

j32 The importance of the Burgess shale < soft bodied fauna >

Only about 33 animal body plans are presently [*sic*] being used on this planet (Margulis and Schwartz, 1988).

—Scott F. Gilbert, *Developmental Biology*, 1991.¹

Almost all animal phyla known today were already present by 505 million years ago—the age of the Burgess shale, Middle Cambrian marine sediments, discovered at the Kicking Horse rim, British Columbia, in 1909 by **Charles Doolittle Walcott**, that provide a unique window on life without hard parts that had continued to exist shortly after the time of the Cambrian explosion (*see* Topic j34).² Legend has it that Walcott, then secretary of the Smithsonian Institution, vacationing near Field, British Columbia, was thrown from a horse carrying him, when it tripped on, and split open a stray fallen slab of shale. Walcott, with his face literally rubbed in it, saw strange, but not hallucinational, forms crisply etched in black against the blue-black bedding surface of the shale: a bonanza of fossils of sea creatures without mineralized shells or backbones. Many are preserved whole; including those with articulated organic (biodegradable) exoskeletons. Details of even their soft body parts can be seen (best using PTM)³ as silvery films (formed of phyllosilicates on a coating of kerogenized carbon) that commonly outline even the most delicate structures on the fossilized animal.⁴



Charles Doolittle Walcott⁴ (1850-1927) a self-educated farm boy, who with aid of packhorses and pemmican in the field, gathered material for his voluminous publications on the Cambrian rocks of North America. By the end of his life, as documented by Ellis Leon Yochelson in *Smithsonian Institution Secretary*, 2001, he had so many honors that he scarcely bothered to record a new one in his diary.⁵

The Burgess shale is part of the Stephen Formation of greenish shales and thin-bedded limestones, which is a marine-offlap deposit between the thick, massive, carbonates of the overlying Eldon formation, and the underlying Cathedral formation.⁶ As referenced in the *Geological Atlas of the Western Canada Sedimentary Basin - Chapter 8*, the Stephen Formation has been “informally divided into a normal, ‘thin Stephen’ on the platform areas and a ‘thick Stephen’ west of the Cathedral Escarpment. The ‘thin’ formation is 109 m thick at its type section, thins to 21 m at Ghost River, and is 370 m thick at Chaba River.”⁷

The Burgess shale fossils are soft bodied marine fauna in two Lagerstätten (*see* Topic j33), the lower of which, the Phyllopod Bed, has alone yielded about 65,000 specimens. More than 140 species of these animals have been described. The fauna are mostly arthropods, but also occur, sponges, echinoderms, priapulid worms, *Odontogriphus omalus*,⁸ soft-bodied mollusk with radula, and species belonging to several that are truly unique in form: some with five eyes, others have no apparent front end. One, aptly named *Hallucigenia*,⁹ was so exotic that publication of its details was little disputed¹⁰ until it was belatedly found to belong to a group of less-strange organisms (“armoured” velvet worms, phylum Onychophora) in the shale, and that its “strangeness” (to Steven Jay Gould’s chortling amusement)¹¹ was because it had been described upside down with its back spines interpreted as legs.¹² All the small vagrant animals are judged to have been grazers. But amongst them is at least one giant predator, *Anomalocaris*.¹³

Walcott found the source of his fallen fossiliferous slab 300 feet above the trail, in what are otherwise unfossiliferous sediments. He initiated quarrying the source for fossils the next year. As a matter of record, Walcott did not remotely glimpse the astounding import that the Burgess fossils represented. But we have Pasteur's remark about serendipity (**Footnote j32.1**): "In the field of observation, chance favors only the prepared mind." Walcott had been an avid collector of fossils as a small boy and since in the area of Utica, NY, but his only received training from amateur fossil collector, farmer William Rust, for whom he worked at age 20, was not in how to classify fossils but in how to best collect and prepare them for sale.¹⁴ To quote Gould: "Snatching defeat from the jaws of victory, Walcott then proceeded to misinterpret these magnificent fossils in the deepest possible way. He managed to shoehorn every single Burgess species into a modern group, calling some worms, others arthropods, still others jellyfish [sic]."¹⁵ The lie to this was Harry Wittington's restudy, fifty years later, that Burgess fossils (which include the chordate, *Pikaia*), not in number of species but in their bizarre anatomies, arguably exceed the breadth of diversity of all animals living today!¹⁶ Now a National Monument, "Walcott's quarry" is closed and only Desmond Collins, Royal Ontario Museum paleontologist, has been permitted to excavate the 505-million-year old Burgess shale at a second small site that he discovered nearby. Nevertheless, the Burgess shale animals in their nearly pristine setting in Yoho National Park on the western flank of the Rockies can be *viewed* (taking a fossil is subject to stiff fines, even imprisonment) first-hand. Mountain-building, 150 million years ago raised the fossil site to its present elevation and erosion has exposed it in a spectacular setting. *Yoho* is the Cree Indian word for wonderment (refers to the scenery). The park is small (507 square miles), is accessible only by foot, and is open from mid-July, when the last snows melt off the Burgess Trail, into October, when they accumulate again.¹⁷

Paleontologists have since found extraordinarily well preserved fossils of Early Cambrian animals at two additional sites: outer-continental shelf facies (about 518 My) at Passet Sirius, northern Greenland,¹⁸ with giants as *Kerygmachela kierkegaardii*,¹⁹ and shallow-water facies (about 530 My)²⁰ at Chengjiang, southwestern China, with many bizarre animals as *Yunnanozoon* (securely identified by D. Snouffer in 1966 from fossils of its juveniles and adults as the earliest known hemichordate),²¹ *Halkieriid* (previously known only from abundant isolated scales in "small shelly fauna" of earliest Cambrian age and now seen from a complete specimen collected by Conway Morris in 1984²² as "an armored slug with a big shell at either end"),²³ and, as a clue to events in our genealogy, swimming among these are chordates *Haikouella lanceolata*,²⁴ *Cathaymyrus diadexus*,²⁵ and *Myllokunmingia*.²⁶

What other strange creatures are yet to be found? Goethe (1749-1832) has said, "We see what we know." Certainly life did not originate with the Cambrian explosion. That major ecological shift was that many organisms were advantaged *if* they did acquire hard parts. An importance of the Burgess shale is that from its study is derived the cautionary principle that when, at any time, much diverse life does not possess hard parts, great bias (favoring organisms with hard parts) is inevitable in usual fossil collections.²⁷

Gould in *Wonderful Life*, 1989,¹¹ portrays the bizarre animals of the Burgess shale as victims of "bad luck" who died without issue, bolstering his view that much of present life reflects a blind and random pruning of an earlier and vastly more diverse world. However, studies since have found that most Burgess shale, fragile, squishy, creatures *are* forerunners of existing species. Also, Richard Fortey (*A Natural History of the First Four Billion Years of Life on Earth*, 1998) would diminish Gould's famous claim that if evolution were replayed, the vagaries of chance would populate the modern world with creatures substantially different from those that we know.²⁸ □

Footnote j32.1 Horatio (Horace) Walpole (1717-1797) coined the word *serendipity* for what can be treasured of the otherwise "silly [ancient] fairy tale, called *The Three Princes of Serendip [Sri Lanka]*: as their highnesses traveled, they [being schooled and gifted] were always making discoveries, by accidents and sagacity, of things which they were not in quest of: ..."²⁹