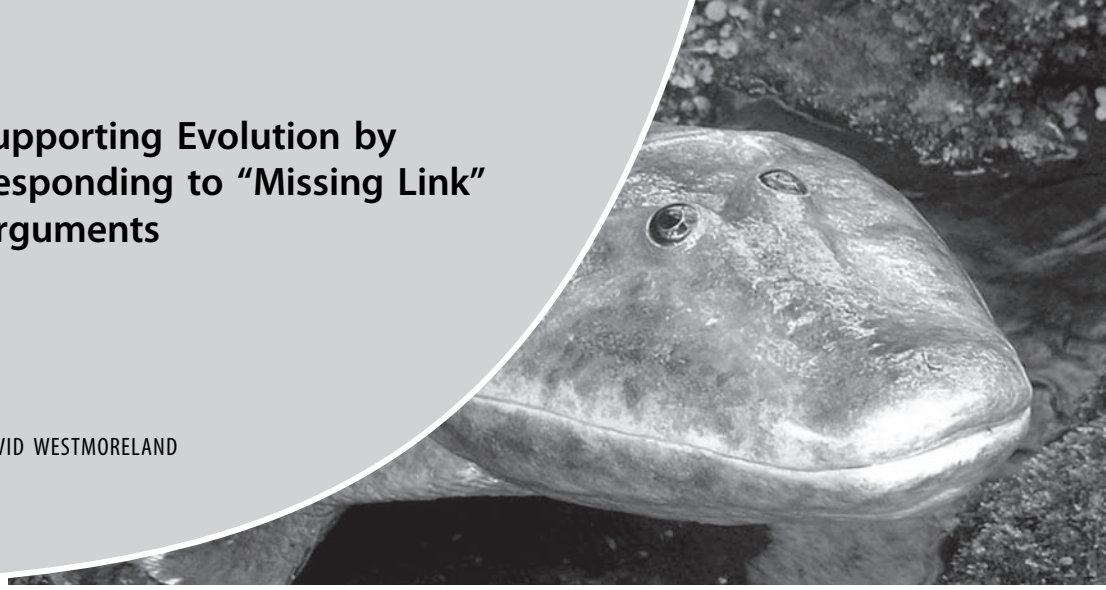
FEATURE ARTICLE

Supporting Evolution by Responding to "Missing Link" Arguments



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Abstract

The missing link argument is a common challenge raised by students to evolutionary theory; it notes that the majority of evolutionary transitions are not represented in the fossil record. A typical response is to present examples of fossils that have a combination of ancestral and derived traits, but I argue that this approach is largely ineffective because it does not address the broader question of whether the fossil record accords better with evolutionary theory than with creationist narratives. A better response is to agree that the fossil record is largely incomplete because fossilization is rare, and to direct the conversation toward addressing how a rich, yet incomplete, collection of evidence can be reasonably interpreted. Evolutionary theory and creationism pose starkly different expectations about trends in fossil diversity, and evolution is strongly supported while creationism is not.

Key Words: *evolution; missing links; critical thinking; transitional species.*

○ Introduction

Instructors of evolutionary biology are often challenged by students, particularly with regard to macroevolution. Large-scale evolutionary change is a socially controversial subject that requires an understanding of conceptually challenging and often abstract evidence. Whereas student challenges can be disconcerting to the instructor, they also offer an opportunity for critical thinking, provided the instructor and student devote the time to carefully examine the structure of the argument presented and the empirical evidence that can provide a resolution. This article examines one of many challenges to macroevolution—"missing link" arguments—and suggests an approach to responding that fosters critical thinking and steers the participants away from endless debate.

In this article I typically attribute the missing link argument to biblical literalists, but in fact, I have been challenged with it by students of diverse religious and non-religious backgrounds. Most of the responses I suggest are generally applicable to the argument itself, rather than to biblical literalism *per se*.

○ Structure of the Argument

The missing link argument can be stated as a formal syllogism in which two premises are presented as true, and a conclusion follows:

Premise 1: Evolution requires a continuous lineage of organisms from the first cells to all species that exist today.

Premise 2: The fossil record does not contain a continuous lineage.

Conclusion: Therefore, the fossil record does not support evolution.

Presentations of the argument in the biblical-literalist literature usually expand the conclusion to state that evolution is disproven in favor of the Genesis account of creation. For example, Patterson (2006) states:

> The geologic record should … be riddled with thousands of transitional forms that show a slow and gradual progression, as well as the many dead ends in the evolutionary story. The absence of these transitional forms and the abrupt appearance of many complex life forms is evidence that these groups were created by God and then later buried in the global Flood of Noah's day.

Literalists often state that Darwin expected fossil discoveries to fill in the gaps as scientific exploration continued in the 19th and 20th centuries (Thomas, 2009), but in fact, Darwin (1859) did not express such optimism. In chapter 10 of *The Origin*, which is devoted to the geologic record, he acknowledges the scarcity of fossils and does not predict substantial change:

> … we have no right to expect to find in our geological formations, an infinite number of those fine transitional forms … We ought only to look for a few links, some more closely, some more distantly related to each other …

Clearly, Darwin expected the fossil record to remain largely incomplete.

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○ Three Problems with the Argument

The primary weakness of the missing link argument is an assumption that underlies Premise 2, the assumption that fossilization is a common occurrence. Realistically, the probability of a species being captured in the fossil record is low (Prothero, 2007) due to several multiplicative factors: the prevalence of hard tissues in a decaying organism, the population density and geographic range of a species, whether the species occupies a habitat where sedimentation is ongoing, and the length of time that the species persists (Scott, 2005). The rarity of fossilization however, is more than just an argument; it can be empirically verified by estimating how many existing species are present in fossil form. For plants and animals, there are approximately 1.5 million named species currently in existence, and 250,000 named species of fossils from these kingdoms (Prothero & Singer, 1999). Thus, fossil diversity is about 15 percent of extant diversity. Few of the named fossils represent existing species, however, so the percentage of extant species that have fossilized is actually much lower. If fossilization were as common as biblical literalists presume, most extant species would be found in the fossil record.

A second problem with the missing link argument is that it is virtually nonfalsifiable, and thus is misaligned with scientific reasoning. In Figure 1, imagine that species A is proposed as the direct ancestor of species D, and the gap between them is presented as one in which a "missing link" should be found. If an intermediate species, B, is found, the record now contains two gaps; if yet another intermediate C is discovered, the skeptic can claim three gaps (Shermer, 1997). In essence, the structure of the argument ensures that the demand for evidence is always one step ahead of the evidence accumulated. For this reason, it can be futile to challenge the argument by presenting transitional fossil forms.

In fact, when teachers counter that "missing links" have been discovered, they are likely to leave the impression that an evolutionary lineage can be fully delineated from a sketchy fossil record. When scientists speak of a species being part of a lineage, the public understands this to mean that one species is a direct lineal connection between others, like the mother in a grandmother → mother → granddaughter relationship. There is, however, always the possibility that the lineage is collateral, like a grandmother → aunt → niece relationship; the aunt is a member of the lineage, but is not a lineal ancestor to the niece. Consider Figure 2. For one species to be the ancestor of another, it must occupy a branch or a node that is part of the direct lineage leading to the more recent species. Because the fossil record represents a small, nonrandom sample of the species that have existed, there is no way to determine whether any given fossil is collateral or lineal between two species (Prothero, 2007).

This confusion is easily reinforced by media reports. For example, the recent discovery of *Homo naledi* was appropriately described in the original publications as "a new species of hominin" (Berger et al., 2015; Dirks et al., 2015), and was described in the popular science media as a member of the human lineage (Wilford, 2015) in one case, and as a new species of human ancestor (MacDonald, 2015; Shreeve, 2015) in others. All of these descriptions are accurate if one does not attempt to distinguish between lineal and collateral relationships. But if they are interpreted to claim a lineal fossil sequence, the statements from the popular science media imply a deeper knowledge of evolutionary relationships than is justified by fossil evidence alone. (The use of complete lines in fossil diagrams can give the impression that a lineage is fully known. Better-designed fossil diagrams use dotted lines to identify the inferred relationships among fossils.) For this reason, teachers should avoid using the term "missing links," and instead refer to "transitional forms"; the latter term refers to a fossil that has characteristics of both the older and younger fossils, but does not imply that an exact lineage is known.

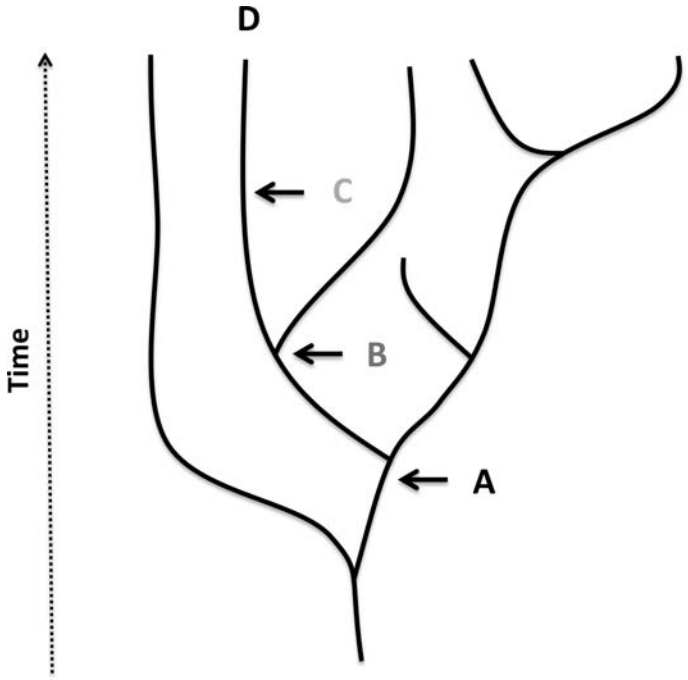

Figure 1. The missing link argument is inconsistent with scientific thinking because it is nonfalsifiable. If fossil B is discovered with transitional traits between A and D, two new missing links result (A → B and B → D). If fossil C is discovered to fill the transition between B and D, it again creates two more missing links (B → C and C → D). Thus, the missing link argument establishes a demand for evidence that is always one step ahead of the evidence discovered.

Finally, the missing link argument creates a communication hurdle because it is inherently based on the concept of species being static and non-evolving at certain time intervals. In Figure 1, the literalist perceives species A and D as static forms that were captured in the fossil record at different times. This perspective frames evolutionary change as something that occurs in the time interval between A and D, and if the purported transitional form is not found there, the fossil record can be claimed to have no evidence of evolution. The evolutionists' concept is markedly different; since evolution is an ongoing process, any given fossil is a snapshot of a lineage. From this perspective, a fossil can only occupy one of two states with respect to evolutionary change: it is either a species in transition, or a species on the brink of extinction. By the evolutionists' viewpoint, transitional fossils are not scarce in the geologic record—rather, they almost certainly make up most of the fossils that have been discovered.

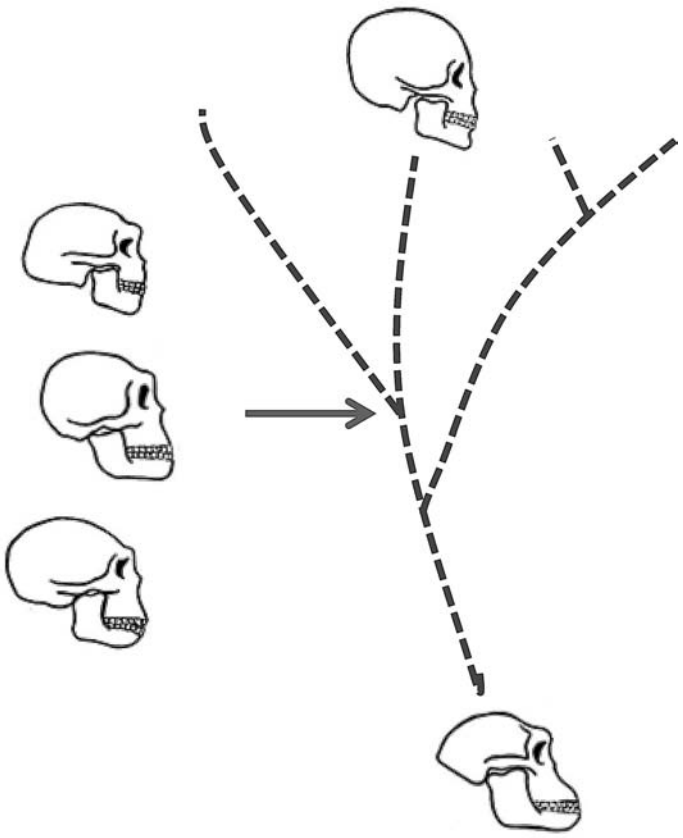

Figure 2. Why the missing link argument usually cannot be answered by the presentation of transitional species. The argument expects scientists to identify the species that occupies the direct lineage between an older and a younger species. The scientist can present transitional forms (in this case three) of species that have a mixture of old and new traits, and can often identify the most likely of the three species to occupy the lineal position. But since most species are not captured in the fossil record, there is seldom an empirical justification to conclude that any particular fossil is *the* lineal descendant of a previous species, as opposed to belonging to a side branch.

○ Responding to the Argument

As explained above, responding to the missing link argument with examples of transitional species is unlikely to form a convincing counterargument, and perpetuates the idea that fossils can be categorized as evolving or static, or that a fossil species can be verified as a member of the direct lineage between two species. A better approach is to acknowledge that the fossil record is largely incomplete and that fossilization is rare. This should not be a difficult position for either the teacher or the student, because the frequency of fossilization does not lend itself to either biblical literalist or evolutionist perspectives; it is simply an observation about how often a natural event occurs.

Given an agreement that fossilization is rare, a teacher can redirect the discussion to focus on how scientists might sensibly interpret a fossil record that is rich in information, but certainly a scant representation of the enormous diversity of life that must have existed if evolution is true.

Participants in the discussion can begin by considering the implications of a single fossil discovery. What can be said? Actually, quite little—only that a species with a certain set of characteristics existed at a period in time. When multiple fossils of the same species are known, the period can be bracketed by the ages of the oldest and youngest fossils, but no broader conclusions are justified from the record of a single species. Broad, conceptual ideas can only be developed by examining trends among fossils of multiple species.

Distinguishing Positive from Negative Evidence

Positive evidence—the presence of a fossil—has a straightforward interpretation. Negative evidence is more challenging. Can the absence of a fossil be interpreted to mean that a purported species never existed? No. Analogy to a photo album may clarify. In a series of photos depicting a family, positive evidence supports the conclusion that the family existed for some period of time. If the series stops—negative evidence—finding an explanation is more challenging. One can propose that the family was devastated by a disease, that they moved to a new location, or that the family camera broke. The point is that explanations for *individual* instances of negative evidence are principally speculative, and hard to evaluate empirically.

It is different, however, when there are consistent *trends* in evidence. If family photograph albums show up in a culture and spread rapidly (positive evidence), then disappear across that cultural group (negative evidence), it is likely that the population shared a common experience that led to these trends. A researcher could test competing explanations—changes in technology for storing photographic images, a mass migration from the region, or the emergence of cultural practices that constrain the practice of photography. Because broadly shared trends are more likely to leave evidence of causation, both positive and negative evidence are open to testable explanations.

And so it is with the fossil record. Even though it is largely incomplete, there is enough information to determine whether known trends in diversity are consistent with evolutionary theory. And indeed, some trends in fossil diversity are hard to explain except by evolution. For example, there are five periods of mass extinction in the fossil record, during which species diversity drops by more than 50 percent over a short period of time (Taylor, 2004). For all five mass extinctions, the record shows an increase in fossil diversity after the extinction, and the diversifying lineages are always related to species that existed before the extinction event. Figure 3 shows such a trend for vertebrates. At the end-Permian extinction around 250 Ma (million years ago), there was a substantial loss of diversity for cartilaginous and bony fish, amphibians and reptiles; following this, each of these groups exhibits an increase in fossil diversity. Evolution explains this as an adaptive radiation of those species that survived the extinction. In fact, evolution is the only scientific theory that offers an explanation for such patterns.

Contrasting the Predictions of Evolutionary Theory and Biblical Literalism

This discussion should be approached cautiously, since a teacher may be perceived as aggressively critiquing a student's faith. Whereas it is a legitimate goal of education to encourage students

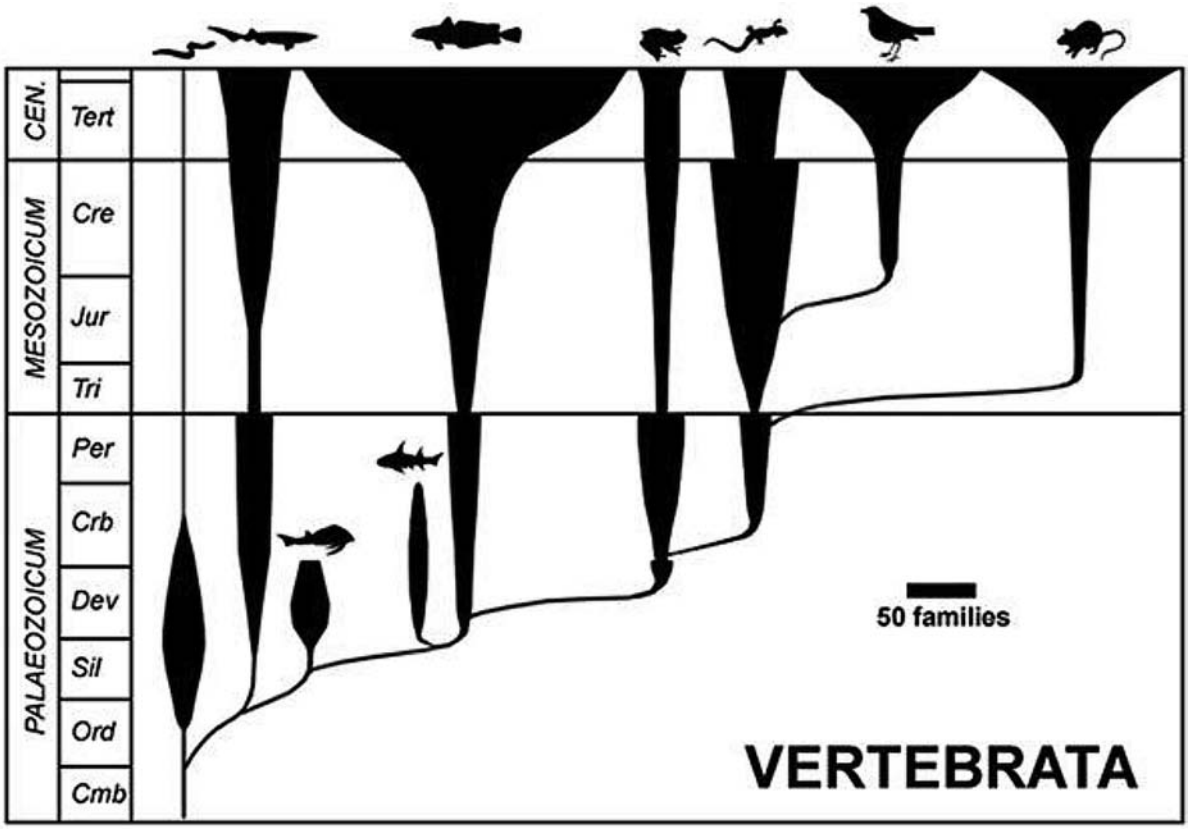

Figure 3. A trend in the fossil record that is inconsistent with creationist thinking, but explained by evolution. After mass extinction events, surviving lineages diverge. Strict creationism has difficulty explaining where the new species come from, and why they are based on taxonomic groups that existed before the event. The diagram is based on Benton (1998).

to question ideas, many students may not have developed the intellectual maturity to skeptically examine deeply held beliefs. Most students do not realize that religious and scientific thinking follow different rules, and have the goal of answering different types of questions (Gould, 1997). Science is committed to providing naturalistic explanations for observed phenomena, whereas religion does not recognize such a limitation. Likewise, science primarily seeks an understanding of how and why the natural world works the way it does, whereas religion is more concerned with determining an ultimate reason for human existence.

Nevertheless, biblical literalists make claims about the natural world that can be evaluated by science. For students who are ready for a discussion of such topics, there are straightforward examples of why evolution supplanted literalist thinking around Darwin's time.

The first example comes from the pattern of extinctions followed by diversification described above. Although this is consistent with evolutionary theory, it is incompatible with biblical literalism. Where do the new species that follow mass extinction events come from? One might hypothesize a separate creation following each mass extinction, but that idea does not explain why the diversifying groups are similar to a subset of the previously existing species; and in any case, the explanation is at odds with standard biblical literalism, which only allows for one creation event.

Similarly, evolutionary theory and biblical literalism make different predictions about the overall trend in fossil diversity. Evolution posits that the earliest fossil deposits should have low diversity, and subsequent deposits should vary in diversity as extinctions and adaptive radiations occur over time. Biblical literalism makes very different predictions. Early fossil beds should have greatest diversity since all species that ever existed were created then. Following that, there should be an extraordinarily rich fossil bed associated with the worldwide flood, followed by a period during which fossils are virtually absent due to universal depopulation. None of these predictions is supported by trends in fossil diversity.

The most powerful contrast, however, is related to the difference in precision between the predictions from evolutionary theory and biblical literalism. Evolutionary theory predicts the existence of species with transitional characteristics within defined time windows, whereas literalism makes no predictions about the characteristics of as-yet-undiscovered species, and is open-ended about the time window for any species' existence. Consider Figure 2. By literalist thinking, a species can be captured in the fossil record at any time between the original creation event and its extinction. In contrast, evolutionary theory is much more precise. Because evolutionary trends are studied by comparing older fossils, which have "ancestral" traits, to younger fossils with "derived" traits, organisms with a combination of ancestral and derived traits are predicted to be found in fossil deposits that were formed in the period between the two. This not only enables paleontologists to focus their search efforts, but generates a testable prediction that allows one to determine whether the fossil record is more compatible with biblical literalism

or evolution. If evolutionary theory is correct, fossils should be typically be found in the time window predicted. If literalism is correct, fossils should commonly be found outside the expected time window. Two examples will clarify.

In 2006, Daeschler et al. announced the discovery of a fossilized tetrapod-like fish. Far from an accidental discovery, they deliberately targeted the specific time window during which such a species should have existed. The scientists set out to find a fossil that shared characteristics between gars, the ancestral group whose fossils date to around 380 Ma, and early tetrapods which date to about 365 Ma. Scanning geological maps for sedimentary deposits, they identified an island north of the Arctic circle as a good hunting ground because it has exposed sedimentary rocks formed at 375 Ma (Shubin, 2009). They began the search in 2000, and after four years discovered *Tiktaalik roseae*, a fossil with ancestral features (a diamond-shaped scale pattern, the absence of a dorsal fin, paired frontal bones) and derived features (forefins with weight-bearing bone structure, a moveable neck, and spiracles on top of the head). To date, three fossils of *Tiktaalik* have been found, and all occur around the narrow time window predicted by evolutionary theory. By literalist reasoning, since *Tiktaalik* is confirmed to have existed in a fossil bed dated at 380 Ma, it could also be found in any older sedimentary deposit. It simply isn't.

The fossil record of horses provides a broader example. In 1940, the authoritative text on horse evolution described 15 genera in relatively recent sedimentary deposits (50 Ma to present) (Stirton, 1940). Since that time, fossil discoveries have more than doubled the known genera to 34 (MacFadden, 1994), all of which were found in deposits bracketed by the previously known genera. Biblical literalism would not have predicted the discovery of any additional equid fossils, and if any such fossils were discovered, they should have been distributed in multiple sedimentary deposits, ranging from the original creation until the near present day. There is simply no reason 19 new genera should have been discovered in a narrow time frame.

○ Closing the Discussion

As a final point, it can be instructive to move to the topic of how hypotheses and theories are evaluated in science. When multiple explanations compete to explain a set of observations, how do scientists resolve which is best? One approach is to determine which explanation is consistent with a broader collection of observations, while also noting the observations that remain unexplained by either theory. At the same time, scientists employ "if, then" reasoning (Lawson, 2000) to predict future observations on the basis of each idea—for example, that a fossil with a certain combination of characteristics should be found in deposits with a certain date range. It is on this basis that evolutionary theory has triumphed over biblical literalism.

Even before Charles Darwin proposed the theory of evolution, European geologists had accepted the principle of faunal succession, that fossilized species replace one another in a predictable sequence over broad geographic regions, and a single creation event was giving way to the idea of a series of creation events spread over time. What Darwin offered was an idea that explained a much greater range of observations, and which made specific predictions about future discoveries. Those predictions have been confirmed.

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