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The Ediacaran Enigma

Were the oldest animals actually lichens?

By RICHARD MONASTERSKY

They are the black holes of paleontology, fossils so inscrutable they swallow up every theory thrown at them.

Taking their name from a site in southern Australia called Ediacara, these 565-million-year-old puzzles hold a pivotal position in evolutionary history. After billions of years in which bacteria, algae, and other microscopic single-celled organisms ruled the planet, life got large.

Reaching up to a meter in size, the Ediacaran behemoths provide the first evidence of complex life on the planet. Their fossils have turned up in rocks around the world, from Namibia to Newfoundland to arctic Russia. Scientists have identified more than 30 species of these simple, beautiful impressions. Yet the question remains: What were they?

Paleontologists originally interpreted the fossils as impressions left by animals related to modern jellyfish and corals. Such creatures, if they existed, would represent the first animals known in the fossil record. But this theory has failed to explain many critical features of the Ediacaran remains, leading later researchers to offer alternatives. In recent decades, the fossils have been called plants, giant single-celled organisms, and even a failed evolutionary experiment completely separate from all known kingdoms of life.

One investigator has now stepped forward with an entirely novel idea. Brushing aside all previous suggestions, Gregory J. Retallack of the University of Oregon in Eugene envisages the Ediacaran fossils as the remains of large lichens that covered much of Earth during Precambrian time.

Retallack admits that initially, even he did not accept this idea, which he describes as heretical. "I had a terrible time believing it at first. I thought it was a stupid idea, and I have waited for somebody to point out why. But they never did. And I found I was having increasing difficulty falsifying it. I couldn't see what was the matter with it." Retallack published his theory late last year in the fall issue of PALEOBIOLOGY.

The Ediacaran fossils hail from the tail end of Precambrian time, the vast 4-billion-year-long stretch of history that reaches back to the birth of the planet. Although this span constitutes almost 90 percent of geologic time, paleontologists and geologists have generally viewed it as an obscure prelude to the truly interesting events of the Cambrian period, some 540 million years ago.

When the curtain opened on the Cambrian, a profound evolutionary explosion gave birth to most of the animal phyla that now swim, slither, or buzz around the planet. Animals appeared for the first time sheathed in mineralized shells, bearing claws, jaws, and other impressive biological innovations. Ediacaran organisms seemed a preview of these animals.

Following the discovery of fossils at Ediacara in 1946, Australian researchers identified them as impressions of simple, soft-bodied animals related to jellyfish, corals, and segmented worms. In line with this interpretation, the late Australian paleontologist Martin F. Glaessner referred to the late Precambrian as the Age of the Jellyfish.

Whereas Glaessner and others originally fit the Ediacaran fossils into animal groups, later paleontologists tried to pull them out. In 1983, Adolf Seilacher of Tübingen University in Germany overturned all conventional interpretations when he called the Ediacaran organisms a separate kingdom of life. In Seilacher's interpretation, the fossils displayed an "alien" body architecture totally unlike anything seen on Earth today.

The Precambrian species evolved a unique solution to the problem of growing large bodies,

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says Seilacher. In modern animals, multiple cells connect, forming a three-dimensional body. Animals must then employ networks of tubes, such as blood vessels, to transport nutrients and gases to the innermost cells. But the bodies of Ediacaran organisms resembled giant, single cells of connected, fluid-filled compartments, much like an air mattress. By remaining extremely thin, these quilted beings maintained a large surface area across which nutrients and gases could diffuse, according to Seilacher.

The vendobionts, as he called the organisms, must have been immobile. To survive, they may have absorbed nutrients from seawater or harbored symbiotic microbes that provided nourishment through photosynthesis or chemosynthesis.

Like Seilacher, Retallack questions the animal interpretation of the Ediacaran organisms. His hypothesis that the Ediacaran fossils represent ancient lichens emerged from experiments he performed to deduce the structural strength of the beings that produced the fossils.

Retallack compared the thickness of three Ediacaran species with the dimensions of fossilized jellyfish and fossilized logs. He concluded that the Precambrian organisms could not have been as soft as worms or jellyfish, otherwise the weight of rock piled on top of the dead bodies would have squeezed them much flatter than the fossils now appear. The Ediacaran organisms apparently had the same strength as some large plants, for example cacti or the tree ferns found in the tropics.

"They don't look like what they're said to be. Their behavior under compression indicates they are a lot tougher than jellyfish." he maintains.

The lichen hypothesis solves the structural problem. Lichens produce a molecule called chitin, which makes them rigid. "As unpalatable as it may seem, the lichen interpretation is a way to get around that issue," says Retallack.

A lichen is a community of algae living symbiotically with fungi or, less commonly, with bacteria. The algae, harvesting the sun's energy through photosynthesis, are the breadwinners of the union. The fungi or bacteria provide a protective structure for the algae: They build the house. Most lichens live on land, but some live in the water.

The photosynthetic ability of lichens could explain other puzzling aspects of Ediacara, notes Retallack. Animals must have some means of eating and digesting nutrients. But on the subject of food, the Ediacaran fossils are silent. They show no openings for mouths or anuses, and they have no obvious internal digestive or circulatory systems. Scientists have long wondered whether the organisms truly lacked such features or whether mouths and other body parts existed but were not preserved.

If the Ediacaran organisms were lichens, the problem disappears. Lichens produce their own food.

In support of his idea, Retallack notes that some Ediacaran fossils from Namibia, as well as other Precambrian fossils from China, have microscopic tubelike structures similar to modern lichen filaments.

Instead of calling the late Precambrian the Age of Jellyfish, Retallack proposes calling it the Age of Lichens. He pictures a world dominated by lichens and microbial ecosystems that have since had to cede most of their territory to the wildly successful plant kingdom. Today, lichens have withdrawn to the extreme environmental margins—outcrops of rocks, high mountains, deserts, even Antarctica—where plants can't eke out a living. But back in the Precambrian, with no competition from green plants, lichens could have thrived.

Geerat J. Vermeij of the University of California, Davis, calls Retallack's argument an intriguing explanation of the Ediacaran fossils. "There's nothing about it that strikes me has utterly and obviously wrong. It may be wrong, but this is as good a suggestion as any I've heard."

Seilacher sees some similarity between the lichen idea and his own vendobiont theory. "In

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principle, I like it very much because this is, in other words, what I meant when I said they were most likely photosymbiotic. That means they had symbiotic algae of some kind in their tissues." Seilacher, however, rejects the idea that the Ediacaran fossils were actual lichens composed of fungi living together with algae. He believes they represent some other kind of symbiotic organism that left no heirs in the modern world.

Other paleontologists also dismiss the lichen idea. "I don't like it. I don't think it is based on very much," says Bruce Runnegar of the University of California, Los Angeles.

Runnegar finds the arguments about structural strength flimsy. All Ediacaran fossils, he points out, are impressions in rock. The organisms that made the impressions never actually fossilized, so unlike logs, which remain in the rock at the time they get compacted, the Ediacaran organisms had disappeared by the time compaction started. What they left behind was a cast made of sand, which got squeezed by overlying rock. Thus the thickness of the fossils tells more about the compressibility of the sand than that of the Ediacaran organisms, says Runnegar.

Benjamin M. Waggoner of the University of California, Berkeley, also criticizes the compression measurements, noting that Retallack examined only three types of Ediacaran fossils found at a single site in Australia. Such fossils, he notes, exist at nearly 20 other sites around the world in a variety of rock types, all with different characteristics of compression.

Moreover, many scientists have reinterpreted some of the Ediacaran impressions as the remains of anemonelike animals, which would have been much stiffer than jellyfish. Yet Retallack did not make any comparisons to fossil anemones, only to fossil jellyfish.

Waggoner admits that some of the Ediacaran fossils could have been lichens. "My main problem with Retallack's paper is not that he said they were lichens. Some of them could have been. Who the heck knows? The Precambrian was a weird time to be around. My main problem is that a lot of his conclusions are based on skimpy data," says Waggoner, whose comments on Retallack's paper will appear this September in PALEOBIOLOGY.

The lichen idea is only the latest in a long string of theories that make unsubstantiated claims, laments Waggoner. "We've got a lot of very sweeping hypotheses and not enough rigor in trying to pin some of them down."

Retallack, like Seilacher and other previous researchers, has tried to find one explanation for all the Ediacaran fossils. But some paleontologists now contend that it might not be necessary to put all the organisms into one taxonomic basket.

UCLA's Runnegar, who just returned from collecting fossils in Namibia, sees diverse groups in the Ediacaran fossils. "I'm not enthusiastic about putting all of them onto one team." Some resemble corals. A few, such as the genus *Dickinsonia,* were probably mobile animals. Certain troublesome species, such as *Phyllozoon,* may even have been acellular, as Seilacher has proposed, says Runnegar.

James W. Valentine of UC-Berkeley also envisages diversity in the Ediacaran world. "There may well be some lichens represented among those fossils, but there are also a lot of convincing animal fossils of various kinds. The most plausible interpretation is that they represent a whole spectrum of organisms."

Whatever they were, Ediacara were not alone. Judging from fossilized trails preserved in rocks of that age, scientists know that mobile, wormlike animals must have shared late Precambrian Earth. Such creatures even left behind what are interpreted as fecal pellets, a testament to a relatively advanced, one-way gut.

The track makers themselves never fossilized. Their thin bodies disintegrated before they could stamp a lasting impression in the sand. Even so, scientists find it easier to interpret these invisible worms than the theory-thwarting corpses from Ediacara.

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Ediacara: Where are you now?

Although paleontologists can't agree on the identity of the Ediacaran organisms, they all accept one fact: No such species exist on Earth today.

Beyond that, the theories diverge. Adolf Seilacher proposes that the quilted Ediacara suffered a mass extinction at the end of the Precambrian, leaving no descendants in the modern world. When they died, so did their unusual body architecture.

Proponents of the animal idea, however, hold that relatives of Ediacara evolved into the creatures now populating the planet. The soft-bodied forms presumably lived on into the Cambrian, but they did not generally fossilize; tissue lacking any hard parts seldom does, they note.

Supporting this theory, Simon Conway Morris of the University of Cambridge in England found what appears to be an Ediacaran survivor in the Burgess Shale, a deposit in the Canadian Rockies dating to the middle of the Cambrian period. The Burgess Shale animal, which Conway Morris has identified as a form of soft coral, resembles an Ediacaran species called *Charniodiscus* (SN: 7/18/92, p.47).

Gregory Retallack holds that the Ediacaran lichens do not resemble any modern forms exactly and probably did not contain any species still extant. But the Precambrian forms would fit the lichen classification of a symbiotic association between algae and fungi or bacteria. □

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