Weird Wonders

Was the Cambrian explosion a big bang or a whimper?

The turbulent sediments of paleontological thought are being roiled by a new and passionate debate. At issue is why so many curious animals seem to have evolved at more or less the same time, at the start of the Cambrian era, about 560 million years ago.

At the center of the dispute is the iconoclastic Harvard paleontologist Stephen Jay Gould. He rejects the usual explanation for the "Cambrian explosion." According to this view, many new ecological niches—such as becoming a predator—opened up when animals first evolved extensive hard tissues. Gould does not see how such an event can account for the astonishing range of bizarre creatures exquisitely preserved in the mid-Cambrian Burgess Shale in British Columbia.

In his 1989 book, *Wonderful Life,* Gould argued that special evolutionary processes must have occurred to create such "weird wonders." He scandalized paleontologists even further by arguing that chance rather than genetic fitness was the principal agent that selected which of the curious animals then living would populate the earth with their descendants.

More traditionally inclined paleontologists are not letting such radical notions harden into accepted theory. "We are concerned that Gould's claims are rather larger than the evidence can actually bear," says Richard A. Fortey of the British Natural History Museum. And Derek E. G. Briggs of the University of Bristol, who reconstructed many of the Burgess fossils and was one of the heroes of Gould's tale, is now arguing against its conclusion. Briggs says he is trying to "dampen the Cambrian explosion."

The fossils in the Burgess Shale are indeed puzzling. Most of them, just a few centimeters long, have been reconstructed over the past decade by paleontologists working in England. Among them are Briggs and his colleagues Harry B. Whittington and Simon Conway Morris of the University of Cambridge. Many of the fossils are thought to be arthropods, but some resemble crustaceans, whereas others have characteristics of spiders and scorpions, horseshoe crabs or trilobites. Yet most of the fossils are not strictly any of these things. They have too many head segments or too few antennae or some other feature that prevents them from fitting into known groups.

Gould recounted in *Wonderful Life* that at least eight Burgess Shale forms did not conform to any of the high-ranking groups called phyla. Among these evolutionary quirks were *Hallucigenia,* a wormlike creature that Conway Morris named for its "dreamlike appearance," and *Wiwaxia,* also reconstructed by Conway Morris. *Hallucigenia* apparently walked on a double row of spines and bore a single row of tentacles along its back. *Wiwaxia* was a flattened oval creature that crawled through bottom sediments, its back covered with plates from which protruded two rows of spines.

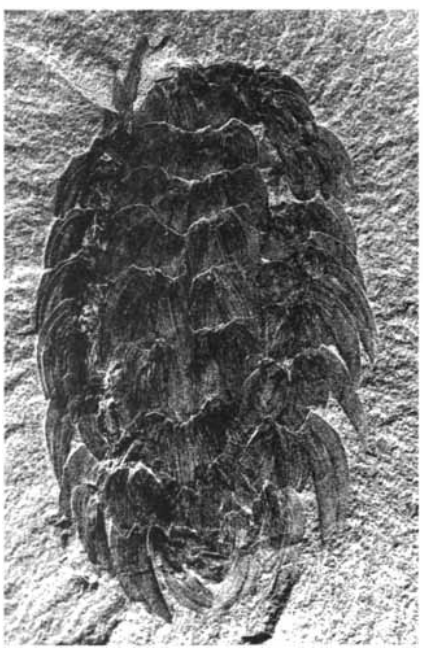
Inspired by such strangeness, Gould suggested that "today's oceans contain many more species based on many fewer anatomical plans." After the early Cambrian flowering, Gould argued, "the history of life is a story of massive removal followed by differentiation within a few surviving stocks."

It did not take long for other biologists to start picking holes in Gould's claim that the diversity of Cambrian animals could not have been produced by conventional evolution. Several reviewers pointed out that Gould's arguments rely on the taxonomist's habit of putting unfamiliar fossils into new classes. That practice "has the effect of exaggerating the apparent degree of disparity resulting from the Cambrian radiation," Briggs asserts. "The sample of [Cambrian] organisms available to us is both morphologically and ecologically less rather than more diverse than the living arthropod fauna."

Other paleontologists have come to similar conclusions about the dangers of using taxonomic oddity as a means of assessing diversity. Andrew B. Smith of the British Natural History Museum believes that several studies of echinoderms—starfish and the like—have fallen into the same error, falsely concluding that evolution was in overdrive during the Cambrian.

Moreover, some of Gould's prime examples of Cambrian uniqueness have started to disappear. Although at the time Gould wrote *Wonderful Life* paleontologists classified both *Wiwaxia* and *Hallucigenia* as creatures with no known relatives, opinions are changing. In 1990 Nicholas J. Butterfield of Harvard University published in *Paleobiology* a high-magnification study of the spines and plates of the enigmatic *Wiwaxia.* According to Butterfield, the results indicate that the creature can be classified as a polychaete worm, a well-known group with more than 5,000 living species.

Then, last year, L. Ramsköld and Hou Xianguang argued in *Nature* that *Hallucigenia* had seemed so strange to Conway Morris mainly because he had got it upside down. Minute comparisons with other fossils indicated that *Hallucigenia*'s two rows of spines were actually armor, not legs. And the single row of preserved tentacles was almost certainly half of a pair of rows of tentacular legs. The inverted *Hallucigenia*



BIZARRE FOSSILS from the Burgess Shale in British Columbia are being recognized as members of known groups. **Wiwaxia corrugata (left)** ***may be related to the living*** **Bhawania heteroseta (right),** ***a polychaete worm.***

thus became recognizable as a member of the phylum of soft-legged worms known as Onychophora (although some researchers, including Butterfield, are not convinced).

Other anomalous Burgess Shale fossils might follow *Wiwaxia* and *Hallucigenia* into respectability. *Amiskwia,* a rare Burgess Shale swimming organism that Gould believed was an orphan, might actually belong to the obscure phylum known as Chaetognatha, Butterfield contends. And according to Conway Morris, even Gould's prize superweirdo, a startling, large predator called *Anomalocaris,* may be related to a newly discovered fossil group.

Gould is not giving up the fight. He says the recent recognition that *Hallucigenia* and *Wiwaxia* may belong to known phyla cuts both ways. Their new status may decrease the number of Cambrian phyla, he points out, but it increases the diversity within the remaining phyla. And in any event, there are plenty of other strange cases. "Much as I hate to lose an example," Gould says, "if I had to lose one it would be *Hallucigenia.* The fact remains that the Cambrian was a melting pot."

But Gould has made one tactical retreat. In *Wonderful Life* he derives strong support for his argument from Burgess Shale creatures that cannot be assigned to known groups. But he now concedes that taxonomic strangeness is itself irrelevant for assessing diversity. Gould acknowledges that his claim of extraordinary variety "cannot be confidently established until we develop quantitative techniques for the characterization of morphospace."

Unfortunately, it is far from clear how evolutionary variety can be measured without bias, because the entire Linnaean classification system for animals is based on living organisms. "Our modern prejudices influence our perceptions of morphological disparity," says Mark Ridley, an evolutionist at Emory University. But Fortey and Briggs are trying to assess diversity in an unbiased way, and according to Fortey, "so far the evidence is either ambiguous or does not support Gould."

Despite the disputes, everyone agrees that the Cambrian was a period of rapid change. The question is whether it was so rapid that unconventional evolution is needed to explain it. Until paleontologists achieve a better understanding of the Cambrian explosion, Ridley says, such unconventional hypotheses are "a solution awaiting a problem." And Lady Luck remains tantalizingly in the shadows, pulling some of evolution's strings—but nobody knows how many. —*Tim Beardsley*