The Paleontograph

A newsletter for those interested in all aspects of Paleontology
Volume 11 Issue 2 June, 2022

From Your Editor

Welcome to our second edition of the year. I hope this issue finds you and your family healthy and safe.

Well it seems we are back to what you might call normal, although many changes that are here to stay, at least for a while, have made the new normal somewhat different. But life seems to be okay. As usual, I'm very busy and always running behind on things such as this newsletter. I'm starting to feel my age (69) and don't seem to have the energy I used to have.

It was great to go back to NJ in May and see many old friends. I've managed to go on a few collecting trips and have a few more set for July and August. I love being in the field searching for fossils with friends, nothing is better.

I made a mistake while setting this issue up so you will see an unusual page added in. I told you I was getting old.

The Paleontograph was created in 2012 to continue what was originally the newsletter of The New Jersey Paleontological Society. The Paleontograph publishes articles, book reviews, personal accounts, and anything else that relates to Paleontology and fossils. Feel free to submit both technical and non-technical work. We try to appeal to a wide range of people interested in fossils. Articles about localities, specific types of fossils, fossil preparation, shows or events, museum displays, field trips, websites are all welcome.

This newsletter is meant to be one, by and for the readers. Issues will come out when there is enough content to fill an issue. I encourage all to submit contributions. It will be interesting, informative and fun to read. It can become whatever the readers and contributors want it to be, so it will be a work in progress. TC, January 2012

Edited by Tom Caggiano and distributed at no charge

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The Many Possible Ways For Dinosaurs to Breathe, and a New Proposal for Ornithischian Dinosaurs

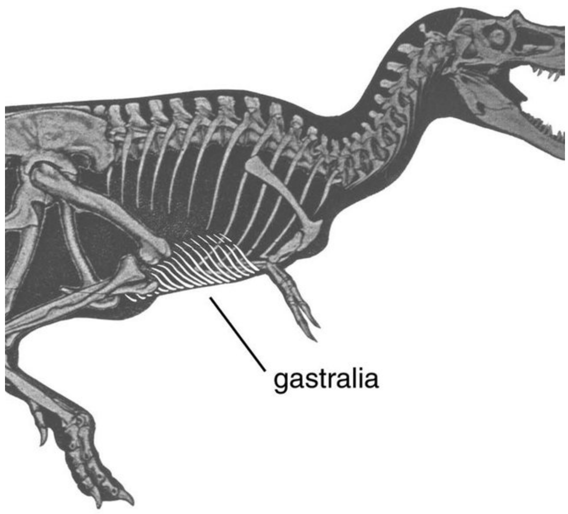
Bob Sheridan July 15, 2021

First a little background on breathing. Amniotes need to mechanically pump air in and out of their lungs, but how that is done can vary. In mammals, the diaphragm muscle separates the chest from the abdomen. During expiration, the diaphragm is convex toward the lungs, but during inspiration it flattens, thus increasing the volume of the chest cavity and inflating the lungs. In birds, there are air sacs as well as lungs. The air flow through the lungs and air sacs is one-way. The lungs are constant in volume, but muscles lift the ribs and sternum outward and increase the volume of the air sacs. In living crocodilians, it has long been thought that a "hepatic pump" is the method of ventilation. That is, a muscle attached to the pubic bone (called the diaphragmaticus) pulls the liver backward. The diaphragm, which is attached to the liver, is pulled back and the chest cavity expands. More recently, it has been a matter of debate whether the hepatic pump or expansion of the ribs is more important for crocodilians, and if the relative importance changes with age.

The next topic is gastralia (i.e. abdominal ribs). These are slender bones found in the abdominal body wall of some modern and extinct reptiles, including some early birds, dinosaurs, and pterosaurs. Most relevant for this discussion, gastralia are found in saurischian dinosaurs, but not ornithischian dinosaurs. Each left and right "rib" might articulate with each other and articulate to the gastralia in front and back. The forward-most gastralia might articulate with the sternum but are not attached to the vertebrae. The gastralia can collectively be regarded as a single unit called a "basket." We might be underestimating the number of dinosaurs with gastralia, since they are easily distarticulated, very thin, and easy to mistake for something else like an ossified tendon.

Finally, dinosaur hips. There are three bones in the hip: ileum, ischium, and pubis. In saurischian ("lizard-hipped") dinosaurs, the pubis points forward and down. In ornithischian ("bird-hipped") dinosaurs, the pubis points backwards. However, there is a process off the pubis called the "anterior pubic process" (APP) that points forward. (It is always a matter of confusion that birds and their immediate dinosaur ancestors are saurischians, but they have a backward-pointing pubis, convergent with the "bird-hipped" dinosaurs.)

Various proposals have been made for how dinosaurs breathed, from purely "hip" (crocodile-like) mechanisms to purely "chest" mechanisms (bird-like), or combinations of those. Since air sacs penetrate bone, and we see corresponding openings on the bones of theropod dinosaurs, it is a reasonable inference that theropods, and perhaps all saurischian dinosaurs, had air sacs. (Similarly with pterosaurs.) However, how those air sacs were inflated is not necessarily the same as in birds. It has also been proposed that gastralia can contribute to ventilating the lungs. That is, a muscle attached to the pelvis called the caudotruncus can pull the basket backwards or outward and expand the abdomen; this indirectly expands the lungs. This system is called "cuirassal breathing," which is another "hip-based" mechanism. Since dinosaurs were a very diverse group, it is perfectly plausible that different types of dinosaurs could have different mechanisms for breathing, and each dinosaur could have more than one mechanism.



At last we come to the main story. Radermacher et al. (2021) describe a new specimen (AM 4766) of *Heterodontosaurus tucki*. Heterodontosaurus is a small (1-2 meters long) bipedal dinosaur from the Early Jurassic, and is considered one of the most primitive ornithischians. It gets its genus name from the fact that it has different types of teeth, in particular short tusks where incisors would be in a mammal.

Cont'd

The authors CT-scanned AM 4766, and also an older specimen SAM-PK-K1332. AM 4766 has nine pairs of unambiguous gastralia, the only gastralia known from an ornithischian. Possible gastralia have been observed in other specimens of Heterodontosaurus, but this is the first time the assignment is unambiguous. The gastralia in AM 4766 are partially disarticulated, but there is evidence of them reaching to the tip of the pubis, which is pointed backwards. The sternal plates of Heterodontosaurus are more complex that those of other ornithischians, having a hole in the middle and having forward and rear processes.

The authors use this specimen of Heterodontosaurus to propose how breathing mechanisms evolved in ornithischian dinosaurs. The proposal is based on the following observations:

1. Heterodontosaurus has a “basket” while later ornithischians do not.
2. Heterodontosaurus has an especially small APP, while later ornithischians (especially hadrosaurs and ceratopsians) have a very long APP with an expanded head. The size of the APP does not seem to be related to whether the dinosaur is a biped or quadruped.
3. The backwards-pointing branch of the pubis gets smaller in later ornithischians.
4. No ornithischian shows signs of air sacs.

The proposal was that early ornithischians depended on their gastralia for cuirassal breathing. In contrast, later ornithischians used a “puboperitoneal” muscle that ran from the APP to the bottom portion of the lungs. This so-called “pelvic bellows” mechanism would be a new type of hip-based breathing. Of course, distinguishing different hip-based breathing mechanisms in extinct animals is intrinsically hard since they depend on different proposed muscles to make it work. Muscles themselves are not preserved in fossils, and all we have are uncertain inferences based on bones. Given that modern crocs have more than one way to inflate their lungs, and we are not certain which mechanism is more important when, it is hard to see how we can say anything definitive about dinosaurs.

Sources:

Radermacher, V.J.; Fernandez, V.; Schachner, E.R.; Butler, R.J.; Bordy, E.M.; Hudgins, M.N.; de Klerk, W.J.; Chapelle, K.E.J.; Choiniere, J.N. “A new Heterodontosaurus specimen elucidates the unique ventilatory macroevolution of ornithischian dinosaurs” eLife 2021, 10:e66036.

Spencer, M.R. “A new ‘hip’ way to breathe”. eLife 2021, 10:e66036.

Bear Feet at Laetoli Site A?

Bob Sheridan December 20, 2021

We have all heard of the Laetoli footprints (in Tanzania), which were described in the late 1970s. The footprints were made 3.6 Myr. in wet volcanic ash by up to three bipedal creatures moving along the same path. There are a total of 70 footprints in a trackway 27 meters long. The individual footprints look very much like that of a modern human (narrow feet, big toe in line with the other toes, deep heel impression), but are very small, corresponding to a height of 1.0-1.6 meters. The presumption is that these tracks were made by members of *Australopithecus afarensuafarensiss* (most famous specimen called "Lucy"), which lived around that time and were the correct size. In paleoart, the track makers are usually depicted walking next to each other, but it is hard to rule out that they may have been walking the same path hours apart.

We seldom hear that there are three sites at Laetoli with footprints of a biped: A, G, and S. The one discussed above is site G. Site A was discovered two years before site G, but not properly prepared until 2019. The footprints at site A (five of them) are not as human-looking as in site G, being almost as wide as long and much wider at the front than the back. The size is smaller also; if the footprints were made by a hominin, the hominin would have been only about 1 meter tall. It has been suggested that the footprints could have been made by a cross-stepping juvenile *Australopithecus afarensis*, a hominin other than A. afarensis, a chimp, or even a young bear.

McNutt et al. (2021) compare the tracks from site A to those of living humans, chimps and bears walking through mud. They looked at size and shape of the footprint (including divergence of the big toe), plus lengthwise distance between prints and distance between the left and right feet. Nowadays, physical trackways are converted to a 3D digital model via photogrammetry and measurements are done on the digital model. A complication for this analysis is possible "cross-stepping"; that is when one plants a foot past the midline of the track, so that, say, the print of left foot appears on the right side of the trackway. This would make the impression of the big toe of the left foot appear to be on the outside edge of the track instead of the middle as expected.

Bears can be eliminated from consideration almost at once. They seldom take as many as five bipedal steps, put most of the weight at the front of the foot instead of the heel, take shorter steps than humans, have a big toe about the same size as the other toes, and leave claw marks. Also, there is no skeletal evidence of bears living in that region at that time. The footprints at site A are intermediate in shape and big toe divergence between humans and chimps. Also, the trackway is narrower from left to right than for chimps, i.e., humans keep their legs close to the midline of the body. So chimps seem unlikely also. The authors feel they can eliminate cross-stepping because it is easy to distinguish right from left feet in hominins, even when done in soft mud. The authors therefore infer that the makers of the tracks at site A are another type of hominin, more advanced than chimps in their bipedal walk, but not as advanced as Australopithecus afarensis. This is plausible because we know from skeletal evidence that more than one type of hominin has existed at one time during the Pliocene. However, at present, there is no skeletal evidence for a hominin with feet consistent with the tracks from site A.

Sources:

McNutt, E.J.; Hatala, K.G.; Miller, C.; Adams, J.; Casana, J.; Deane, A.S.; Dominy, N.J.; Fabian, K.; Fannin, L.D.; Gaughan, S.; Gill, S.V.; Gurtu, J.; Gustafson, E.; Hill, A.C.; Johnson, C.; Kallindo, S.; Kilham, B.; Kilham, P.; Kim, E.; Liutkus-Pierce, C.; Maley, B.; Prabhat, A.; Reader, J.; Rubin, S.; Thompson, N.E.; Thornburg, R.; Williams-Hatala, E.M.; Zimmer, B.; Musiba, C.M.; DeSilva, J.M. "Footprint evidence of early hominin locomotor diversity at Laetoli, Tanzania" Nature 2021, 600, 468-475.

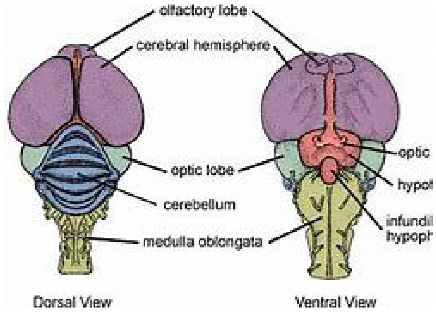
The Brain of Ichthyornis

Bob Sheridan August 6, 2021

Ichthyornis ("fish bird") is a pigeon-size toothed bird from the Late Cretaceous, most commonly found in Kansas. It was first described by O.C. Marsh in 1872, making it one of the first known toothed birds. Aside from the teeth, it is quite modern looking, especially in its wings and sternum. It is usually restored to be something between a seagull and small pelican. One might expect the name "fish bird" to refer to its suspected diet as a seabird, but it has to do with the fact that its vertebrae are concave on both sides like those of a fish.

Another topic of interest is the bird brain. Birds have about 3-fold larger brains then reptiles (including dinosaurs of the same weight), with the exception that the brains of bird-like dinosaurs (e.g. oviraptors, troodonts, dromaeosaurs) are intermediate between most reptiles and modern birds. The size and shape of bird brains, both fossil and living, can be gotten from CT-scanning their skulls. The major limitation to this kind of approach for fossils is that it requires that the skull be preserved uncrushed in three-dimensions, something that is rare, given that bird skulls tend to be very lightly built. The only known brain reconstructions for Mesozoic birds are for Archaeopteryx (Late Jurassic) and Cerebravis (Middle Cretaceous). Only a brain case is preserved for the second! You can think of a reptile brain as being composed of three main lobes, from back to front: the cerebellum, the optic lobes, and the cerebrum. In most reptiles and dinosaurs, the brain has a very "long cylinder" appearance. In modern birds, the cerebellum is expanded top-to-bottom, the optic lobes become more ventral, and the cerebrum is greatly expanded side-to-side, so overall the brain is globular. Not surprisingly, the brain of Cerebravis (Middle Cretaceous) is more modern-looking than that of Archaeopteryx (Late Jurassic). Crown birds have a bulge on either side of the top surface of the cerebrum called the "wulst." The wulst is not seen in early birds or dinosaurs. It is usually speculated that the wulst has something to do with powered flight or other "sensory integration."

Torres et al. (2021) describe the brain of *Ichthyornis diaspar* based on a CT-scan of a mostly complete skull. Given that Ichthyornis is from the Late Cretaceous and has advanced skeletal features, its brain is surprisingly primitive in shape, much like that of Archaeopteryx. On the other hand, the authors feel that Ichthyornis has the beginnings of a wulst.



This is unexpected since Cerebravis has a much more modern brain shape but lacks a wulst. This could imply that many features of the bird brain could be lost and regained with evolution of a lineage.

Another feature with the new Ichthyornis specimen has to do with its palate. Bird palates consist, going back to front, of the pterygoid, palatine, and hemipterygoid. These may fuse in different ways during the life of the bird. Ichthyornis has a long palatine with the hemipterigoid medial to it. This is different from other birds, except for another Late Cretaceous, but modern-looking, toothed bird from Kansas, Hesperornis. An elongated palatine is also observed in some modern birds that are considered to have "mobile palates." On the other hand, paleognaths (ostriches etc.), which are considered "primitive modern birds", have very short palatine and rigid palates. I am not sure I follow all the arguments in the paper about the palate, except the inference is that mobile palates existed before modern birds and that palatal features may be lost and gained within a lineage.

Most of the popular accounts of this paper make a great deal of the fact that modern birds survived the K-T extinction, whereas primitive birds and dinosaurs did not. They imply that this differential survival is connected the relative size and shape of the bird brain, and other features like the "mobile palate" or "elaboration of the visual system." If you read this paper, though, the authors do not make strong claims about extinction. They particularly examine the effect of size (and indirectly on the ratio of brain size and body size) on the probability of going extinct, but conclude that the estimates of body size are just too uncertain to draw a conclusion.

Sources:

Torres, C.R.; Norell, M.A.; Clarke, J.A.
"Bird neurocranial and body mass evolution across the end-Cretaceous mass extinction: the avian brain left other dinosaurs behind."
<u>*Sci. Adv.*</u> *2021*, 7, eabg/7099

890 Million Year Old Sponge?

Bob Sheridan August 9, 2021

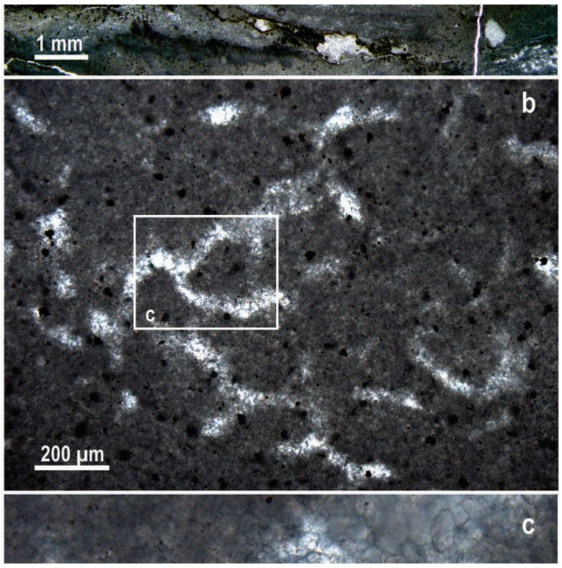
There is evidence for Life on Earth before 3 billion years ago. However, unambiguous evidence of multicellular animals ("metazoans") goes back only to the beginning of the Ediacaran Era (635 Myr) and the Cambrian Explosion (541 Myr.) occurs at the end of that time. Every once in a while someone has claimed to discovered evidence for metazoans from earlier periods. The first article I wrote for the Paleontograph in 1998 concerned the claim by Seilacher et al. (1998) that they had found the tubular tracks of worm-like animals in 1.1 billion-year-old sediments from India. The usual reception for such claims is extreme skepticism. Skepticism is justified on two grounds:

1. There is very little evidence of metazoans other than that being claimed.
2. The evidence could have been generated by a number of processes that don't involve metazoans but simpler life known from the time in question.

On the other hand, molecular clock evidence suggests that modern fauna should have diverged well before the Cambrian Explosion, although there is a great deal of uncertainty in these calculations. So it is conceivable that metazoans were around very early, but were rare and hard to discover.

Here we get into the issue of "burden of proof", which comes up in paleontology all the time, not just on the subject of pre-Ediacaran animals. The claimants insist that "if it looks like X, it is X." The skeptics insist that "extraordinary claims require extraordinary proof", and that all non-X explanations need to be eliminated. The skeptics usually can come up with at least one plausible alternative explanation. These disputes are seldom resolved to everyone's satisfaction.

A new example surfaced last week with the claim by Turner (2021) for evidence of sponges in 890 Myr. deposits from the Little Dal Formation in Canada. These sediments represent reefs built by stromatolites. Stromatolites are domed structures built of layers of blue-green algae and sand. The rocks were studied in thin section by optical microscopy. The evidence is in the form of a branched network of tubules 20-30 micrometers in diameter. These are filled by calcite crystals. The authors note the resemblance of the network in shape and size to the spongin skeletons of keratosan ("horny") sponges. Similar fossils have been described from stromatolite-containing rocks formed when sponges were known to exist (e.g. the Ordovician). However, networks of tubes could be formed in a number of ways, for instance by algae or other microorganisms.



If there was going to be a metazoan older than the Cambrian (350 Myr. older than expected!), it would certainly be a sponge, since sponges are considered the simplest animals.
One difficulty, though, is that the Earth past through some periods of low oxygen and freezing ("snowball Earth") at ~650 Myr. so it is hard to believe sponges would survive to the present day. Although, the counter-argument from Turner is that if they lived on stromatolite reefs they could have enough oxygen.

Sources:

Kozlov, M.
"Sponge-like fossil could be Earth's earliest known animal."
Nature 2021, 596, pg. 19.

Seilacher, A.; Bose, P.K.; Pfluger, F.
"Triploblastic animals more than 1 billion years ago: trace fossil evidence from India."
Science 1998, 282, 80-82.

Turner, E.C.
"Possible poriferan body fossils in early Neoproterozoic microbial reefs."
Nature 2021, 596, 87-91.

Two New Spinosaurid Genera?

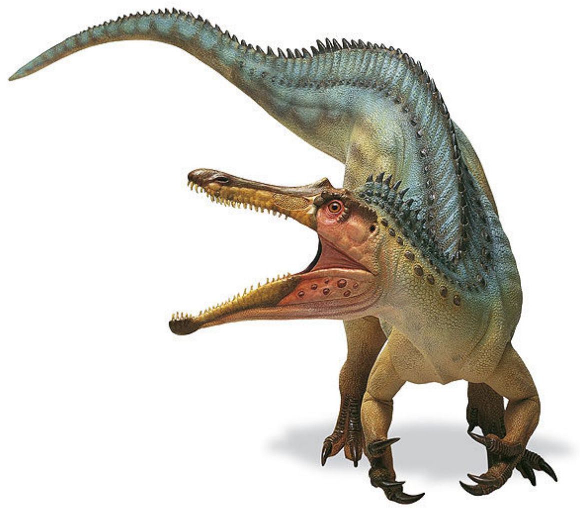
Bob Sheridan October 6, 2021

Spinosaurids, from the Early and Mid-Cretaceous, are somewhat unusual theropods. The most famous example Spinosaurus (from Africa) is very large, has a long narrow snout with a notch between the premaxilla and maxilla, large hand claws, long spines on its back forming a sail, a very deep tail, and probably very short legs. The current consensus is that Spinosaurus had an aquatic lifestyle. Related theropods are Suchomimus (also from Africa), Irritator (from South America), Ichthyovenator (from Southeast Asia) and Baryonyx (from England and Portugal). These have the same type of snout as Spinosaurus, and possibly large hand claws, but legs more normal for theropods. Ichthyovenator may have slightly long spines. It is quite common to find isolated spinosaurid teeth, and sometimes separate taxa are based on them.

Barker et al. (2021) introduce two new specimens from the Wealdon Formation in the Isle of Wight (off the southern coast of England). This formation is thought to be Early Cretaceous in age. These specimens are given the names *Riparovenator milnerae* ("riverbank hunter," plus paleontologist Angela Milner) and *Ceratosuchops inferodios* ("horned crocodile, heron from hell"). Ripanovenator consists of the upper tip of the snout, including the roots of some premaxillary teeth, most of the braincase, and some caudal vertebrae. Ceratosuchops consists of the same parts of the skull, but no vertebrae.

Ripanovenator by Emily Stepp

Phylogenetically, Riparovenator and Ceratosuchops are most closely related to each other, then to Suchomimus, and then to Baryonyx. The Baryonyx-like and Spinosaurus-like theropods together form the group of spinosaurids. One interpretation of this phylogeny is that, since Baryonyx and Suchomimus are so closely related, spinosaurids originated in Europe. Also, the tail of Riparovenator seems to be on the deep side, similar to what is seen in Spinosaurus.



Baryonyx

The authors feel that Riparovenator, Ceratosuchops, and Baryonyx are anatomically different enough that they deserve separate genus names, even though they lived in about the same place at about the same time. A simpler scenario would be that they are all Baryonyx, but vary from the previous Baryonyx specimens due to age or sex. Multiple genera would also be inconsistent with the ecological consideration that different but similar species would not compete against each other, and the authors acknowledge this. Given the scrappy nature of the current Riparovenator and Ceratosuchops specimens, we would need much more material to be sure these are really different. Some investigators think Baryonyx and Suchomimus are not really distinct genera, just regional variations of the same animal.

Sources:

Barker, C.T.; Hone, D.W.E.; Naish, D.; Cau, A.; Lockwood, J.A.F.; Foster, B.; Clarkin, C.E.; Schneider, P; Neil J. Gostling, N.J.

"New spinosaurids from the Wessex Formation (Early Cretaceous, UK) and the European origins of Spinosauridae."

Scientific Reports 2021, 11:193

Burmese Amber Shows Maternal Care in Spiders

Bob Sheridan October 4, 2021

Spiders, despite being solitary and opportunistically cannibalistic, can be good mothers. Maternal behaviors include carrying around their eggs in a silk-wrapped sac in silk, regurgitating "milk" for its offspring, and gathering food for their offspring before they hatch. Sometimes the mothers even serve themselves up as the food, sacrificing another chance to reproduce. Such behavior has evolved many times in unrelated spiders, so it must have some evolutionary advantage.

Spider behavior is not easily fossilized. However, Guo et al. (2021) describe inclusions in Burmese amber (~99Myr) that reflects on spider behavior. There are four specimens CNU009371, CNU009431, CNU009432, and CNU009476, which are studied by optical microscopy and CT-scanning. CNU009432 contains a large (8 millimeter long in the body), almost complete, spider. On the dorsal side of the abdomen is a broken egg sac, made of silk (with thread diameter about 1 micrometer), and containing several dozen eggs. The eggs are close to hatching because some details of the embryos can be seen. CNU009476 has 24 spiderlings, most of which are distorted or broken. Spider silk threads and other types of insects are present. CNU009431 contains distorted spiderlings and other insect inclusions. CNU009371 contains 34 spiderlings plus a wasp. All the spiderlings are 0.5 millimeter long in the body. The fact that we see so many spiderlings of the same species together probably implies they stayed close to the nest when young.

The spiders appear to be lagonomegopids, a group of extinct Cretaceous spiders with a pair of large eyes and spineless shortish legs. It is usually assumed that they are ambush hunters, rather than web-builders. Lagonomegopids are previously known from North America, Eurasia, and the Middle East, including from other specimens of Burmese amber. It is not clear whether the mother spider in CNU009432 is carrying the egg sac on its abdomen or just guarding it, but it is clear that lagonomegopids evolved that behavior before mid-Cretaceous.

Sources:

Guo, X.; Selden, P.A.; Ren, D.
"Maternal care in mid-Cretaceous lagonomegopid spiders."
Proc. Royal Soc. B. 2021, 288:20211279.

Two More Unusual Amber Inclusions

Bob Sheridan October 29, 2021

Most inclusions in amber are invertebrates, particularly arthropods, but the diversity of creatures in amber is increasing. This is particular true about Burmese amber, where we see parts of birds, lizards, etc. It seems anything small enough not to escape from running tree sap will eventually be found in amber.

The first story has to do with tardigrades ("slow steppers"), which are found in moist land environments anywhere in the world, including Antarctica. Tardigrates are popularly called "water bears" or "moss piglets". They are small (0.5-1.5 millimeter) creatures with eight pairs of limbs,each ending in a few claws. To me, tardigrades seem to be a cute combination of teddy bear, pig, and caterpillar. It is not clear where tardigrades belong in the tree of life, but they might be a sister group to arthropods. Tardigrades are known for surviving extreme conditions: heat, radiation, freezing, vacuum, etc., especially when in a dehydrated state. The earliest probable tardigrade fossil is from the Cambrian. Only two tardigrade specimens have been found in amber previously, both from the Cretaceous (from Canada and New Jersey). Mapalo et al. (2021) describe an amber specimen in Domincan amber (~16 Myr.) which they name *Paradoryphoribius chronocaribbeus* ("resembles Doryphoribus", "time", and "Carribean"). This specimen (~0.4 millimeters long) is studied with confocal optical microscopy. It is not particularly well-preserved (some body fluid seems to be leaking out), but there are enough details to the claws and mouth that the specimen can be linked to the modern Isohypsibioidea superfamily of tardigrades.

A Tardigrade

Cont'd

Our second story deals with crabs. The evolution of crabs is complex in that there is evidence that lobster-like crustaceans evolved toward a crab-like form (wide carapace with a much reduced abdomen folded under the carapace) several times independently. This phenomenon of convergent evolution even has a name: carcinization. Thus, zoologists often divide crab-like creatures into “true crabs” and “false crabs.” The earliest crab-like crustaceans are known from the Early Jurassic. Modern crabs inhabit marine environments, fresh water, and sometimes live in moist land environments. Luque et al. (2021) describe a well-preserved crab specimen in Burmese amber (~99 Mr.) which they name *Cretapsara athanata* (“chalk”, after the cloud spirit “Aspara” and “immortal”). This specimen was studied with optical microscopy and micro-CT scanning. It is unusual for a crab in that the carapace is as long as wide (both ~2 millimeters), and has a arrowhead shape with the point toward the rear. The claws are relatively small and narrow. The mouthparts and gills are preserved in detail. The eyestalks are very large, about one-third the width of the carapace. To me, the narrow body and large eyes give Cretapsara a very “cartoony” appearance (somewhere between Sebastian from “The Little Mermaid” and Mister Krabs from “Spongebob Squarepants”, although both these characters have largish claws). Despite its small size, it is not clear whether Cretapsara represents an adult or juvenile, since very small adult crabs do exist today.

Phylogenetic analysis places Cretapsara among the modern true crabs, which may inhabit a variety of habitats. Since Cretapsara was engulfed in amber, we can assume it was near a tree, which eliminates a purely marine habitat. From this we can infer non-marine crabs existed at least as far back as the Middle Cretaceous.

Sources:

Luque, J.; Xing, L; Briggs, D.E.G; Clark, E.G.; Duque, A.; Hui, J.; Mai, H.; McKellar, R.C.
“Crab in amber reveals an early colonization of nonmarine environments during the Cretaceous.”
Scientific Advances 2021, 7: eabj5689

Mapalo, M.A.; Robin, N.; Boudinot, B.E.; Ortega-Hernández, J.; Barden, P.
“A tardigrade in Dominican amber.”
Proc. R. Soc. B 288: 20211760.

Cambrian Bryozoans

Bob Sheridan November 17, 2021

Bryozoans are a phylum of aquatic invertebrates that live in colonies. The skeleton of colonies can be of the form of sheets, fans, bushes, etc., and the skeleton may or may not be mineralized. Individual animals in the colony, typically a millimeter long or smaller, are called “zooids”. Zooids are fairly complex multicellular animals, with a digestive system, nerves, muscles, etc. Zooids characteristically have a crown of tentacles called a “lophophore,” used for filter-feeding. Zooids in a colony are not identical or independent; some zooids have specialized jobs, and food can be passed between them.

Bryozoans are very abundant as fossils. Tens of thousands of fossil species have been named. Molecular clock evidence suggest bryozoans originated in the Cambrian, but the earliest known unambiguous bryozoan fossils are from the Early Ordovician.

Zhang et al. (2021) describe phosphatized sheet-like fragments (a few millimeters long) isolated from lower Cambrian rocks of China and Australia. These are prepared by dissolving limestone in acetic acid. These are studied by scanning electron microscopy and x-ray tomography. The sheets have shallow regularly-spaced hexagonal pockets in the surface, about 0.17 by 0.22 millimeters wide, and 0.05 millimeters deep. These pockets are seen on both sides of the sheets. This type of fossil was described before by other workers and given the genus name Protomelission (“first honeycomb”). The contribution of Zhang et al. is to assign this fossil as a bryozoan. Presumably, the holes are where zooids would sit. The authors’ phylogenetic analysis would assign Protomelission as a stem-group bryozoan lacking mineralization. This would make sense for an early bryozoan, but it must be acknowledged that the analysis is based only on the size and shape of the pockets, without information about the zooid itself. If the assignment of Protomelission as a bryozoan is correct, that would place the earliest fossil 35 million years older than the previously known specimens.

Sources:

Zhang, Z.; Zhang, Z.; Ma, J.; Taylor, P.D.; Strotz, L.C.; Jacquet, S.M.; Skovsted, C.B.; Chen, F.; Han, J.; Brock, G.A.
“Fossil evidence unveils an early Cambrian origin for Bryozoa”
Nature 2021, 599, 251-257.

Fairing in Pterosaur Wings?

Bob Sheridan November 16, 2021

In aerodynamics, "fairing" is any structure that reduces drag by smoothing outlines and covering openings or irregular surfaces. For example, wheels may be covered by a tear-drop-shaped structure called "wheel pants." For our story, another relevant example is "wing root" fairing, which smooths the interface between the fuselage and the wing. Wing root fairing is seen in birds; feathers form a convex surface from the chest to the wing membrane. Bats use fur on their necks to partly cover the junction between the wing and the body. Recently, Pittman et al. (2021) discuss evidence for fairing in pterosaurs.

Pittman et al. redescribe a specimen of a complete, articulated pterodactyloid pterosaur from Solnhofen Limestone in Southern Germany (Late Jurassic). Pterodactyloid pterosaurs, as a general rule, have long necks, long skulls (sometimes toothless), and no tail. This particular specimen was discovered in 1937 and is well known. In fact, I have a cast of it in my china cabinet. It is usually labelled as the genus Pterodactylus. Pterodactylus was the first pterosaur recognized (in the 18th Century from less complete specimens). The body of this specimen is about five inches long, and it has a narrow head about three inches long. Its wings are mostly folded, but the wingspan would be about 20 inches if they were spread. As with many Solnhofen specimens, there is some trace of soft tissue. In particular there is some raised limestone around the body and at the ventral side of the neck. However, as with Solnhofen specimens, the specimen is two dimensional and one-sided; we are looking down at its back.

The new aspect of the study of this specimen is to use laser-stimulated fluorescence (LSF). The idea is that one shines a laser on the specimen, and any persevered soft tissue glows in visible light. In this specimen there is a pink glow around the base of the neck and the forward part of the chest, pretty much where the raised limestone is visible in ordinary light. The authors interpret this as muscle. The muscle might extend to the inside of the elbow, which might imply the front part of the wing membrane contains muscle. (However, given this interpretation, one wonders why the rest of the body, which should have some muscle, does not glow.) There is a hint of violet glow around where the wing and tail membranes would be expected to be, but this is hard to be sure of in the provided photograph. Clearly, there is fairing in the sense that the putative muscle smooths the interface between neck and body as seen from the top. The authors are also claiming this is evidence of wing root fairing, i.e. smoothing of the interface between wing and body as seen from the front. Given that the specimen is squashed in the back-to-belly direction, we cannot look at it from the front to check, and the authors admit this is a difficulty.

Sources:

Pittman, M.; Barlow, L.A.; Kaye, T.G.; Habib, M.B. "Pterosaurs evolved a muscular wing-body junction providing multifaceted flight performance benefits: advanced aerodynamic smoothing, sophisticated wing root control, and wing force generation."

Proc. Natl. Acad. Sci. USA (2021), 118, 210631118.

Beasts Before Us—A Review

Bob Sheridan November 23, 2021

Fossil mammals have less popular appeal than dinosaurs, and popular books on that topic are less common. "Beasts Before Us" is the newest example I have come across. The author Elsa Panciroli currently works for the Oxford Museum of Natural History and the National Museum of Scotland. Her research interests are mostly concentrated on early mammals, especially those from the Isle of Skye. Her current role is mostly as a speaker and writer. "Beasts Before Us" is her first book.

As with many popular books on fossil animals, BBU is a mixture of personal memoir, discussion of the current scientific wisdom, and some pontification on some special topics, with a little humor thrown in. Sometimes this is a good combination, sometimes not. Popular books also vary in how up-to-date they are. I usually judge books by how many points of discussion are unfamiliar to me, as a person who has followed paleontology as a hobby for a few decades now.

These are the chapter headings for BBU:

1. Isle of Mists and Lagoons.

This details the authors prospecting on the Isle of Skye (off the Scottish coast), which is particularly rich in the fossils of Jurassic mammals.

2. A Thoroughly Modern Platypus

This reviews fossil hunting and evolutionary ideas from the 19th century. Two shocking ideas from that period: mammals existed during the reign of the dinosaurs, and that the platypus was a mammal that laid eggs.

3. Like a Hole in the Head
A review of the Devonian, when amniotes originated. Plus the distinction between synapsid "reptiles" (one hole the skull behind the eye) and diapsid reptiles (two holes behind the eye). The first are the ancestors of mammals, and the second are the ancestors of dinosaurs, pterosaurs, snakes, and lizards. There is a discussion of why we should not use the traditional term "mammal-like" reptile to refer to the synapsids.

4. The First Age of Mammals
The author's experience in South Africa, and the Permian as the first "Age of Mammals".
There is a particularly good discussion of sail-backed Dimetrodon, which is sometimes labelled a "dinosaur" in children's books, but is really an early synapsid. Whereas originally the sail was hypothesized to have something to do with temperature regulation, nowadays it looks more like a device for sexual selection, like a peacock's tail. There is also a good discussion of tiny-headed synapsid herbivores.

5. Hot-blooded Dinosaurs
A discussion of radiometric dating, plus stories of the author prospecting in the Perm region of Russia (after which the Permian is named). This chapter also has a good discussion of dinocephalians like Moschops (mostly herbivores) and saber-toothed synapsid predators like Gorgonops. Some discussion of synapsid trackways in Clackach sandstone in the north of Scotland. Finally, a very good discussion of "warm-bloodedness" vs. "cold-bloodedness", specifically what correlates can be seen in the bones (microstructure in the bone indicating dense arrangements of blood vessels and or the presence of nasal turbinates being the most frequently cited). It seems like pre-mammalian therapsids (late in the Permian) might have been the first synapsids to show signs of warm-bloodedness.

6. A Total Disaster
This chapter discusses the end-Permian extinction. The author prospecting in the Karoo region of South Africa for Triassic fossils. The story of Lystrosaurus, a dicynodont (a type of synapsid with a beak and tusks) which seemed to survive from the Permian to the Triassic after most synapsids went extinct. The Triassic was a time of great diversity for diapsid reptiles, especially crocodiles. Eventually, though, dinosaurs took over all the niches for large-bodied animals. However, it appears one dicynodont Lisowicia survived to the Late Triassic; it was about the size of an elephant, much larger than expected.

7. Milk Tooth
This chapter contains a discussion about mammalian characteristics that arose for the first time in the Triassic: seconday palate (so breathing and eating can be done at the same time—essential for nursing young), a modified jaw joint and inner ear bones (for enhanced hearing), specialized teeth that were replaced only once (allowing good occlusion), and enlarged eyes (presumably for better night vision). This chapter also contains a good summary of the career of Robert Broom, a Scottish doctor who moved to South Africa to study the origin of mammals.

8. Digital Bones
This chapter has a very good discussion of the use of CT-scanning of small fossils. In particular, this details the author's use of the European Synchotron radiation facility. Synchotrons use a ring of electrons accelearated to near the speed of light to generate x-rays strong enough to scan specimens with rock-like densities. CT-scanning is needed to see details in the skull like the passages for nerves. At some point in mammalian evolution the path for the facial nerves goes from the maxilla to the side of the snout; one inference is that is the point when wiskers became a feature of mammals.

9. Chinese Revelations
China has an extensive record of Jurassic mammals. Some fossil mammal and mammaliform classifications are based on teeth alone (because they are often the only thing preserved). This chapter has a discussion of several types of molars: docodontan, haramiyidan, tribosplenic—presumably reflecting a shift of diet from insects to plants. China is also the home of Jurassic specimens showing a larger diversity of lifestyles than was previously suspected for Mesozoic mammals: mole-like, beaver-like, flying squirrel-like, etc. Finally, this chapter contains a good discussion of the evolution of the mammalian jaw joint, and the specialization of middle ear bones. The specialization may have occurred several times independently.

10. Time of Revolt
This contains a good discussion of tritylodontids, a set of almost-mammals that lived from the Triassic to the Cretaceous, living alongside true mammals. They had an unusual conveyor-belt system of continuously replacing their molars (unusual today in mammals except for elephants). This chapter also contains a good discussion of the origin of flowering plants in the Early Cretaceous, which greatly expanded the type of food available for mammals

and dinosaurs. I had never heard of Polish paleontologist Zofia Kielan-Jaworoska. She lead expeditions to Mongolia in the 1960s to look for Createaceous mammal fossils. Discoveries here greatly expanded the known specimens of multituberculates, which are probably the first modern mammals (sister to marsupials and placental mammals) and which converged on a bony anatomy that resembles modern rodents.

11. The Journey Home
This discusses the K-T extinction and the beginning of the "Second Age of Mammals." Most of this chapter deals with possible reasons that mammals survived this extinction whereas dinosaurs (with the exception of birds) and pterosaurs were completely obiliterated. Small size, generalized diet (including eating insects), warm-bloodedness. This chapter also contains a short discussion of whether the dinosaurs kept mammals from increasing in size. Some constraint seems to be in the data, but the exact reason is not clear.

12. Triumph of the Little Guy
This is a discussion of a possible "sixth extinction" due to humans modifying the environment, in particular due to climate change.

I generally like this book; it did contain enough material new to me to make it interesting. You should be aware BBU is not trying to be comprehensive. It can be considered "special topics in Permian synapsids and Mesozoic mammals." My biggest criticism is that the book is deficient in illustration. There is a set of color plates in the center, mostly photographs of fossils and localities. There is a black and white drawing for each chapter, illustrating a reconstructed animal, but these seem mostly decorative rather than informative. There are only a few diagrams or drawings that help the reader understand the concepts. It would be nice to have more. For example, if you are going to discuss the jaw joint of true relative to the jaw joints of other synapsids, you need a picture to illustrate the anatomy. Another issue I have is that BBU could have been better organized. If you are going to talk about tooth types, for example, you should have all that information summarized in same chapter. You can see from my summary above that each chapter contains at least some material that is not obviously related. I would guess that BBU is assembled from a collection of individual pieces.

A criticism I have seen in the Amazon reviews of BBU is that the author often points out that the paleontologists under discussion are privileged white males with racist attitudes. What the author says is undeniable, but I am not sure it is fair to single out these particular people, since those things were true of most scholars before a few decades ago. I agree with the critics that those parts are something of a distraction, but I wouldn't say it was a deal-breaker.

If you are looking for a comprehensive popular book on fossil mammals with lots of illustrations, my recommendation is Donald R. Prothero's "The Princeton Field Guide to Prehistoric Mammals". Two caveats: it is from 2017 and is drifting out of date, and it does not have much about pre-mammal synapsids.
Sources:

Panciroli, E.
"Beasts before us. The untold story of mammal origins and evolution."
Bloomsbury Sigma, London, 2021, 320 pages, $28 (hardcover).

Social Structure for Mussasaurus

Bob Sheridan November 19, 2021

We are now quite used to the idea that sauropods were at least partlysocial and laid eggs in nesting grounds. There have been multiple discoveries of titanosaur (probably Rapetosaurus) eggs, some containing embryos, in Cretaceous Patagonia (the southern end of Argentina and Chile). Pol et al. (2021) very recently describe a fossil assemblage from the Laguna Colorado Formation (Santa Cruz Province, Argentina), which is from the Early Jurassic (~193 Myr.).
This formation contains two partially preserved eggs, juvenile specimens, and adult specimens of the prosauropod Mussasaurus patagonicus ("mouse reptile"). Mussasaurus is a prosauropod, which are considered ancestral to sauropods.

Pol et al. describe 69 new specimens of Mussasaurus, plus a number of egg clutches, within an area of 1 square kilometer. The Mussasurus can be put into 4 or 5 size classifications, indicating different ages. There is an aggregate of 11 small juvenile specimens (estimated mass 8-10 kilograms), which are articulated and overlapping, suggesting they died in a common event. Bone histology of the long bone can be used to estimate the age of the animals by counting LAGS (lines of arrested growth). Histology confirms that these juveniles are under 1 year old.
Cont"d

There are also specimens of two intermediate sizes (estimated 100 kilograms and 600 kilograms) which appear to be over one year old. Finally there is the largest specimen (estimated 1500 kg), which appears to be about 8 years old.

The accumulation of individuals of different ages in the same place at the same time suggests herd behavior, including behavior other than nesting, i.e. if reproduction were the only goal for congregating, we would see only adults. This becomes the earliest know example of social behavior in dinosaurs. Since sauropods and prosauropods diverged sometime in the Triassic, we might infer that group nesting behavior dates back that far.

Sources:
Pol, D.; Mancuso, A.C.; Smith, R.M.H.; Marsicano, C.A.; Ramezani, J.; Cerda, I.A.; Otero, A.; Fernandez, V.
"Earliest evidence of herd-living and age segregation amongst dinosaurs."
Scienfic Reports (2021) 11:20023

Stegouros

Bob Sheridan December 13, 2021

Nodosaurs and ankylosaurs, of which there are many known genera from the Late Cretaceous, are related "armored dinosaurs." These are fairly large (~1 ton in weight), wide and low animals covered with rounded bony plates ("osteoderms") on the top and spike-like projections on the side. Their limbs tended to be short and robust. The plates on the head are almost always completely fused onto the skull. Both have very small, primitive, leaf-shaped teeth. Ankylosaurs are distinguishable from nodosaurs in that they have bony clubs at the end of their tails. Collectively, nodosaurs and ankylosaurs form a group "Ankylosauria". The ankylosaurs are thought to be a sister group to the stegosaurs (named after Stegosaurus), most of which lived in the Late Jurassic. In contrast to ankylosaurs, stegosaurs were tall, narrow from side-to-side, and had more gracile limbs. Stegosaurs also had a type of "armor," most of which were plates or spikes that protruded from the back, plus sideward-facing spines on their tails. Stegosaurs and ankylosaurs can be grouped together as "Eurypoda" (broad foot).

Today's story concerns a new genus that links ankylosaurs and stegosaurs. Soto-Acuna et al. (2021) describe an ankylosaur specimen from Late Cretaceous (~73 Myr.) southern Chile. The authors assign the name *Stegouros elengassen* ("roof tail" and after mythical armored beast). The specimen is almost complete, and includes bones and osteoderms. Stegouros is small (only six feet long), and has a tail that is short for an ankylosaur. There are two unexpected features:

1. The skull is very ankylosaur-like, especially in the arrangement of tooth rows. However, there are no osteoderms armoring the skull. Also, the limbs are slender, much like that of stegosauria.
2. The tail has four osteoderms at the end of the tail expanded sideways. This constitutes a type of tail "weapon" that is flat from top-to-bottom (like a cricket bat), unlike the bulbous tail club of ankylosaurs.

Overall phylogenetic analysis puts Stegouros close to a previously described genus from Late Cretaceous Antarctica called Antarctopelta. Antarctopelta is very incomplete, specifically it lacks a tail. There is also an Australian ankylosaur called Kunbarrasaurus which is also close. (Notice all three dinosaurs are from the southern hemisphere.) The authors propose that Stegouros, Antarctopelta, and Kunbarrasaurus collectively represent a group they call Parankylosaurs ("at the side of ankylosaurs") which is a sister group "Euankylosaurs" (ankylosaurs and nodosaurs). The Parankylosaurs are suggested to represent a transition between stegosaurs and ankylosaurs, and that would imply that they arose sometime in the Jurassic. Since not all Euankylosaurs have tail weapons, but Stegouros does, this suggests Stegouros developed its tail weapon independently.

Sources:
Soto-Acuña, S; Vargas, A.O.; Kaluza, J.; Leppe, M.A.; Botelho, J.F.; Palma-Liberona, J.; Simon-Gutstein, C.; Fernández, R.A.; Ortiz, H.; Milla, V.; Aravena, B.; Manríquez, L.M.E.; Alarcón-Muñoz, J.; Pino, J.P.; Trevisan, C.; Mansilla, H.; Hinojosa, L.F.; Muñoz-Walther, V. ; Rubilar-Rogers, D.
"Bizarre tail weaponry in a transitional ankylosaur from subantarctic Chile."
Nature 2021, 600, 259-265.

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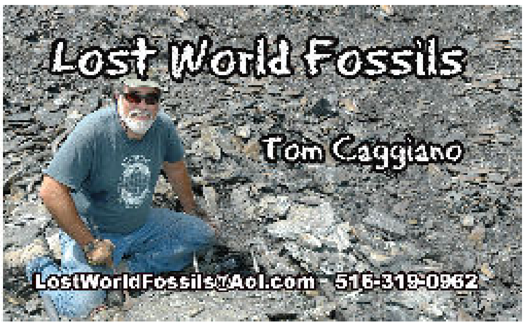
The Paleontograph back issues are archived on the Journal Page of the AAPS website.
https://www.aaps-journal.org/



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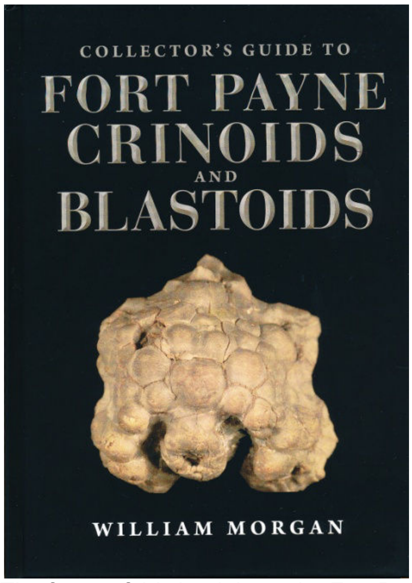

The focus of this book is on the Fort Payne Formation and the fossil crinoids and blastoids, which are found there. Although, it is not widely known outside of academic programs in geology and/or paleontology, the Fort Payne is one the largest Mississippian-age formations in the middle and southeastern United States.
Unlike the crinoids found in the Edwardsville Formation, which are world-renown for their completeness and aesthetic qualities, crinoids from the Fort Payne are rarely complete. Therefore, the first chapter of the book introduces the anatomy and the descriptive terminology essential for identifying crinoids collected from the Fort Payne.
The second chapter of the book introduces the ongoing revision of the classification of crinoids. This process was still ongoing at the time that is book was written.
The third chapter briefly reviews the better known of the fossilfiorous formations found in the Mississippian. More detail is provided for the geology and paleontology of the Fort Payne.
Collections of crinoids and blastoids from the Fort Payne are rarely publically displayed. Therefore, Chapter four proves high quality color photographs of some the best preserved specimens curated at major museums in the United States. In almost every case there are two photographs of each specimen, one unlabeled and a second with key features labeled and identified.
The fifth chapter reviews the morphology of blastoids and discusses the blastoids species currently known from the Fort Payne.

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