

Why “Sudden Appearance” Is Not as It Appears

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Abstract Recent action taken by the Texas State Board of Education has opened the door to the inclusion of creationist arguments into public school science curriculum in that state and—because of the critical role of Texas in textbook adoptions—perhaps in many other states as well. One of the arguments that have been targeted by creationists is the “sudden appearance” of animal phyla at the base of the Cambrian period (i.e., the Cambrian explosion). While the creationist argument is both misleading and deeply flawed, high school biology teachers are often lacking the relevant paleontological knowledge to refute the argument. This paper attempts to provide teachers with a set of core counterpoints to the creationists’ claims along with a list of online resources that are highly visual in nature and should provide the means to help stimulate genuine student critical thinking about this issue, an alleged goal of the creationist agenda.

Keywords Cambrian explosion · Sudden appearance · Fossil record · Creationism · Science standards · Critical thinking

The recent dispute between the legitimate scientific community and the Texas State Board of Education (TSBOE) has once again raised the specter of neo-creationism worming its way into public school biology classrooms. Although the ways in which the amended Texas science standards might be interpreted by both teachers and textbook publishers remain to be seen, the door for various creationist proponents to cast

doubt on evolutionary theory is clearly now open. A significant component of the arguments used by creationists to question evolution has always focused on interpretations of the fossil record. One area specifically singled out as a target by the creationist majority on the TSBOE is the issue of “sudden appearance” in the fossil record (National Center for Science Education website 2009; Newton 2009). As Newton (2009) points out, “sudden appearance” is creationist code for their explanation of the Cambrian explosion. This explanation asserts that the first appearance of fossils that can be assigned to many major animal phyla over a time period that could be as short as five to ten million years at the base of the Cambrian constitutes evidence for creation of these phyla by an “intelligent designer” whose identity must, of course, remain anonymous for constitutional reasons.

In the present article, the author will address the question of “sudden appearance” and its relation to the Cambrian explosion with the purpose of providing teachers with information that should help them refute attempts to use this invalid and deliberately misleading argument to raise doubts about evolution. As a biologist himself, the author believes this issue does present a very real problem for many high school biology teachers, mainly because they often have only a limited knowledge of the relevant paleontological evidence—a limitation which creationists are counting on. The central purpose here will be to provide a conceptual framework and a set of online resources that should allow high school teachers to address the Cambrian explosion and the “sudden appearance” argument preemptively and to make it crystal clear to students why the evidence strongly supports evolutionary theory. Furthermore, the resources cited are in a visual format that is conceptually appropriate for high school students.

The ostensible demand that creationists are making is that they just want students to be able to think critically about

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the evidence for evolution. It is time to call this creationist bluff. If teachers do a good job of presenting material of the type discussed in this article, and they motivate students to think critically about it, the “sudden appearance” argument will not succeed.

The Actual Fossil Record and What It Really Says About Animal Evolution

Let us begin by talking briefly about the pre-Cambrian. Creationists who deal with the “sudden appearance” argument like to leave students with the impression that the Cambrian explosion actually provides fossil evidence for the Creation as described in the books of *Genesis*. They will therefore conveniently neglect to present the clear fossil evidence that life extends back to at least 3.5 billion years before the present. To address this misconception, teachers should show students some of the many images of pre-Cambrian microfossils that are available on the web. The University of California Museum of Paleontology—<http://www.ucmp.berkeley.edu>—is a good place to start. Other good sites include: www.pnas.org/content/97/13/6947.figures-only and <http://www.cushmanfoundation.org/resources/slides/stromato.html>. Teachers should make it clear that these pre-Cambrian microfossils account for the majority of the history of life (about 80% of it in fact). If inclined to be philosophical, teachers might also raise a question here about why it took such a long time (i.e., just under three billion years) to evolve the earliest animals. Why were nearly three billion years required before single-celled creatures could give rise to the first animals?

The second point to make about the pre-Cambrian fossil record is that there are already a number of animal fossils present in rocks of late pre-Cambrian age—now often designated as the Ediacaran period. Although the precise phyletic affinities of these fossils are not fully resolved, there are clearly sponges, radial animals, and some bilateral forms present. Furthermore, there is additional evidence from molecular clock studies and paleobiogeography that many of the taxa that first appear as distinct fossils in the Cambrian have roots that extend well back (tens of millions of years back) into the pre-Cambrian (Knoll and Carroll 1999; Lieberman 2003). This should also be a central point that teachers make. In other words, the Cambrian explosion does not document the “sudden appearance” of *all* animal phyla. A significant number of animal phyla are *already* present prior to the explosion. It is simply that we remain unsure of their exact classification precisely because they are so different from living animals. To illustrate this, a page within the Berkeley museum site provides a series of excellent pictures and descriptions of these pre-Cambrian

animal fossils (<http://www.ucmp.berkeley.edu/vendian/critters.html>). Indeed, a fun and informative classroom activity can be built around having students try to hypothesize about the actual affinities of these early animal fossils. Such an exercise can perhaps lead students to think critically about the ultimately artificial nature of the concept of a phylum (or of any other taxonomic unit above the species level). In one of the evolution courses that the author teaches, student groups are assigned specific Ediacaran fossils from the Berkeley site and are required to develop a class presentation on their assigned fossil including any evidence that can be brought to bear on the taxonomic interpretation of the fossil. Another excellent site dealing with early animal life is the Queen’s University Miller Museum of Geology at: <http://geol.queensu.ca/museum/exhibits/dawnex.html>.

The next logical element in a discussion of the Cambrian explosion should be a clarification of just what “exploded.” The answer is actually reasonably straightforward and has been known to paleontologists for many years. What we see for the first time in life’s history at the base of the Cambrian 543 million years ago are animal “hard parts” (i.e., shells, skeletal elements, plates, etc.). The presence of such “hard parts” makes fossilization much more likely. Consequently, we do see a large-scale increase in the number of species that we can now see as fossils, not because they are suddenly arising *de novo* but because many are being preserved as fossils for the first time. In this context, teachers should also note that the five to ten million year minimum time span generally allotted to this proliferation of animal “hard parts” is hardly “sudden.” Approximately the same time frame encompasses the entire hominin fossil record leading to modern humans. For teachers who would like a somewhat more comprehensive treatment of these issues, see the articles by Lieberman (2003) and Knoll and Carroll (1999). Originally published in *Science*, the Knoll and Carroll article can be accessed online at: http://cas.bellarmine.edu/tietjen/Ecology/early_animal_evolution.htm.

So what did these Cambrian animals look like? In fact—and this is another major point for teachers to make—most looked nothing like the species living in the animal world today. Once again, the web can provide teachers and their students with striking images of these Cambrian fossils. The Utah Fossil Page at the University of Utah College of Mines and Earth Sciences is a great place to start (<http://www.earth.utah.edu/utahfossil/>). The Smithsonian has an excellent page on the famous Burgess Shale fauna (<http://paleobiology.si.e.du/burgess/>). Another excellent website dealing with many aspects of the Cambrian is found at the University of Kansas (<http://www.kumip.ku.edu/cambrianlife/>). Finally, the Virtual Fossil Museum has a

lot of information on the Cambrian explosion, with images of many of the fossils that document it, including the famous Chengjiang location in China (http://www.fossilmuseum.net/Fossil_Sites/Chengjiang.htm). When teachers have their students search these sites, they should challenge them to find fossils of species that can still be found today. *They will not find any* (see discussion of key questions below). *Put simply, a critical examination of the various Cambrian faunas will directly falsify any implied creationist claims that these somehow represent the sudden creation of animals that are living today.*

Key Questions to Ask Students to Think Critically About

One question that is frequently not addressed in superficial discussions of Cambrian animal fossils is this: “Which fossil species that we can identify at any time throughout the entire 53 million year span of the Cambrian period are still living today?” The answer is striking and easy to understand. The percentage of known Cambrian species alive today is *zero*. No known Cambrian species has survived to the present. Now, if the Cambrian explosion did actually represent evidence for “special” creation, it would indeed be odd that none of these creations remain. In fact, the overwhelming message of the fossil record is that more than 99% of the species that have lived are extinct! If we really want students to think critically about this, we ought to ask them to think about why this should be so. In other words, is constant and unrelenting extinction of species throughout the fossil record actually consistent with good design?

Another seminal question to ask is this: “What kinds of species are *not yet* present in the Cambrian?” The answer is clear and the list is long and informative. There are no birds, no mammals, no reptiles, no amphibians, no jawed fishes, and no insects, nor are there any higher plants of any kind. Indeed, macroscopic life in the Cambrian is still restricted to aquatic habitats. Any vertebrates that are present are limited to extinct types of jawless fishes whose relationships to living vertebrates are obscure at best. The diversity of species that we see living today is accounted for largely (more than 90% of known species) by two groups—the insects and the flowering plants, *none* of which are present in the Cambrian.

The bottom line here is simple—and teachers should drive the point home. Animals were clearly present *before* the Cambrian explosion and *almost none* of the species that we associate with the dominant forms of

animal life today appear *anywhere* in the Cambrian, let alone “suddenly”!

One of the mantras of the most recent variety of creationists’ attacks on the integrity of science education is to let students “critically evaluate the evidence both for and against evolution” (the “teach the controversy” strategy; see Scott and Branch 2003). But the fact is that the alleged evidence against evolution simply is not there. Indeed, I believe that almost all of my colleagues share my very real enthusiasm for teaching students to think critically (or, more accurately, helping them to learn to do so). But most of us do not believe that is really what creationists have in mind. Rather, they want students to see only bits and pieces of carefully filtered “evidence” that will be contrived by teachers who hold a creationist perspective so as to raise doubts about evolution in the minds of students. Their incomplete and misleading presentation of the Cambrian explosion as evidence for “sudden appearance” is typical of this approach. As shown above, their treatment of the early fossil record typically neglects the nearly three billion years of documented evolution at the cellular (i.e., microfossil) level, tries to minimize the pre-Cambrian fossil record of animal evolution, makes inferential claims about the appearance of most animal phyla in the Cambrian that ignore the lack of similarity of these Cambrian animals to modern forms, tries to falsely equate a five to ten million year span of time to an instantaneous event, and usually fails to mention both the total extinction of Cambrian animals and the absence among Cambrian fossils of many modern groups including most vertebrates as well as the insects and flowering plants, the two groups that account for the vast majority of macroscopic organismic diversity in the living world of today. “Sudden appearance” is certainly not as creationists want it to appear. As stated at the beginning of this article, a clear presentation of the fossil evidence combined with some genuine student critical thinking about this evidence should make “sudden appearance” disappear as an objection to evolution.

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