

FOSSIL SUCCESSION: FURTHER DEBATE



*Darwin himself was well aware of the problems that the fossil record posed for his theory. He spent two chapters in the **Origin** discussing the fossil record, the first of which was devoted almost entirely to analysing why the fossil evidence did not fit better with the theory of Common Descent. Where were the multitudes of transitional forms connecting different groups, as predicted (and expected) by his theory?*



According to Darwin, the answer was clear: the fossil record is “extremely imperfect.” It simply failed to document transitional forms. “Nature,” wrote Darwin, “may almost be said to have guarded against the frequent discovery of her transitional or linking forms.”²⁵

Artifact Hypothesis: Are the “Gaps” Real?

Modern neo-Darwinists have proposed an explanation for the imperfection of the fossil record, an explanation that supports Darwin’s view. They call this explanation the “artifact hypothesis.” According to this view, events like the Cambrian explosion do not show that new forms of life arose suddenly. Instead, they simply show that the fossil record has been poorly sampled, and that the fossils themselves were not consistently preserved. The unfortunate and misleading result is an apparent absence of ancestors. In other words, advocates of the artifact hypothesis say that the Cambrian explosion is not real; it is only

the result—or an “artifact”—of having too small a sample of fossils to work with.

Critics of the artifact hypothesis have pointed out a number of problems with this explanation. They agree that a poor (small) data sample could create an artifact, or false impression. But *is* the sample too small? Many palaeontologists would argue that we have plenty of fossils. Palaeontologist Mike Foote points out that, although we continue to find new fossils, those we find belong to phyla and other major groups that we already knew about.²⁶ This strongly suggests that the pattern of the fossil record (sudden appearance, stasis, and distinct gaps between major groups) is truly representative of the history of life, not just an artifact of poor data sampling.

As Foote concludes, “We have a representative sample... and therefore we can rely on patterns documented in the fossil record.”²⁷

Soft and Small?

Is it possible that the missing Precambrian transitional forms were too small to be fossilised?

Could it be that the intermediates weren't fossilised because they didn't have hard body parts like teeth or exoskeletons? Some defenders of Common Descent say yes, and point out that small structures and soft tissues are more susceptible to decay and destruction, and are, therefore, harder to preserve. This would explain why they are absent from the fossil record.

Critics agree that soft, small structures are more difficult to preserve. However, they point out that Cambrian strata around the world have yielded fossils of entirely soft-bodied animals representing several phyla.²⁸

This point has been further emphasised by a recent Precambrian fossil find near Chengjiang, China. Scientists there recently discovered incredibly preserved microscopic fossils of sponge embryos. (Sponges are obviously soft-bodied. Their embryos are small and soft-bodied, too—other than their tiny spicules.) Paul Chien, a marine biologist at the University of San Francisco argues that this discovery poses a grave difficulty for the artifact hypothesis. If the Precambrian rocks can

preserve microscopic soft-bodied organisms, why don't they contain the ancestors to the Cambrian animals?²⁹ If a soft-bodied embryo can be preserved, why not an adult animal?

New “Soft” Evidence

Trace fossils provide additional evidence that the Cambrian Explosion was real. When an animal burrows through sediment, it leaves tracks or burrows behind. These tracks can be fossilised. We call these fossilised animal tracks *trace fossils*. Both soft- and hard-bodied animals could leave trace fossils. Here's the point. If lots of soft-bodied animals existed before the Cambrian, then we should find lots of trace fossils. But we don't. Precambrian sedimentary rock records very little activity. However, at the beginning of the Cambrian explosion, we see a dramatic increase in trace fossils all over the world.³⁰

Punctuated Equilibrium

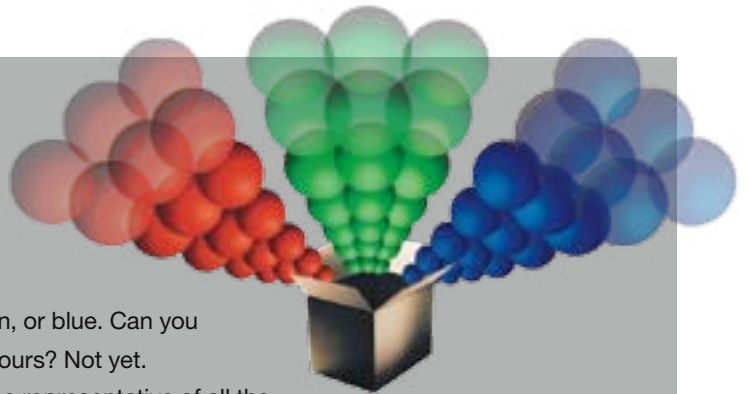
Many palaeontologists are well aware of the conflict between the fossil record and neo-Darwinian

Statistical Sampling 101

Suppose you find a big box of marbles. You reach in and grab six marbles at random. When you remove the marbles, you discover that each marble is either red, green, or blue. Can you assume that the box contains only these colours? Not yet.

This sample is so small that it may not be representative of all the colours in the box. There could be a rainbow of intermediate colours in there. The “three colours only” hypothesis might be an artifact of a small sample.

However, you keep going until you've pulled about 1,000 marbles out of the box. You look at them all, and still find only red, green, and blue ones. There are still some marbles left in the box. What colours would you guess they are? ■



The Vendian Fossils: Was the “Cambrian Explosion” Really Explosive?

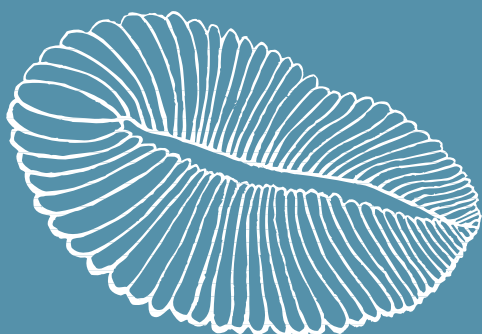
Some exciting fossil finds have revived the hope that the fossil record does, in fact, reveal evidence of Precambrian transitional forms. Four types of fossils of multicellular organisms have been found in a Precambrian stratum called the Vendian layer (565-570 million years ago) in numerous locations, including England, Newfoundland, the White Sea in northwest Russia, and the Namibian desert in southern Africa.*

The Vendian layer contains a number of strange creatures with strange names: *Kimberella*, *Dickinsonia*, and *Spriggina*. Some scientists have suggested that these odd creatures may well be the fossilised precursors that neo-Darwinists have been looking for.

Other scientists contend that the Vendian fossils aren't much help in explaining the Cambrian explosion. At best, the Vendian creatures might represent ancestral forms of a small fraction of the many new phyla that arise in the Cambrian. Except for *Kimberella*, a primitive mollusk, the body plans of these fossilised organisms have no clear relationship to any of the new organisms that appear in the Cambrian explosion, or thereafter. Others, like *Dickinsonia* and *Spriggina*, do not have eyes, mouths, or anuses, which has led many biologists to question whether these organisms were even animals. ■

*The new fossil discoveries include the strange Ediacaran fossils named for the site of the first Vendian find in the Ediacaran Hills in the Australian outback.

A. H. Knoll and S. B. Carroll, “Early animal evolution: Emerging views from comparative biology and geology,” *Science* 284 (June 25, 1999):2129-2136.



Dickinsonia Illustration by Andrew Johnson

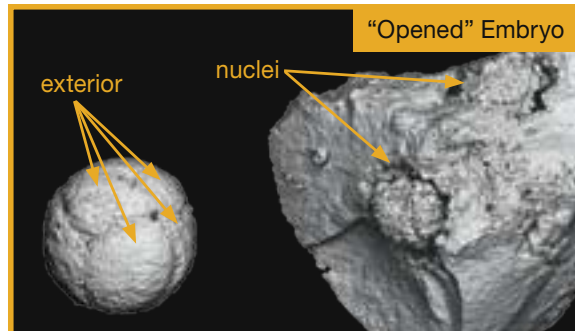


Figure 1:10 These are actual photographs of fossilised sponge embryos in early stages of cell division. The image on the left shows a sponge at the 8-cell stage of division, with four of its cells marked in the foreground.

theory. In the traditional view, the fossil record was always to blame for the missing pieces of the evolutionary puzzle. Darwin, himself, had said the fossil record was “woefully incomplete.”³¹

By the early 1970s, some scientists, including palaeontologists Niles Eldredge and the late Stephen Jay Gould, began to become dissatisfied with this explanation. “We palaeontologists,” wrote Eldredge, “have said that the history of life supports that interpretation [of gradual adaptive change], all the while really knowing that it does not.”³²

Eldredge and Gould decided to take a different approach. Instead of blaming the fossil record, they accepted the fossil data at face value. They agreed that the fossil record really does show many groups of organisms appearing abruptly, continuing unchanged for millions of years, and then going extinct. “Stasis is data,” they insisted.³³

Eldredge and Gould advocated a new evolutionary theory called “punctuated equilibrium,”³⁴ a theory that says the history of life is still best represented as a single branching tree (Common Descent), but the branches split off very quickly.

This brings up an interesting question. How could the branches split off so quickly? Different advocates of punctuated equilibrium have

suggested various theories of how biological change could occur rapidly.³⁵ One of the most popular is called *species selection*.

Species Selection

Traditional neo-Darwinism emphasises competition among *individuals* within the *same* species. Species selection stresses competition among rival *species*. This mechanism, say the theory's advocates, would produce rapid changes in body structure. Species selection acts on larger differences in biological form—differences between whole species, rather than differences between siblings. Evolutionary change would thus take place in bigger jumps. As a result, the branches in the Tree of Life would split off so abruptly that they would appear virtually horizontal.

Sudden species change means that fewer intermediate forms between species would have existed, and would only rarely be preserved. So, the fossil record would not preserve the “punctuation,” it would only preserve the “equilibrium”—the new forms of life which remained stable over long periods of time.

Big Change in a Short Time?

Punctuated equilibrium was immediately attractive to many palaeontologists because it described the fossil record more accurately than neo-Darwinism had done.³⁶ However, many critics of the theory pointed out that punctuated equilibrium has never explained how the major changes recorded in the fossil record could have taken place in such a short time.³⁷

Though scientists have proposed mechanisms to complement the theory of punctuated equilibrium, they have not solved this problem, critics contend. They note that species selection can at best only explain the origin of new species. It does not explain the origin of higher taxonomic groups (like phyla and classes). To describe how

one species of trilobite evolved into another is not the same as explaining how trilobites arose in the first place. Nor does species selection explain the origin of new body plans or new structures (like wings and eyes) that arise with the higher taxonomic groups. Why not? Higher taxonomic groups are distinguished from one another by their distinctive traits and physical features. But what produces these new traits? Even advocates of punctuated equilibrium acknowledge that the driving force behind this process is still natural selection acting upon small genetic variations. But generating a phyla-level degree of biological change in this way takes time—and lots of it.

And that's the dilemma, say the critics. If the theory of punctuated equilibrium is right about the rate of evolutionary change—if it accurately describes how rapidly the branches of the Tree of Life split off—then it has no mechanism that can produce new structures as rapidly as the fossil record shows them arising. As invertebrate zoologist Jeffrey Levinton argues, “[I]t is inconceivable how selection among species can produce the evolution

- Some critics say neo-Darwinism is not consistent with fossil data.
- Other critics say that punctuated equilibrium is consistent with fossil evidence, but lacks an adequate mechanism.
- Critics of both views argue that there are still far fewer transitional forms in the fossil record than we would expect, even if new forms of life did arise quickly.

