k15 Ediacaran fossils < pronounced *Ee-dee-AK-ran*, 560-580 My, *not* hidden >

The beamish boy slew the burbling jabberwock with his vorpal blade, which went snicker-snack:² He left it dead, and with its head

- He went galumphing [at a gallop and triumphant] back.
- -Charles Lutwidge Dodgson Through the looking-glass, and what Alice found there, 1864.³

Extant athropods are subdivided into subphyla: Hexapoda (insects), Crustacea (crabs, shrimps, barnacles and woodlice), Myriapoda (millipedes and centipedes), Chelicerata (spiders, scorpions, mites, and ticks), and Pycnogonida (sea spiders). These lineages were in place by the beginning of the Cambrian 541 million years ago. Then the seas teamed as well with other macroscopic animals (evidenced by body-fossils and ichnofossils of these). Whence came the diversity?

Conventional wisdom is that Cambrian life derived from a rich biota extant during the Ediacaran.

Ediacaran fossils, as first described by Martin F. Glaessner in 1961 are, in the simple view, "the impressions of lowly, soft-bodied, animals" that had become stranded in a littoral marine environment. Their name is taken from an abandoned, turn-of-the-19th-century, silver mine in the Flinders Ranges, South Australia, called *Ediacara* (pronounced *Ee-dee-AK-ra*), where, near Reg Spring, their fossils in 565 million year old marine sandstones were first found in 1946.⁴ Correctly, the fossils are impressions of soft bodies on bedding surfaces of stacked storm-event sands (deposited in channels near fair-weather wave base) and thin-bedded sands and silts (deposited by waning storm surges below storm-wave base).⁵ The fossils can only be seen when illuminated in grazing sunlight and vanish otherwise. The preservation of fossil impressions in sand is a puzzle. But as bioturbation of burrowing and grazing creatures follows the appearance of the very first horizontal burrow-traces (*Trichophycus pedum*) now used to define the base of the Cambrian,⁶ the undisturbed impressions of the Ediacarans were likely into microbe-matted sand of sunlit seafloors.⁷

Specimens of Ediacaran-type fossils found before had been misidentified. These were from a quarry in England, where in the 1860s they were thought to be inorganic concentric rings left by gas bubbles that had burst forth from a marine bed. Other Ediacaran fossils from Africa returned to Germany during World War I, were deemed then to be landplant fossils.

Precambrian Ediacaran fossils have a proven worldwide distribution (Australia, Namibia, Newfoundland, southwestern Great Basin, U.S.,⁹ northwestern Canada, and arctic Russia). Their classification remains controversial however.

Amongst the large Ediacaran fossils, according to some paleontologists, are recognizable, but mostly tiny, jellyfishes and sea pens (Coelenterata), segmented worms (Annelida), primitive arthropods, and long trails, which trace fossils the primitive bilaterian *Kimberella* could have made.¹⁰

The diversity of the simple impressions of Ediacaran fauna is more than 30 species. Some paleontologists hold that the Ediacara "fauna" (or "Vendian biota") represent a radiation of forms not ancestral to continuing lines. However, at first glance, the majority of these appear to be related to modern jellyfishes and corals. So much so that M. F. Glaessner was inspired to call the late Precambrian the "Age of Jellyfish [*sic*]." Also, judging from (purported) fossilized trails on bedding surfaces, Ediacaran faunas included mobile creatures. Some even left behind what are interpreted as fecal pellets (which would mean that they had a relatively advanced, one-way gut). However, the body-fossils of the track makers have yet to be found. Ediacaran body-fossils occur in different sediments than do the tracks, and have the likeness of jellyfish, which stranded on a beach, desiccated before burial but likely were smothered where they lived on the seafloor (recall above).¹¹ On second glance, their bodies do not appear to be multi-celled. In modern animals, multiple cells connect to form a three-dimensional body. Animals must then employ networks of tubes, such as blood vessels,

to transport nutrients and gases to the innermost cells. However, this is not the only plan as extant vestimentiferan tubeworms (near deep sea hydrothermal vents) rely on chemoautotrophic bacterial symbionts for nutrition and when adult are sans mouth, or stomach, or ways to eliminate waste.

The bodies of Ediacaran organisms resemble giant, single cells with connected fluid-filled compartments, much like an air mattress. Species, such as *Phyllozoon*, may even have been acellular (a carapace to the protoplasm). By remaining extremely thin, even though measuring from tiny to a meter or more in diameter, these immobile organisms living as they did in seawater, relied on diffusion to obtain nutrients and handle wastes. They could have also harbored symbiotic microbes which provided nourishment through photosynthesis or chemosynthesis. To gain an insight into how water currents may have affected *Dickinsonia* if in life it lay bathmat-like on a seafloor of fine sand, Kenneth M. Schopf and Tomasz K. Baumiller in 1998 have fashioned two *Dickinsonia* models, one using latex molds and the other employing plastic bags filled with solutions of Karo syrup. They observed how at densities from a value equal to that of water to a much meatier substance, these fared in a tank with a moving current of water. Models with densities resembling those of worms and of protoplasm were so light that they got pushed by the current. So *Dickinsonia* was denser than previously suspected or was held down by microbial mats that covered the seafloor at the time.¹²

In 1983, Adolf Seilacher, called these Ediacaran sans heads or tails, distinguishable insides or outsides, fronts or backs, carpeting, disks, blobs to feathery fronds, variously pouched with radiating, concentric or parallel corrugations, organisms "vendobionts." According to Gregory J. Retallack, *Phyllozoon* and most other common Ediacaran organisms were large lichens that covered much of Earth during the Precambrian. Promoting that idea in 1994, Retallack called the Ediacaran an "Age of Lichens" and this is cheered on by Nicholas J. Butterfield.¹³ In recent decades, the Ediacaran fossils have also been called plants, giant single-celled organisms, and even a failed evolutionary experiment completely separate from all known kingdoms of life.

The beginning of the Cambrian is when multicellular animals proliferated and came to occupy a wide range of ecological niches. To do so, as Simon Conway Morris has pointed out, they developed behavioral sophistication. But what of the macroscopic Ediacaran fossils? Were they all extinct soon after the beginning of the Cambrian? What was their time range?

Conway Morris recognizes at least one Ediacaran holdover in the 505 My Middle Cambrian Burgess Shale of Canada fossil assemblage. Peter Crimes reports on frisbee-like "Ediacaran" fossils in 510 My sandstones in Ireland. John Grotzinger describes Ediacaran fossils in Namibia that could be latest Precambrian. Also, rare Ediacaran-type fossils with fronds in Cambrian age rocks were preserved, as described by Mary L. Droser, in the typical Precambrian mode (on bedding surfaces free of tracts and fecal pellets). So "at least some 'holdover' Ediacaran forms existed in the Cambrian and ... closure of the preservational window was as important as extinction of the Ediacaran-type organisms." ⁸

Do these finds blur the Cambrian's sharp beginning demarkation? Ediacaran fossils occur as impressions on bedding surfaces along the sea-cliffs of the Avalon Peninsula (Mistaken Point, eastern Newfoundland) (*Footnote k 15.1*, p. 617). Here, zircons in an overlying layer of volcanic ash (U-Pb) date 565 ± 3 My. The oldest Ediacaran fossils were recently described from 600 My sediments in the Sonoran Desert in Mexico and from 610 My sediments in the Canadian Rockies.

Late Precambrian formations in which Ediacaran fossils are found (in some of their sedimentary layers) collectively span 100 million years; a significant length of time in anyone's book. Preston Ercelle Cloud (1912-1991)¹⁴ and Martin Fritz Glaessner (1906-1989)¹⁵ jointly proposed an Ediacaran Period as the first period of the Paleozoic Era. This was formally recognized by the IUGS in March 2004 but the ICS does not. The Ediacaran global stratotype section and point (GSSP) is at the base of a texturally and chemically distinctive marine carbonate layer that overlies glaciogenic rocks in outcrop along Enorama Creek in the Flinders Ranges, South Australia.¹⁶