

Yorkicystis, the 500-million-year-old relative of starfish that lost its skeleton

May 24 2022, by Samuel Zamora



Reconstruction of the prehistoric *Yorkicystis haefneri* adapted from fossil evidence. Credit: Hugo Salais (Metazoa Studio). Samuel Zamora, [CC BY-ND](#)

After four years of digging for fossils in a churchyard in York, Pennsylvania, amateur paleontologist Chris Haefner made an intriguing find. "I knew it was worth keeping," he said. He posted his discovery on Facebook.

I spotted his post, and realized it was a major discovery: [I study fossil](#)

[invertebrates](#) at the Spanish Research Council. When I contacted Haefner, he agreed to donate the fossil to London's Natural History Museum.

Working with colleagues in the U.S. and U.K., we determined that this was a 510 million-year-old relative of today's starfish and [sea urchins](#). It is highly unique, new to science, and has only a [partial skeleton](#). We named it [Yorkicystis haefneri](#), after its finder.

Yorkicystis has revealed new information about how [early life](#) was evolving on Earth at a time when most of today's animal groups first appeared.

The Cambrian explosion

Yorkicystis lived during the "Cambrian explosion," 539 million to 485 million years ago. Before this time, bacteria and other simple microscopic organisms lived alongside [Ediacaran fauna](#), mysterious, soft-bodied creatures that scientists know little about.

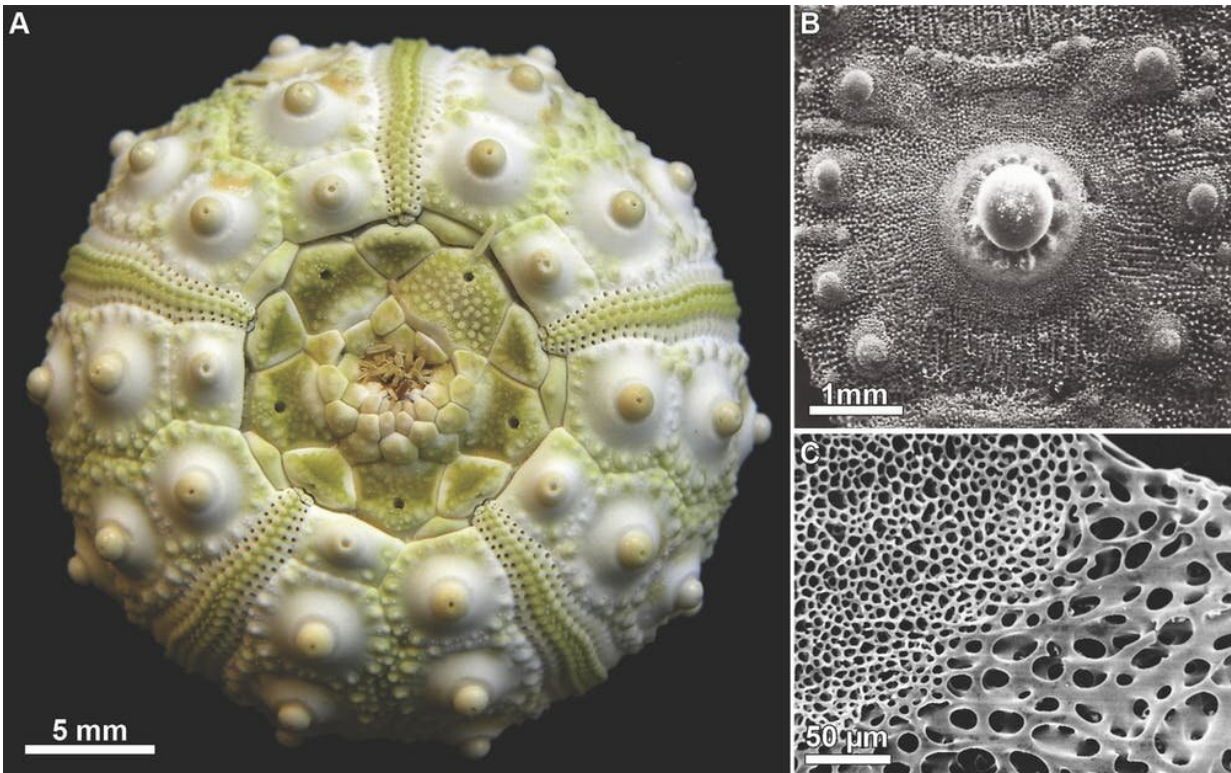
The Cambrian brought a huge proliferation of species that emerged from the seas. They included [groups of organisms](#) that would eventually dominate the planet and representatives of most of today's animal groups.

Within a few million years, complex animals with skeletons and hard shells appeared. Why this happened remains unclear, but [a major change in ocean chemistry](#), with a higher concentration of calcium carbonate, likely played a key role.

Echinoderms weren't the first of these found in the geological record. [Brachiopods](#)—marine animals that lived protected within seashells—predated them. So did [arthropods](#), a group that had well-

formed [calcite exoskeletons](#), including [trilobites](#).

For context, dinosaurs appeared 294 million years after the dawn of the Cambrian.



Sea urchins are among *Yorkicystis*' surviving relatives. Credit: Samuel Zamora, [CC BY-ND](#)

The first echinoderms

There are more than [30,000 extinct echinoderm species](#), but they are very rare in places with exceptional Cambrian preservation, like [the Burgess Shale](#) in Canada and [Chengjiang in China](#).

Some of the first primitive echinoderms were quite different from their present-day relatives, which have five arms extending from the center of their bodies, a structure called "pentamerous symmetry."

More ctenocystoids facts kids: They are key to understanding the evolution of echinoderms as they sit at the base of the echinoderm evolutionary tree. The tree shows how echinoderms evolved from worm-like organisms into the star-shaped creatures we see today! [#FossilFriday pic.twitter.com/zLpGT3GNdB](https://twitter.com/zLpGT3GNdB)

— Oxford University Museum of Natural History
(@morethanadodo) [June 8, 2018](#)

Cambrian echinoderms had a wide range of [body structures](#). [Eocrinoids](#) had vase-shaped bodies protected by geometrically patterned plates and a number of armlike structures. [Helicoplacoids](#), shaped like fat cigars, were plated in calcite armor with a "mouth" that spiraled around its body. [Blastoid](#) species took various shapes, often resembling exotic flowers.

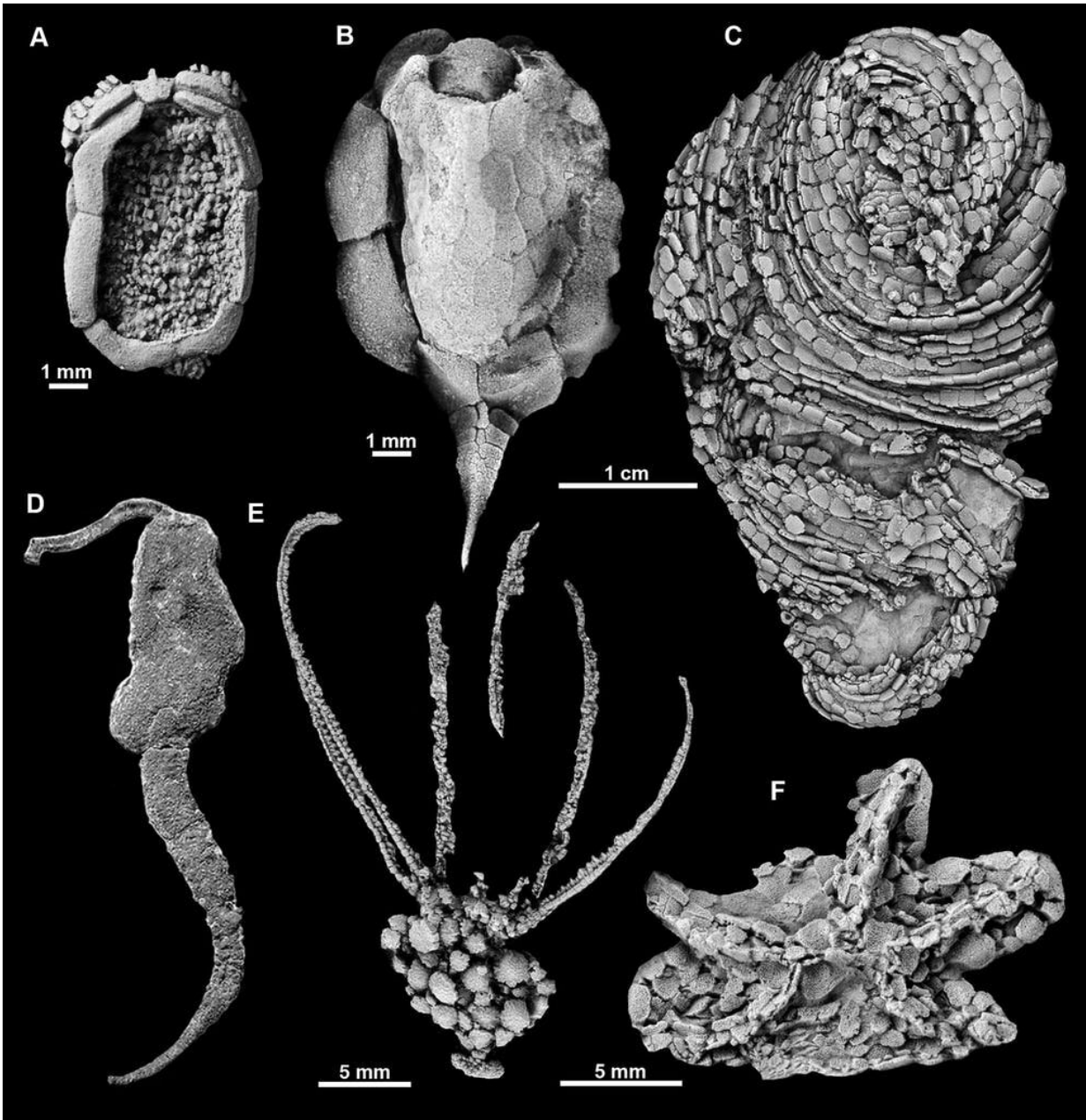
The Edrioasteroidea looked similar to [today's sea star](#), and with five arms that radiated from its mouth, it is the organism that *Yorkicystis haefneri* most resembles. So we [classified it within this group](#) on the [evolutionary tree](#).

Yorkicystis, the echinoderm without a skeleton

While many Cambrian organisms formed sophisticated skeletons and defense structures to protect them from predators, *Yorkicystis* did the opposite. It "demineralized" its [skeleton](#). It was a partially soft animal, with no protection over much of its body.

To understand this organism's anatomy, we partnered with a

paleoillustrator to visualize this creature from the fossil evidence we had. Hugo Salais first modeled each part of the skeleton in 3D and then used that to create a reconstruction, a high-resolution replica.



Representatives of Cambrian echinoderms with a mineralized calcite skeleton. A. Ctenocystoid. B. Cincta. C. Helicoplacoid. D. Solute. E. Eocrinoid. F.

Edrioasteroid. Credit: Samuel Zamora, [CC BY-ND](#)

From this replica, we observed that only its arms, or ambulacra, were calcified, protecting its "food grooves"—its feeding parts, which are yellow in the fossil. A series of plates covered its tentacles and opened and closed during feeding. The rest of its body was soft, represented in the fossil by a dark, carbon-enriched film.

Most present-day echinoderms, which are found from the world's coastlines to the ocean's dark abyssal depths, have an internal skeleton. The exceptions are sea cucumbers and some species that live buried beneath the seabed. Their skeletons, like *Yorkicystis*, are formed by porous calcite plates.

Bringing *Yorkicystis* to life

As paleontologists, we seek to understand extinct organisms. *Yorkicystis* presented a major challenge, since no similar animal is known, neither living nor extinct.

Very little is known about why and how some echinoderms lost parts of their skeleton. But advances in [molecular biology](#) have revealed that there is [a specific set of genes](#) responsible for the formation of a skeleton in echinoderms. All living echinoderms carry these genes; we assume that extinct groups did, too.

But in *Yorkicystis*, there is a marked difference between the calcification of its rays, or arms, and the lack of it on the rest of its body. It raises the hypothesis that the genes involved in skeleton formation may have acted independently in different parts of *Yorkicystis*' body. It's a mystery that only molecular biologists will be able to unravel.

Our studies have allowed us to form some hypotheses about this animal, though many questions remain. We believe that without a skeleton in an important part of its body, *Yorkicystis* was able to conserve energy for other metabolic processes such as feeding or breathing. It also enhanced flexibility, allowing for more active respiration by means of pumping.

There's another intriguing possibility: The lack of skeleton might be related to some kind of stinging protection system, like that used by present-day [anemones that paralyze prey](#) with stinging cells on the tentacles that surround their mouths. That question, though, and many others, can't be answered with just a fossil.

But the amazing discovery of *Yorkicystis* has provided more insight into a period in divergent evolutionary history at the dawn of the Cambrian explosion, a time when some organisms adopted skeletons to avoid predators—and others adapted in very different ways.

More information: Samuel Zamora et al, Cambrian edrioasteroid reveals new mechanism for secondary reduction of the skeleton in echinoderms, *Proceedings of the Royal Society B: Biological Sciences* (2022). [DOI: 10.1098/rspb.2021.2733](https://doi.org/10.1098/rspb.2021.2733)

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