Eldredge and Stephen Jay Gould in their 1972 seminal article on the theory of Punctuated Equilibria. It is analyzed how Eldredge and Gould proceeded through three steps that, sequentially integrated, made their argument compelling. It is shown how they made use of analogies, metaphors and other rhetorical tools. It is sustained that they began by priming the reader to distrust the current interpretation of the fossil record offered by most paleontologists and then, in a second step, they used specific visual representations in order to suggest that the competitor theory was committed to the idea of an even and slow evolution at a constant rate, an image utilized by them as straw man. Finally, it is analyzed how, in their third step, Eldredge and Gould made use of several rhetorical arguments to present their theory as new for paleontology while, at the same time, placing it well inside the frame of the modern synthesis, and how they also managed to present their theory as more promising and capable of making predictions for future researches than the competitor theory.

KEYWORDS – Evolution, Eldredge, Gould, Punctuated Equilibria, Rhetoric

Introduction

Several recent studies have explored the role of rhetoric in social, political, and scientific discussions. The significance of rhetoric in scientific controversies is now widely recognized. Texts with important impact on the scientific community have been analyzed from the perspective of their rhetorical construction, seeking to show how the authors use rhetoric in order to make their arguments persuasive. Examples are the book by Shapin and Schaffer (1985) on Boyle's work with his air-pump,

and the studies of V. Betty Smocovitis (1996) and Leah Ceccarelli (2001) on Dobzhansky's *Genetics and the Origin of Species* of 1937.

The article where the theory of punctuated equilibria (PE) was first proposed (Eldredge and Gould 1972) is an important scientific text that has only been analyzed once, by Lyne and Howe (1986), as part of their larger examination of the ensuing controversy and only from the stand point of the audience it was targeted for. But we consider that an analysis of the arguments and rhetorical tools used in that paper is still absent and that it is especially appropriate because of the paper's influence on the paleontological community and the ensuing debate between the proponents of the theory of PE and the defenders of the modern evolutionary synthesis, a debate that lasted more than two decades. Therefore, we shall seek to show how rhetorical tools played a central role in the argumentation advanced by Niles Eldredge and Stephen Jay Gould in their seminal article.

The systematic study of the art of rhetoric began with the sophists of Classical Greece in the fifth century B.C. The sophists offered education in the arts of verbal discourse, inventing arguments and presenting them persuasively to a large audience. Rhetoric took hold as a major aspect of culture and education. According to sophists such as Gorgias, Protagoras, and Isocrates (all three disciples of Socrates), rhetoric was the mastery of persuasive discourse. These sophists viewed rhetoric as central for civilized and democratic social life, and as the center of education.

According to Plato's dialogue *Gorgias*, written in the opening decades of the fourth century B.C., the sophists' rhetoric was aimed to persuade about justice through the manipulation of public opinion. Plato recognized the power of persuasive language but thought that the power of rhetoric in the service of personal motives and directed to an uneducated audience would lead to the ruin of society.

For Aristotle, rhetoric was the counterpart of dialectic, a logical method of debating issues of general interest, starting from widely accepted propositions. In his most influential book on rhetoric, Aristotle defines the field as the ability of discerning in any given case the available means of persuasion. Rhetoric's "function is not simply to succeed in persuading, but rather to discover the means of coming as near such success as the circumstances of each particular case allow" (Aristotle 1355b). It is in this Aristotelian sense that we shall use rhetoric to discover the means of persuasion selected by Eldredge and Gould.

The theory of PE was first published in 1972, in a joint paper by Eldredge and Gould, which appeared in *Models in Paleobiology*, a book edited by Thomas J. Schopf. The theory proposes that most morphological

changes[1] in the evolution of organisms take place at the time of speciation[2]; that such speciation is allopatric[3] and occurs rapidly; and that, after the speciation event, the norm for a species is morphological stasis.[4] Since the beginning, the theory of PE was presented as a paleontological implication of the allopatric theory of speciation as developed by Ernst Mayr (1954; 1963), one of the founders of the modern (synthetic) theory of evolution. In spite of this claimed antecedent, the theory of PE soon became the center of a strident scientific controversy, which reached a climax in 1980 within the pages of *Nature*. By 1993 more than 23 articles by more than twenty authors had appeared in the journal, in support or against the theory. The scientific controversy was also pursued in other journals, such as *Science* and *Paleobiology*.[5]

The theory of PE has experienced various elaborations since its original formulation, mostly concerning the theory's implications, such as in the differential survival of species throughout the geological record (due, according to PE proponents to species selection). Nevertheless, the 1972 article formulated the basic core of the theory and established a theoretical model that would be followed by its supporters in their own investigations.

Eldredge and Gould developed three steps that, sequentially integrated, would make their argument compelling.

(1) Priming the audience to reject the current interpretive frame by arguing that a specific "picture" constrains our understanding without being conscious of it.
(2) Discrediting the competitor theory ("phyletic gradualism").
(3) Convincing the audience that the new theory ("punctuated equilibria") had greater explanatory power than the competitor theory ("phyletic gradualism") and that it could effectively explain phenomena that had not yet been satisfactorily explained.

Furthermore, Eldredge and Gould used different metaphors and rhetorical tools in each one of these steps. We shall show how the effective use of these tools helped the article to achieve significance within the paleontological community.

[1] Morphological changes are all changes that can be detected by studying the external appearance of an organism, alive or fossil. Physiological, behavioral, and other types of change not preserved in the fossil record are not included.

[2] Speciation is the process by which one species splits into two or more descendant species.

[3] Allopatric speciation occurs when the early genetic reproductive barriers – the crucial step for speciation – evolve between populations that are geographically separated.

[4] Stasis implies absence of morphological change for some period of evolutionary time.

[5] For a detailed account on the controversy and publication, see Cachón (2003).

First Step: Priming the Audience to Reject the Current Interpretative Frame of the Fossil Record

The first step in Eldredge and Gould's rhetorical argument was to create a need for the formulation of their own theory. To achieve this, they sought to persuade their audience that the current interpretation of the fossil record was misguided and that it was not based on actual facts. In order to make their point, Eldredge and Gould proceeded in an atypical mode for a scientific paper – they grounded their arguments on the philosophy of science, arguing that there cannot be completely objective observations in the absence of theory. The current interpretation of the fossil record was not objective, no matter how much we thought it was, but rather it was colored by a particular theoretical construct.

The first four pages of their 1972 article are devoted to showing that the inductivist credo of restricting causal explanations to actual facts is a chimera. This section is entitled "The Cloven Hoofprint of Theory" and just beneath is a brief head-note from P.B. Medawer, "Innocent, unbiased observation is a myth." The title contains Eldredge and Gould's first unusual metaphor for a scientific paper: Cloven Hoofprint suggests the devil. And the devil plus "unbiased observation is a myth," suggests a fall from innocence. But what devil and what innocence do they mean? The answer soon becomes clear. "All observation is colored by theory and expectation" (Eldredge and Gould [EG], 1972, 85)[6]; there is not an objective truth just waiting, as it were, to be captured by the observer. The failing is that we "do not recognize that all our perceptions and descriptions are made in the light of theory" (EG 85). Therefore the devils are the unconscious theories hidden beneath our perceived neutral observations and it is from this erroneous assumption, this innocence of thinking that facts can be collected under no theory, that we must awake.

Once Eldredge and Gould had philosophically established this general principle that all observations are theory-laden,[7] they tackled the paleontological issue. Congruent with their rhetorical argument, they began by warning that in paleontology " . . . even the most 'objective' undertaking, the 'pure' description of fossils, is all the more affected

[6] Quotations from the primary text we are examining (Eldredge and Gould 1972) are cited with the abbreviation EG.

[7] Eldredge and Gould do not explicitly commit to any particular version of the thesis that observation is theory-laden. On p. 83 of EG, they seem to adopt a weak version of it (i.e. two observers committed to different theories will see the same thing but describe it differently), whereas on pp. 85-86 they use a stronger version (i.e. the two observers see different things when they look at the same thing).

by theory because that theory is unacknowledged" (EG, 86). They then caution about the risk of falling in a vicious circle. "A theory compels us to see the world in its light and support. Yet, we think we see objectively and therefore interpret each new datum as an independent confirmation of our theory" (EG, 86). Therefore, we will not be able to notice it when data actually are contradictory unless we begin to see observations under a new and more adequate theory. They add a reminder:

> Science progresses more by the introduction of new world-views or "pictures" than by the steady accumulation of information.[8]
> This issue is central to the study of speciation in paleontology. We believe that an inadequate picture has been guiding our thoughts on speciation for 100 years. We hold that its influence has been all the more tenacious because paleontologists, in claiming that they see objectively, have not recognized its guiding sway. (EG, 86)

Eldredge and Gould are suggesting that what their theory is propounding is a new *picture* of the world, under which one will be able to read the geological record in a more adequate way and be better able to discern what actually happened in the past.

The word "picture," proposed as a neutral expression, becomes a second and dominant metaphor throughout the whole article. They announce that we are confronted with two alternative pictures: phyletic gradualism versus PE. Seeking to avoid the criticism that their own picture of PE may also be viciously circular (it leads us to interpreting fossils and inferring observations in a particular light), they warn that the best we can get from the world is just a picture; therefore, the best we can do is to choose the most accurate one. And "the picture of punctuated equilibria is more in accord with the process of speciation as understood by modern evolutionists" (EG, 99). Here, then, the two proposed metaphors interact: if we cannot avoid the Cloven Hoofprints of theory in our pictures, we should at least be conscious of them and select those pictures more in accord with as many other accepted facts as possible.

In short, by introducing a concept from the philosophy of science that was gaining popularity at the time, and by the use of the word "picture" as a guiding metaphor, Eldredge and Gould encourage their readers to distrust the interpretation of the fossil record offered at the time by most paleontologists.

[8] The parallel of this argument with Thomas Kuhn's (1962) notion of paradigm is evident. Nevertheless, Eldredge and Gould tell us that they will not enter the debate over what is, or is not, a paradigm and therefore they will use the neutral word, "picture."

Second step: discrediting the competitor theory

Eldredge and Gould embraced at least three different tools in their rhetorical argument for discrediting the explicative model (phyletic gradualism) that they had identified as competing with their own.

First, they chose specific visual representations in order to suggest that the competitor model defended the idea that speciation always – or at least usually – proceeds evenly and slowly, involving the entire ancestral population and producing "a long and insensibly graded chain of intermediate forms" (EG, 89). This is what we see in their figure 5-2, which purports to show a case of phyletic evolution (via G.G. Simpson's term of 1944; see below) that Eldredge and Gould rename as phyletic gradualism.

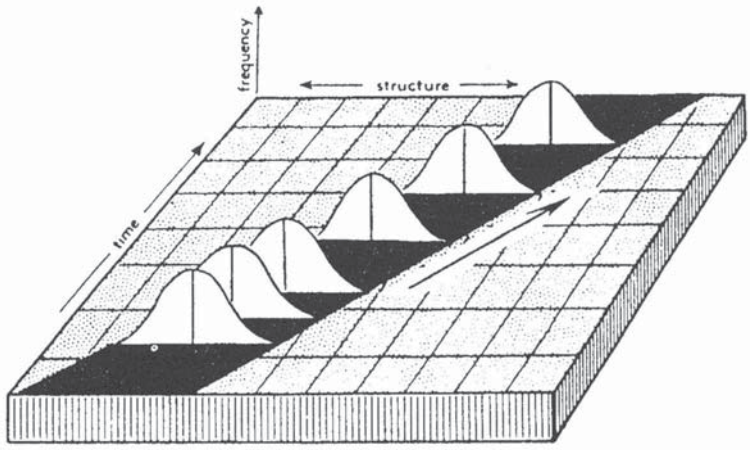

Fig. 1 - A standard textbook view of evolution *via* phyletic gradualism. From: Moore, Lalicker, and Fischer, 1952. (EG 1972, 89, figure 5-2)

Even in the representation of geographic speciation, smooth morphological transitions would remain the norm (as shown in the hypothetical case they reproduce in their figure 5-3; Fig. 2).

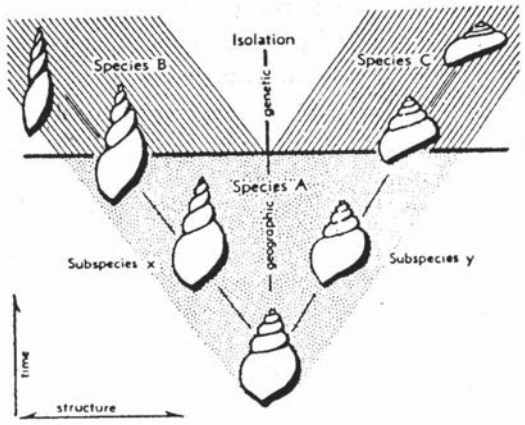

Fig. 2 - A hypothetical case of geographic speciation viewed from the perspective of phyletic gradualism - slow and gradual trasformation in two lineages. From: Moore, Lalicker, and Fischer, 1952. (EG 1972, 95, figure 5-3)

The illustrations that Eldredge and Gould chose as "standard textbook" representations of phyletic gradualism are some that emphasize a gradual, almost uniform process of change through time.[9] In this sense, their choice of these representations is rhetorical and not simply illustrative, as was later shown by Dennett (Fig. 3) in which he seeks to demonstrate that an apparently smooth and even pattern might very well look as "punctuated," if it would be amplified by focusing in shorter periods of time.

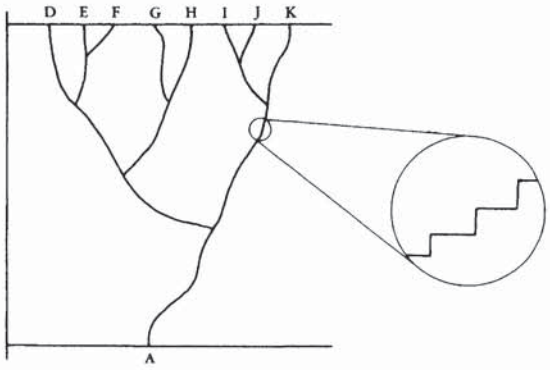

Fig. 3 - From Dennett, 1995, 284, figure 10.7.

[9] Antoni Hoffman (1992) has shown that the dominant American textbooks of the time did not advocate phyletic gradualism as defined and graphically suggested by Eldredge and Gould in 1972.

This figure, of course, is also rhetorically constructed. But it shows how the use of diagrams and illustrations is typically not neutral with respect to their authors' objectives. This was surely the case for the figures Eldredge and Gould used in their paper. The figures were selected for their effectiveness in characterizing the alternative model in a particular way.

The second rhetorical device used by Eldredge and Gould was the use of semantics for the same purpose of characterizing the competitor model. The type of evolution shown in Figure 1 was named *phyletic evolution* by George Gaylord Simpson in his seminal book of 1944. It was also referred to as *anagenesis*. Both terms were in common use well before 1972. Nevertheless, Eldredge and Gould coined a new phrase, "phyletic gradualism." By adding the word "gradualism" to the term "phyletic" they were implying, semantically, that this model was necessarily committed to the notion of a gradual and uninterrupted transition of one species into a new one. Their gradualness was read as a "constant rate" of change by the followers of the theory of PE.[10]

Eldredge and Gould proceeded to derive the implications of a term they had semantically altered. They claimed that the "picture" of phyletic gradualism was committed to the following tenets: new species arise by even and slow transformation of usually the entire ancestral population into its modified descendants; the transformation occurs over all or a large part of the ancestral species' geographic range. Having made these claims, they construct the following argument:

> These statements imply several consequences, two of which seem especially important to paleontologists:
> (1) Ideally, the fossil record for the origin of a new species should consist of a long sequence of continuous, insensibly graded intermediate forms linking ancestor and descendant.
> (2) Morphological breaks in a postulated phyletic sequence are due to imperfections in the geological record. (EG, 89)

These inferred consequences are important because they allow Eldredge and Gould to make their third rhetorical move for discrediting the competitor model: to accuse it of being unfalsifiable.

According to Eldredge and Gould's rhetorical argument, the phyletic gradualism picture prescribes a specific interpretation of the fossil record (i.e. that it is extremely imperfect) and this biased interpretation,

[10] Later, this characterization of phyletic gradualism would be severely criticized by several neo-Darwinian authors (particularly, Dawkins 1986; Maynard Smith 1993; Dennett 1997; see also Stebbins and Ayala 1981; 1985; and Ayala 1982) who would reject it as a "straw man" created so that it could be easily destroyed.

viewed improperly as if it were an "objective" interpretation, supports the picture. This is so, they tell us, because the phyletic gradualism picture of speciation prescribes the cases that are worthy of study. As the second consequence (above) implies, morphological breaks in the fossil record are due to imperfections of the record. Therefore, the sequences in which they occur are interpreted as poor examples for evolutionary surveys. Only stratigraphic sequences that show a noticeable continuous transition between forms are worth studying. Thus, "the picture itself excludes the investigation of the very cases that could place it in jeopardy" (EG, 90).

In short, by using specific visual representations that suggest that the competitor theory is committed to the idea of an even and slow evolution at a constant rate, by reinforcing this suggestion by the use of semantics, including coining the term "phyletic gradualism," and, finally, by blaming the opponent theory of being unfalsifiable, Eldredge and Gould, by the ninth page of their paper, have discredited the competitor model. Consequently, they are ready to attempt the third and most important step of their argument, to convince the audience that their own model is better.

Third step: convincing the audience about the superior features of the new theory

The theory of PE would be radicalized in later years,[11] but in their 1972 paper Eldredge and Gould did not present it as a competitor with the modern synthesis of evolutionary theory. On the contrary, presenting PE as consistent with and even a consequence of the modern synthesis is an important choice made by the authors in order to gain credibility for their new theory.[12]

[11] Particularly with the publication of Gould's (1980) paper on the need for a new evolutionary synthesis, which later in response to criticisms, Gould softened to a need for a revised synthesis (Gould 1982a, b). Gould stated that the modern synthesis has "broken down in both of its fundamental claims: extrapolationism (gradual allelic substitution as a model for all evolutionary change) and nearly exclusive reliance on selection leading to adaptation" (1980, 119), and that "a new and general theory" should be built under the principle that evolution "is a hierarchical process, with complementary, but different, modes of change . ." For a detailed analysis on these claims, see Stebbins and Ayala (1981) and Ayala (1982). For a critical evaluation of Gould's contributions to evolutionary theory see Ayala (2005).

[12] That the theory of PE did not confront the modern synthesis in its first article has already been noted by Michael Ruse (1992), Ernst Mayr (1992) and Antoni Hoffman (1992). However, they all fail to note that, as we believe to be the case, this was as a deliberated choice made by Eldredge and Gould in order to secure the initial survival of their theory.

Early in their paper, Eldredge and Gould announce that they have applied the theory of allopatric speciation to their own field and, by doing so, they have found a different interpretation of the paleontological data:

> If new species arise very rapidly in small, peripherally isolated local populations, then the great expectation of insensibly graded fossil sequences is a chimera. A new species does not evolve in the area of its ancestors; it does not arise from the slow transformation of all its forbears. Many breaks in the fossil record are real. (EG, 84)

Although the PE theory is grounded on Ernst Mayr's (1954, 1963) allopatric theory of speciation, Eldredge and Gould could have chosen to present it as an advance over the allopatric theory, as they did later (Gould and Eldredge 1977; Gould 1980; 1982a, b; Eldredge 1985). But in 1972 they chose to present PE as an attempt to bring paleontology closer to the theoretical framework of the modern synthesis.[13] This becomes clear in several paragraphs.

For example, they proclaim that the biological species concept[14] is a major triumph of the modern synthesis, although its application in the paleontological field has so far been scarcely practical because of "its 'non-dimensional' aspect: species are distinct at any moment in time, but the boundaries between forms must blur in temporal extension [as may be seen in their figure 5-3, which we have reproduced above (Fig. 2)] – a continuous lineage cannot be broken into objective segments" (EG, 92). However, they argue, the biospecies concept of the modern synthesis *has* something to contribute to paleontology – the theory of allopatric speciation.

> During the past thirty years, the allopatric theory has grown in popularity to become, for the vast majority of biologists, *the* theory of speciation. . .
> Most paleontologists, of course, are aware of this theory, but the influence of phyletic gradualism remains so strong that the discussions of geographic speciation are almost always cast in its light: geographic speciation is seen as the slow and steady transformation of two separated lineages – i.e., as *two* cases of phyletic gradualism. (EG, 94)

Eldredge and Gould go on to explain how, by applying properly the allopatric theory to paleontology and by seeking its implications, they

[13] Mayr thought that Eldredge and Gould had gone too far with their use of his allopatric theory, in that they suggest a prevalence of stasis after speciation and restrict most morphological change to the moments of cladogenesis (see Mayr 1992, 48).

[14] A species is defined by Mayr (1963) as "a population of interacting individuals capable of interbreeding, and reproductively isolated from all other groups."

have formulated the theory of PE. This theory, they claim, provides an alternative and more accurate "picture" of the fossil record and of the origin of new taxa. They remind us again that with the new picture they have done nothing but bringing paleontology closer to the modern synthesis.

> This alternative picture merely represents the application to the fossil record of the dominant theory of speciation in modern evolutionary thought. (EG, 108)

Thus, Eldredge and Gould are claiming originality by introducing in paleontology the theory of allopatric speciation already accepted by the modern synthesis. But is it correct that paleontology had previously failed to incorporate an allopatric model of speciation? It is not. G.G. Simpson (1944, 134, 193-195) had coined the term *tachytelic phylum* three decades earlier to describe a fast evolving group that separates from its stable adaptive zone to invade a new adaptive zone (thus implying allopatric speciation), and producing a pattern of "step-like" evolution, where it could be observed.

> The pattern of step-like evolution . . ., appearance of successive structural steps, rather than directly sequent phyletic transitions is a peculiarity of paleontological data more nearly universal than true rectilinearity and often mistaken for the latter . . . The steps preserved in the record represent the relatively abundant, relatively static populations of successively occupied adaptive zones, while the rare, rapidly changing transitional populations are, as a rule, absent from the record. (Simpson 1944, 194-195)

If Eldredge and Gould's concern had been to present their theory as an attempt to make paleontology congruent with and closer to the modern synthesis, they might have mentioned the similarity between their theory and Simpson's theory of *tachytelic phyla* (and they still could have pointed out that Simpson had addressed the issue from the perspective of adaptive zones, whereas they were dealing with its geographical implications). But they omitted any reference to Simpson's *tachytelic* model of speciation and referred, instead, to Mayr's allopatric theory of speciation.

Semantics played once again a role, given that the term *punctuated equilibria* describes much more graphically the visual consequences of geographic speciation in the fossil record than *tachytelic evolution* does. The choice of terms made by Eldredge and Gould was important in the perception by paleontologists that they were the first authors to bring allopatric geographic speciation into their own field.

Thus, Eldredge and Gould were successful in eloquently presenting their theory as something new for paleontology while, at the same time, grounding it on a speciation theory formulated within the modern synthesis. In this manner, they intended to show that the theory of PE was more in accordance with the modern synthesis than phyletic "gradualism" was and, hence, should be preferred over phyletic gradualism. It seems likely that Eldredge and Gould wanted to avoid, at that time, a confrontation with the supporters of the modern synthesis. An initial rejection of their theory by the community of evolutionary biologists might have been hard to survive. By presenting the theory of PE as in harmony with the modern synthesis, they managed to avoid a dangerous confrontation with the scientific disciplines that had framed the modern synthesis. That the theory of PE was not perceived as a menace by the supporters of the modern evolutionary synthesis becomes evident by the fact that the controversy between the supporters of the two theories did not start in earnest until 1980.[15]

However, by the time the controversy around the PE arose, the theory had already been well accepted within the paleontological field.[16] It had gained both strength and a hard core of supporters that could join Eldredge and Gould in the theoretical battle, as they actually did when the controversy started.[17]

One of the most important ways in which Eldredge and Gould could make their argument more persuasive was to present their theory as more fruitful and promising for understanding the actual pattern of evolution. Thus, PE was presented as a theory capable of solving, for example, the

[15] The controversy inside the pages of *Nature* began in July 1980 with an article from Mark Ridley (1980). Stebbins and Ayala (1981) and Ayala (1982) refuted the negative claims of Gould (1980) against the modern synthesis, while granting his central claim that macroevolutionary theory is, *epistemologically*, independent of population genetics theory. Stebbins and Ayala (1981) and Ayala (1982) pointed out that the claim of theoretical independence made by Gould conflated several issues, and that PE is not theoretically independent from, or incompatible with evolutionary genetics in two senses, "constitutive" (whether microevolutionary processes are involved in the changes described by the paleontologists) and "causal" (whether the mutation, selection, and other microevolutionary processes are sufficient to account for the paleontological observations or, rather, additional microevolutionary processes need to be postulated). Stebbins and Ayala (1981) and Ayala (1982) also pointed out the circularity, indeed vacuity, of Gould's (1980) claim that the fossil record shows that morphological change is invariably associated with speciation. The circularity of this claim emerges from the fact that paleontologists identify new species by showing that certain fossils are morphologically different from others. More strident criticisms of PE came later from two well known opponents of the theory, Maynard Smith and Richard Dawkins (Maynard Smith in 1984 and Dawkins in 1985).

[16] Michael Ruse (1999) has shown how, in the course of the first five years (1975-1979) since the first issue of *Paleobiology*, 24 articles cited Eldredge and Gould's paper, and in the course of the following five years (1980-1984) the number of articles citing their work grew to 64.

[17] The hard core was provided, among others, by P. G. Williamson (1981a, b; 1982), Steven Stanley (1975; 1982) and Elisabeth Vrba (1980; 1984).

old Darwinian problem of the apparent inconsistency between the fossil record and the record that should be expected if it adequately reflects the actual history of life:

> As a consequence of the allopatric theory, new fossil species do not originate in the place where their ancestors lived. It is extremely improbable that we shall be able to trace the gradual splitting of a lineage merely by following a certain species up through a local rock column. . . .
> Thus, in the fossil record, we should not expect to find gradual divergence between two species in an ancestral-descendant relationship. Most evolutionary changes in morphology occur in a short period of time relative to the total duration of species. (EG, 94-95)

But, if Eldredge and Gould were to convince their audience about the superior potential of the punctuational model, it was not enough to solve old problems. They also needed to be able to make predictions. The heuristic features of the new theory would need to be shown. And this they did.

> Tracing a fossil species through any local rock column, so long as no drastic changes occur in the physical environment, should produce *no* pattern of constant change, but one of oscillation in mean values. Closely related (perhaps descendant) species that enter the rock column should appear suddenly and show no intergradation with the "ancestral" species in morphological features . . . it is likely that the two species will display their greatest difference when the descendant first appears. (EG, 95)[18]

Therefore, with the punctuational theory there was not any need for subsidiary hypotheses about the incompleteness of the fossil record. The theory could make predictions that later could be tested by their opponents (who Eldredge and Gould thought in 1972 would be mainly other paleontologists).

> . . . theory predicts that most variation will be found among samples drawn from different geographic areas rather than from different stratigraphic levels in the rock column . . . .
> In any *local* section containing the ancestral species, the fossil record for the descendant's origin should consist of a sharp morphological break between the two forms. This break marks the migration of the descendant from the peripherally isolated area in which it developed, into its ancestral range. (EG, 96)

Nowhere in the 1972 article is the claim made more forcefully for the heuristic potential of the theory of PE than in its last section, "Some

[18] Notice the circularity of this claim, pointed out earlier (footnote 15).

Extrapolations to Macroevolution." Here Eldredge and Gould describe how their theory might be applied to predict the way macroevolution proceeds. And then, they argued that if their extrapolation fits the actual events better than phyletic gradualism as recorded by fossils, we should concede that their theory is more accurate than the competitor theory.

As a first example, they assert that "To many paleontologists, nothing is more distressing than the current situation in echinoderm systematics" (EG, 110). They refer to the recognition of at least 21 classes already present by the Ordovician (although only five survived the Devonian), along with the fact that eight of those classes had each only five or fewer genera; some of the classes had just a single genus:

> There are two aspects of this tale that fit poorly with the traditional view [of the phyletic gradualism model] of stately unfolding:
> (1) The presence of 21 classes by the Ordovician, coupled with their presumed monophyletic descent, requires extrapolation to a common ancestor uncomfortably far back in the Precambrian if Ordovician diversity is the apex of a gradual unfolding. . .
> (2) We expect that successively higher ranks of the taxonomic hierarchy will contain more and more taxa: a class with one genus is anomalous and we are led either to desperate hopes of synonymy or, once again, to our old assumption – that we posses a fragmentary record of a truly diverse group. (EG, 110)

This enigmatic situation, they argue, would disappear under the light of PE:

> Since speciation is rapid and episodic, repeated splitting during short intervals is likely when opportunities for full speciation following isolation are good. . . . When these repeated splits affect a small, isolated lineage. . . and when extinction of parental species commonly follows the migration of descendants to the ancestral area, then very distinct phenons with few species will develop. (EG, 110-111)

A second example was of greater consequence. It was about macroevolutionary trends (i.e. "a direction which involves the *majority* of related lineages of a group"). There are several well known trends, as the one that shows the evolution of horses towards increased body size and reduction in the number of toes. Although orthogenetic ideas had been excluded in the modern synthesis,[19] trends shown by the fossil record remained without a comprehensive explanation.

[19] George Gaylord Simpson (1944) took special care in this matter. He coined the term "orthoselection" to exclude the metaphysical implications of the word "orthogenesis."

> Many, if not most, trends involving higher taxa may simply reflect a selective rendering of elements in the fossil record, chosen because they seem to form a morphologically-graded series coincident with a progressive biostratigraphic distribution. In this sense, trends may represent simple extrapolations of phyletic gradualism. (EG, 111)

They point out that such a claim is "too facile an explanation for the large number of trends cited in the literature." They proclaim a practical demonstration of the heuristic features of their theory.

> A reconciliation of allopatric speciation with long-term trends can be formulated along the following lines: we envision multiple "explorations" or "experimentations" – i.e., invasions, on a stochastic basis, of new environments by peripheral isolates. There is nothing inherently directional about these invasions. However, a subset of these new environments might, in the context of inherited genetic constitution in the ancestral components of a lineage, lead to new and improved efficiency. Improvement would be consistently greater within this hypothetical subset of local conditions that a population might invade. The overall effect would then be one of net, apparently directional change: but, as in the case of selection upon mutations, the initial variations would be stochastic with respect to this change.[20] (EG, 112)

Eldredge and Gould make, once again, a rhetorical use of visual representations. In their figure 5-10 (Fig. 4), they show two contrasting patterns in a three dimensional sketch, where lineage A would show in the fossil record a pattern of relative stability, whereas lineage B would show a pattern with a clear directional trend. The important point is that the figure graphically shows that there is not any stability in lineage A nor any predictable trend in lineage B. Both lineages are splitting continuously, although by the punctuated model (sudden speciation events followed by stasis) and each speciation occurs in a stochastic direction with respect to the final pattern.

Figure 4 is hypothetical; it does not refer to any specific case. But, by showing with bold lines that the large moments of morphological stasis would be captured in the fossil record much easier than the sudden events of speciation (conveniently drawn with light dashed lines), it works rhetorically as an efficient tool to make their point.

[20] The idea expressed in this paragraph would later be developed by Stanley (1975) and Gould and Eldredge (1977) to form the concept of "species selection."

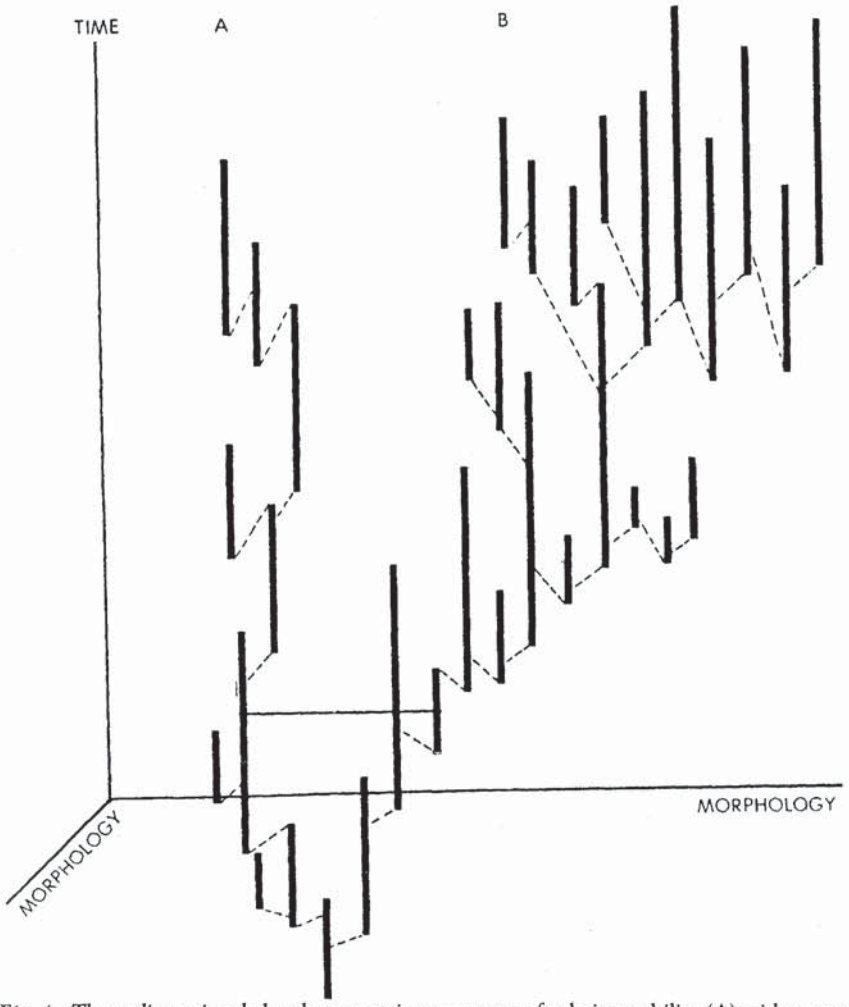

Fig. 4 - Three-dimensional sketch contrasting a pattern of relative stability (A) with a trend (B), where speciation (dashed lines) is occurring in both major lineages. Morphological change is depicted here along the horizontal axes, while the vertical axis in time. Though a retrospective pattern of directional selection might be fitted as a straight line in (B), the actual pattern is stasis within species, and differential success of species exhibiting morphological change in a particular direction. (EG 1972, 113, figure 5-10)

It is worth noting that this figure is designed to be seen as a confirmation to their theory, in much the same way figures 1 and 2 could be used in the opposite direction, for any diagram share the two rhetorical functions of refutation and confirmation.

The next move Eldredge and Gould made was to locate themselves

on the same methodological ground they had placed phyletic gradualism before, so they could not be accused of using their own biased "picture" without recognizing it.

> The idea of *punctuated equilibria* is just as much a preconceived picture as that of phyletic gradualism. We readily admit our bias towards it and urge readers, in the ensuing discussion, to remember that our interpretations are as colored by our preconceptions as are the claims of the champions of phyletic gradualism by theirs. We merely reiterate: (1) that one must have some picture of speciation in mind, (2) that the data of paleontology cannot decide which picture is more adequate, and (3) that the picture of punctuated equilibria is more in accord with the process of speciation as understood by modern evolutionists. (EG, 98)

They also address the likely concern emerging from selecting examples that show their theory as leading to better explanations:

> We could cite any number of reported sequences that fare better under notions of allopatric processes than under the interpretation of phyletic gradualism that was originally applied. This is surely true for all or part of the three warhorses of the English literature: horses themselves, the Cretaceous echinoid *Micraster*, and the Jurassic oyster *Gryphaea*. (EG, 99)

But nothing was better for their rhetorical argument than showing their own important achievements grounded on the punctuational model. They present Gould's (1969) analysis of the evolution of *Poecilozonites bermudensis*, during the last 300,000 years of the Bermudian Pleistocene and Eldredge's (1971; 1972) investigation of the phylogenetic history of the trilobite *Phacops rana* from the Middle Devonian of North America.

Both cases are described with considerable detail, advanced not only as good examples of how the punctuational model yields better results, but also presented with the purpose of their becoming models for future paleontological investigations. The message is that, from then on, if we pay enough attention to geographical details, under the tenets of the PE, the fossil record and the way species arise will finally be – as the model cases illustrate – successfully understood.

In short, in order to accomplish their third step, Eldredge and Gould make use of several rhetorical choices and arguments. First, they present their theory as new for paleontology (omitting any reference to Simpson's preceding ideas) while, at the same time, placing it well inside the frame of the modern synthesis, since they want to underscore that PE should be preferred because it is more consistent with the evolutionary synthesis than phyletic gradualism, but also because they want to avoid a dangerous confrontation. Second, they present their theory as more

promising and capable of making predictions for future researches than the competitor theory. Third, Eldredge and Gould continue making rhetorical use of visual representations, although in this case in support of their statements. Finally, they present their own researches with the intent of their serving as models for future investigations made under the light of the theory of PE.

Conclusions

The rhetorical perspective of Eldredge and Gould's joint paper contributes, we hope, some insight into the dialectical construction of the seminal text of the theory of PE, as well as into the particular arguments and rhetorical tools used to make it more persuasive.

The analysis of how Eldredge and Gould developed a three-step presentation manifests the rhetorical construction of the article. They start by priming the reader to distrust the current interpretation of the fossil record offered by most paleontologists and then they offer visual representations – aided by semantics – that suggest that the competitor theory (i.e., "phyletic gradualism") is committed to the idea of slow evolution at a constant rate, an idea that is not sustained by fossil evidence or by the geographic model of speciation. Moreover, Eldredge and Gould assert that the former theory is unfalsifiable, whereas PE can easily be tested (which would make it a better theory, because of this epistemological improvement). Finally, they seek to persuade evolutionists in general that the theory of PE need not be a matter of their concern, because although new for paleontology, PE fits well within the framework of the modern evolutionary synthesis, while it holds greater promise because it is more suitable for making predictions than phyletic gradualism, so that the theory of PE could well serve as *the* model for future investigations.

We consider that one of the causes that favored the long debate between the proponents of PE and the supporters of the modern synthesis during the 1980s and 90s, was the effective use of rhetoric in Eldredge and Gould's arguments, starting with their 1972 joint paper. But, whatever the individual weight of each one of the rhetorical tools and arguments advanced in order to make the PE theory persuasive, the fact is that the expectations raised by the 1972 article had a major and positive impact on the paleontological field, promoting new and valuable surveys, as may be seen in the several papers related to the PE predictions that were published in the ensuing years.[21]

[21] Among early papers in favor of the punctuational theory: R.A. Fortey (1974), Kellogg and Hays

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