Title: Fossil Focus: Blastoids
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Fossil Focus: Blastoids

by Jennifer E. Bauer*1

Introduction:

The ancient seas of the Palaeozoic era (541 million to 252 million years ago) teemed with unusual creatures that would be almost unrecognizable to us today. Although these animals look very peculiar, they often have living relatives that we are more familiar with. Consider echinoderms, such as sea stars and sea urchins: these marine animals can be recognized easily by scientists and the general public alike due to their distinctive five-fold symmetry and often vibrant colours. However, the Palaeozoic fossil record of echinoderms includes a wide range of forms that are radically different from living species. Indeed, there are only 5 major living groups of echinoderms, but about 20 extinct groups known only from the Palaeozoic. This means that the fossil record is key for understanding echinoderm diversity.

This article focuses on a group of Palaeozoic echinoderms called blastoids. Blastoids are sometimes referred to as sea buds because they are shaped like rosebuds. They have been found in rocks dating from the middle of the Silurian, around 433 million years ago, to the extinction event at the end of the Permian period, 252 million years ago — a roughly 200-million-year range! This is incredibly uncommon, because most extinct groups of Palaeozoic echinoderms are restricted to very short periods of time in the fossil record (for example, cinctans are only known from the middle Cambrian period 509 million to 497 million years ago). Therefore, blastoids are an ideal group to begin to study echinoderm diversity and extinctions through time.

Mode of life:

Blastoids were sessile, meaning that as adults, they did not move. Many species attached themselves to the sea floor using root-like structures (Fig. 1). Like all echinoderms, they had a hard skeleton composed of the mineral calcium carbonate; upwards of several million plates make up the rootlets, stem, theca (body) and brachioles (arm-like structures) of blastoids. Unfortunately, only the theca is commonly preserved in the fossil record, although in rare circumstances portions of the stem and brachioles can also be preserved.

In most cases, the stem lifted the blastoid above the sea floor, with the brachioles aiding in feeding. It is thought that the brachioles were used to collect small food particles from the water and shuttle them towards the mouth, much like what happens in modern sea lilies. Some especially strange blastoids had modified stems for sticking into different types of mud, while whereas others apparently rested directly upon the sea floor without a stem or rootlets.

There is much unknown about how these animals functioned in their environments. Some researchers suggest that blastoid brachioles would have passively moved with the current, whereas others believe

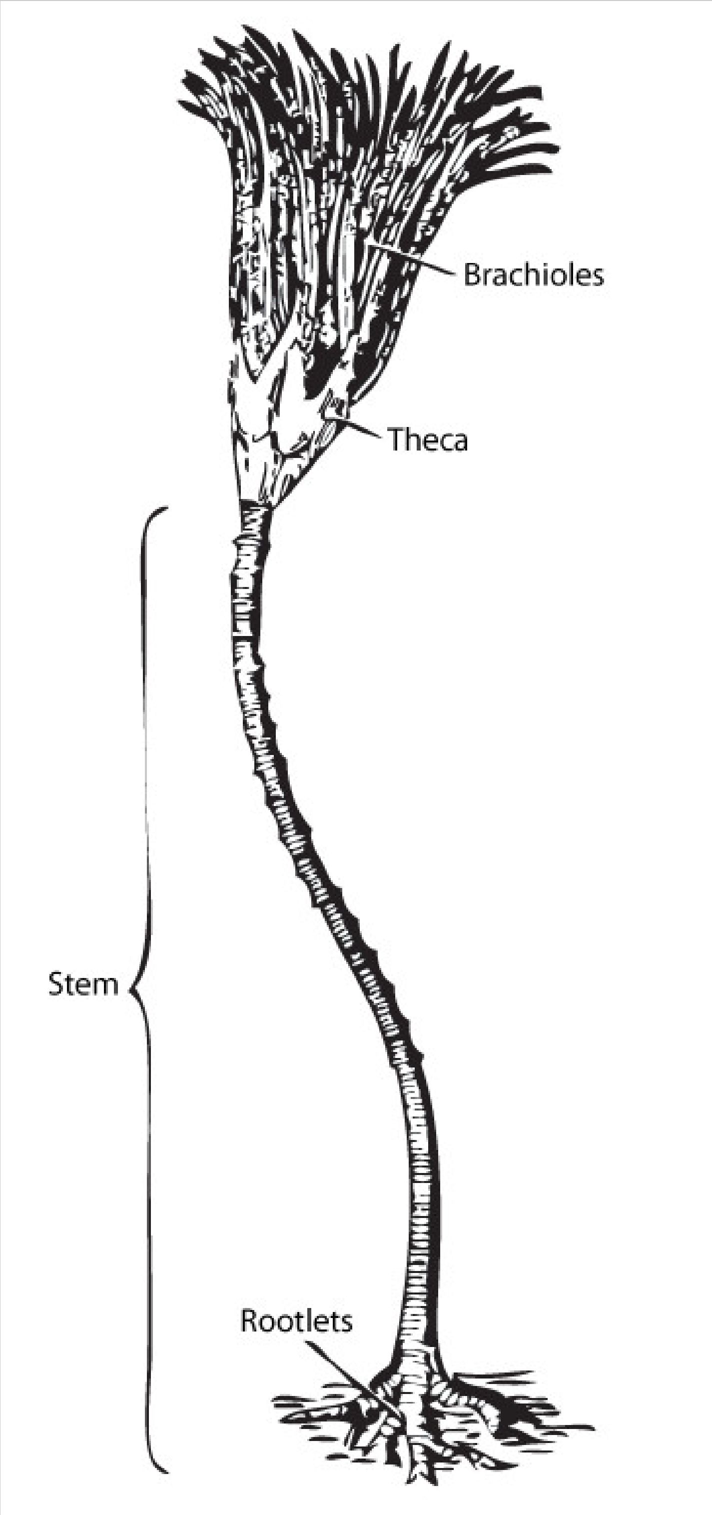

Figure 1 — Generalized diagram of blastoid morphology with regions of interest labeled. Modified from Beaver (1967).

that they were rigid structures that stuck out at right angles to the theca. Work is currently underway to simulate water flow around digital models of blastoids (Fig. 2) to better understand how these animals would have lived in different environments. These simulations will help us better understand the impact of environmental factors, such as water speed, which affected the conditions in which these these animals were able to successfully feed and live.

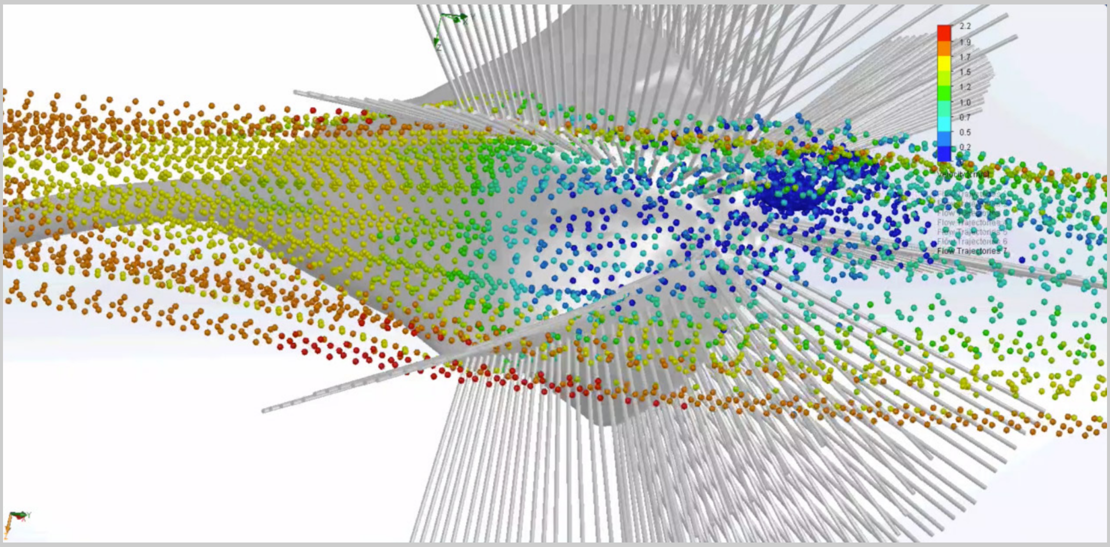

Figure 2 — Fluid-flow simulation of *Hyperoblastus reimanni* with anatomy reconstructed for the brachioles and stem. Warmer colours indicate faster water flow and cooler colours indicate slow or low flow. The cluster of blue is an eddy or slowed circulating water around the mouth. Credit: B. K. Nguyen and J. A. Waters.

Shape:

Blastoid thecae (Fig. 3) have three major plate circlets (circles of plates encasing the internal organs): (1) three 'basals' that attach to the stem attachment site; (2) five 'radials' that hold the ambulacra (feeding structures); and (3) many 'orals', commonly referred to as deltoids, that include four main plates and several smaller ones that surround the anal opening. The brachioles attach along the ambulacra, and food was shuttled along the main food grooves towards the mouth.

Although blastoids have a relatively simple external shape, or morphology, their internal anatomy is quite complex! They have an intricate internal system that carried water through the body. This is thought to have been used for breathing, providing the animal with dissolved oxygen from the water. In blastoids, this system is made of calcified structures called hydrospires, which are preserved on the inside of the thecae. These structures are parts of the interior body wall that have folded inwards, and in cross-section they look similar to lollipops (Fig. 4B). Recent work has been aimed at digitally reconstructing the hydrospires of blastoid species in order to better understand the evolutionary relationships of blastoids.

Relationships:

We can compare the characteristics of different animals to help us understand the specific aspects of morphology that drove them to separate into species or groups. The evolutionary relationships of blastoids are currently being studied. Previous research suggested there are two major groups, Spiraculata and Fissiculata, separated by the presence of pores or slits leading to the hydrospire folds. However, recent analysis suggests that this separation is too simple, and efforts have been made to reassess morphology in terms of homology (shared evolutionary traits). The latest analysis produced a tree showing the relationships of 55 species, which aids in identifying major groups (see Fig. 5).

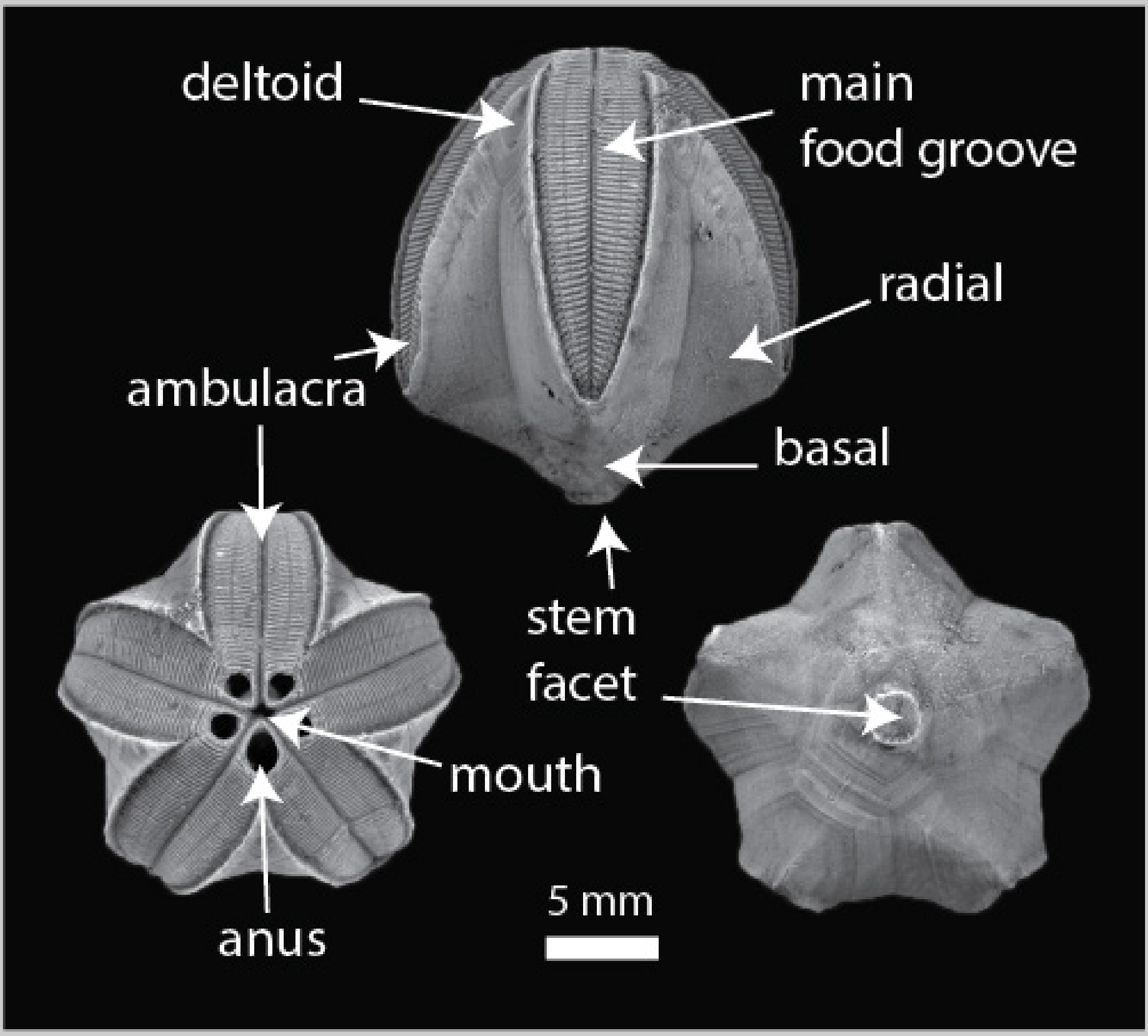

Figure 3 — Specific aspects of blastoid thecal morphology outlined on *Pentremites godoni*. Credit: J.W. Atwood.

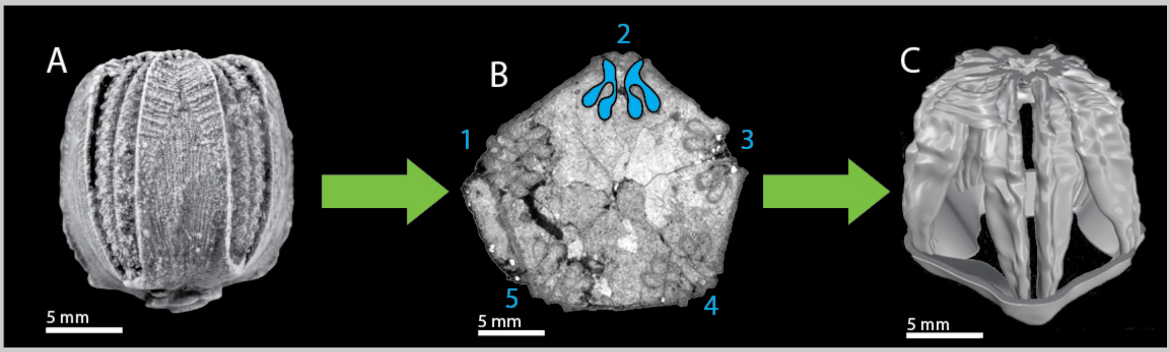

Figure 4 — (A) Specimen of *Diploblastus glaber*. Credit: J.W. Atwood. (B) A horizontal cut of the specimen to visualize the interior and hydrospires. The hydrospires line either side of the five ambulacra outlined here (1–5). (C) Reconstructed hydrospires from many horizontal sections of *Diploblastus glaber* described in detail in Bauer et al. (2015, 2017).

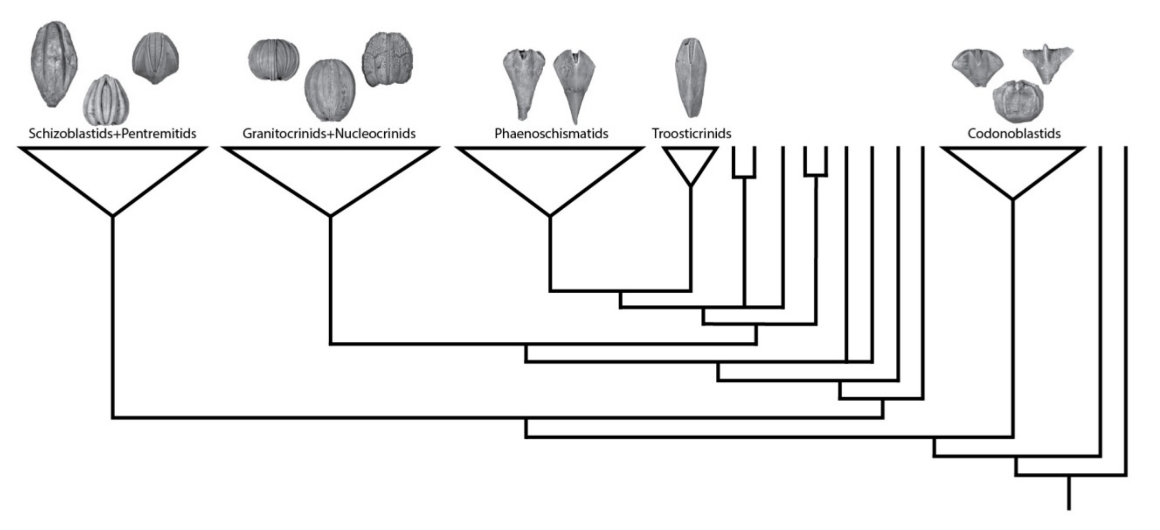

Figure 5 — Simplified evolutionary history of blastoid species. Previously recognized groups are outlined by triangles, which include many species. Those that are isolated or not grouped in triangles do not represent natural evolutionary groupings and require further study to improve understanding of the classification and supporting characters. Modified from Bauer et al. (in preparation).

This represents only a simple understanding of blastoid evolutionary relationships because there are about 300 described species. The tree shows some groups whose existence had already been suggested on the basis of their shapes (Fig. 5), but there are several other groups that had not previously been recognized. These are signified by the region without names.

Evolutionary significance:

Blastoids are a particularly interesting group of ancient echinoderms. First, they are absent from major echinoderm radiations (explosions of species) in the Cambrian and Early Ordovician period (541 million to 470 million years ago) and absent from major echinoderm-rich rock deposits. This makes it difficult to understand the origins of the group and leaves us with many questions to explore. Their conservative body plan of 18–21 stable body plates allows for detailed analysis of morphology through time. Blastoid thecae come in many sizes as adults, ranging from a few millimetres to several centimetres, with a variety of overall shapes (Fig. 6). These varying shapes are produced by differences in the three major plate circlets discussed above and aren’t restricted to a time period, but instead change throughout the blastoids’ 200-million-year range.

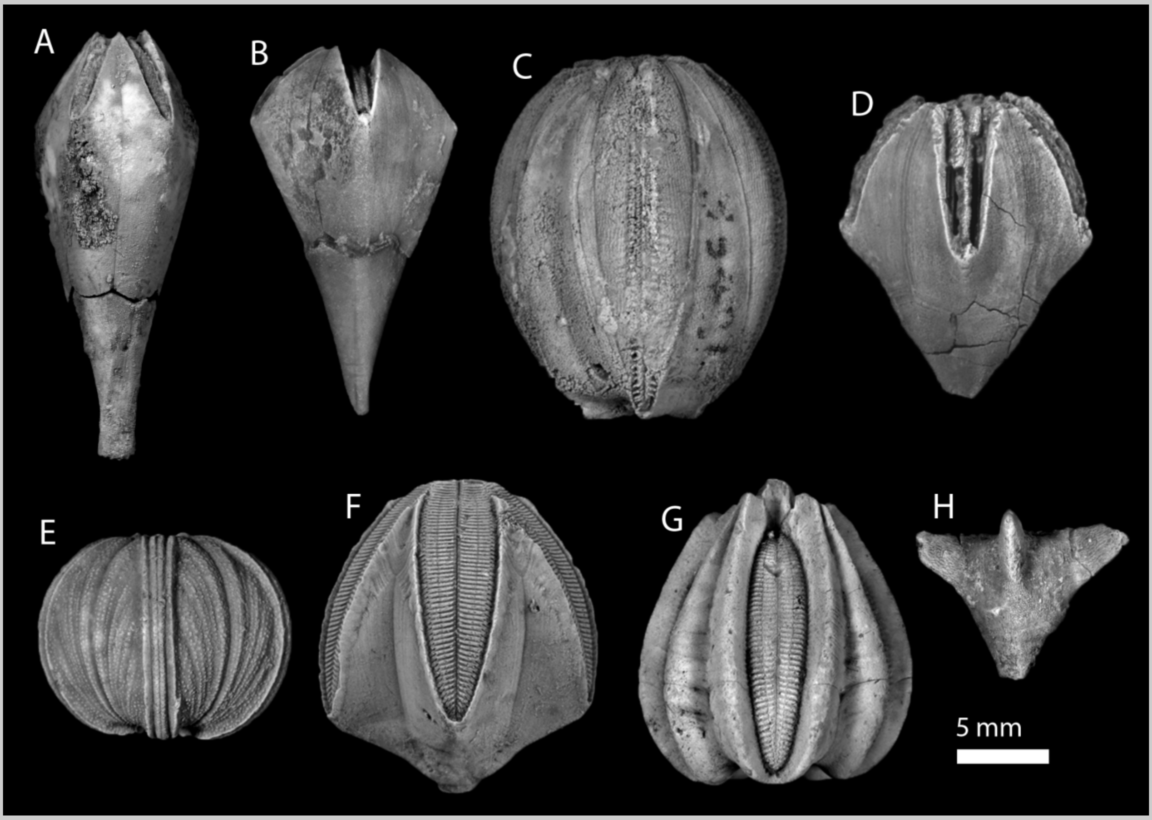

Figure 6 — Demonstrating the variety of blastoid forms. (A) *Troosticrinus reinwardti*, Silurian; (B) *Decaschisma pulchellum*, Silurian; (C) *Elaeacrinus verneuili*, Devonian; (D) *Hyperoblastus reimanni*, Devonian; (E) *Globoblastus norwoodi*, Mississippian; (F) *Pentremites godoni*, Mississippian; (G) *Deltoblastus permicus*, Permian; (H) *Pterotoblastus gracilis*, Permian. Credit: J. W. Atwood and J. E. Bauer.

Summary:

Blastoids are a well preserved and long-lived echinoderm group. These qualities have produced an immense amount of research on their morphology and evolutionary relationships. Technological advances have allowed more recent research to digitally reconstruct these animals and better estimate their evolutionary relationships. Future work aims to examine the remaining species to produce the most comprehensive blastoid evolutionary tree yet. The tree structure will provide a framework in which to begin to address more complex and larger-scale evolutionary questions, such as how fast did blastoids diversify, and how were they distributed around the world throughout the Palaeozoic.

Suggestions for further reading:

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