The Paleontograph

A newsletter for those interested in all aspects of Paleontology
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From Your Editor

Welcome to our first edition of the year. I hope this issue finds you healthy and safe. I've been slacking with getting out an issue and I have a large backload of articles so don't be surprised if you get another issue next month. I've also enlarged the issue for the same reason.

It seems we have finally gotten back to the new normal. I'm glad to not be hearing about Covid and death rates. Of course it's been replaced with people dying from war. Not a good thing.

If anyone lives near NJ, I hope to see you at the Fossil and Gem Show in Edison. See the last page for details. Enjoy your spring.

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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Endocasts of the Brain of Early Homo

Bob Sheridan April 11, 2021

In the 1860s there was a dispute between Thomas Henry Huxley and Richard Owen, both brilliant anatomists. Owen maintained that a particular deep structure in the brain, at the time known as the "hippocampus minor" (now called the "calcar avis"), was present in the human brain, but not the brains of great apes or other primates. The argument was that if this was true, then apes and humans were very different, probably did not share a common ancestor, and that evolution could not be true. The debate was ultimately between two ideas: that animals were similar because they had a common ancestor (Darwin) or because they had separate origins but were based on the same divine plan (Owen). Ultimately, Huxley showed the hippocampus minor was present in monkeys, and the marmoset had a particularly large one. This debate was mentioned in many satires and popular works of the time. From today's viewpoint this seems like a very silly argument. For example, even if apes and humans differ in one brain feature, this by no means would make them "dissimilar", and would in no way eliminate them having a common ancestor. Also, nowadays we would not consider "divine plan" a remotely scientific idea, because it is not testable. However, these men were not stupid; it is just that apes were new to anatomists at the time.

I remembered this when I came across a paper in Science his week. Ponce de Leon et al. (2021) compare brain endocasts of great apes (chimpanzees, gorillas , and orangutans), modern *Homo sapiens*, and a few dozen fossil specimens of the genus Homo *(Homo habilis, Homo erectus, Homo floresiensis, Homo neanderthalis*), plus a few Australopithecines, that go back to almost 2 million years. The idea is to measure changes in the shape of the brain in the course of human evolution. Endocasts are the internal cast of a hollow object such as a skull. These can be real, e.g. when skulls are filled with sediment, or virtual, e.g. one CT-scans a skull, and takes the interior space of a skull as the "endocast." There is a very big limit to the studying the shape of endocasts for fossils. One must have a skull that is mostly complete and not distorted, something fairly rare among fossil humans. The major limit for using endocasts, whether from living or fossil animals: one can see only surface features of the brain that are reflected as grooves or pockets in the skull. Finally, except for size (ape brains are about one-third the volume) ape and human brains look very similar, so we are looking for subtle differences, differences that may not be very large compared to differences among individuals of the same species. Also, the age of the specimen may make a difference, as we expect changes during development.

The authors note a number of endocast features that differ between ape and human brains. Some of these have to do with brain lobes. For example, the inferior prefrontal cortex, occipital lobe and posterior parietal cortex seem somewhat larger in humans. They also considered "sulci" (singular sulcus), which are furrows in the surface of the brain due to the folding of the cortex. For example, the sulci in the top part of the ape brains forms a Y-pattern, while human brains show two parallel lines. Finally, the authors note the position of the coronal suture (the joint between the frontal and parietal bones in the skull) is forward of the precentral sulcus in humans.

One way to represent all the changes among specimens at once is to project them onto two principal components; that way one can inspect the placement of individual specimens on a flat plane. The first principal component represents mostly the width of the frontal lobes (wider in humans) and the placement of the foramen magnum (where the spinal cord joins the brain), reflecting the upright stance of humans. The second principal component measures mostly the overall length, width, and height of the brain. In this plot, although there is appreciable scatter due to difference in individual specimens, there is a clear separation between the three groups, apes, *Homo sapiens*, and fossil Homo. Not surprisingly, most fossil Homo specimens seem intermediate between apes and modern *Homo sapiens*. Exceptions: *Homo neanderthalis* looks very like *Homo sapiens* and *Homo floresiensis* looks very ape-like. Dividing specimens by time, it seems that the sidewards expansion of the frontal lobes took place about 1.7-1.5 Myr., about the time the brain volume increased. The shift of the precentral sulcus relative to the coronal suture seems to have occured at the same time. Another way of looking at this is that the current organization of the human brain arose within the evolution of Homo and not, say, at the transition between Australopithecus and Homo. There does not seem to be a very clear division of brain shape by geography (e.g. *Homo erectus* in Asia vs. Africa) or by whether the specimen is a juvenile.

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Brain casts cont'd

The authors suggest that Homo dispersed from Africa a first time around 2.1 Myr. and those humans retained the primitive brain shape. A new brain shape emerged in Africa 1.7-1.5 Myr. and humans dispersing after that, retained the new shape. This is testable by examining more endocasts of various ages.

It is tempting to link changes in the expanding width of the frontal lobe to changes in stone tools or using language, or some other type of behavior, but that would be a stretch at this point. One has to remember that the overall size of the brain is changing as well, and many important changes in the brain will not be visible in the endocasts.

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Spokes in Neck Vertebrae of Azhdarchid Pterosaurs

Bob Sheridan April 17, 2021

Pterosaurs, like birds, have hollow bones. There are various ways of making the bones as light as possible while keeping them reasonably strong. The most usual way is to have thin walls and a mostly hollow space (which is mostly air) in the middle. The hollow space is crossed with thin rods called "trabeculae" that provide the bracing between the outer walls. Strength of the bones is especially an issue with the largest pterosaurs. Azhdarchids (named for the genus Azhdarcho) are among the latest and largest (with wingspans approaching those of small airplanes) pterosaurs. Quetzalcoatlus is the most famous example. Most azhdarchids have very long necks and long toothless beaks. The necks have only eight or nine vertebrae, but the individual vertebrae are very elongated. Further, the neck vertebrae are simple cylinders without large external bony processes.

Today's story is about the azhdarchid Alanqa (named for a mythical bird in Arab culture). A few fragments of beak and neck vertebrae were found in the Late Cretaceous Kem Kem beds of Morocco and were described in 2010. Alanqa probably had a wingspan about 20 feet. Williams et al. (2020) describe a single neck vertebra (specimen FSAC-KK 5077) presumably from Alanqa. This bone is about 14 cm long and about 5 cm in diameter. Normally, in birds and pterosaurs one would expect a simple hollow tube architecture with dense bone on the outside and a mostly hollow space crossed by trabeculae in the center. However, CT-scanning shows an unexpected "tube-within-a-tube" architecture. There is a central hollow cylindrical core, which is attached to the outer wall by a series of helically-arranged radial "spokes" about 1 millimeter in diameter. The spokes branch and can be fused with other spokes at various points along their length. The spokes are trabeculae, but in an unusual configuration.

Not much detail is given, but the authors do a virtual mechanical analysis of the tube-within-a-tube configuration. The aim is to find out the force needed to buckle the vertebra as a function of the number of spokes. Starting with no spokes, they add additional spokes, positioned at random radial positions, until they achieve the density of spokes seen in the real bone. Not surprisingly, more spokes make the bone overall stronger (up to a factor of 2 stronger when 500 simulated spokes are present) because the spokes transfer force from the outer tube to the inner one. However, close to the maximum strength is achieved with only 50 spokes. The idea being suggested here is that "tube-with-a-tube" achieves greater lightness for a given strength than a simple "hollow tube", something needed for a large animal. The authors estimate that the neck could withstand lifting a prey of 9-13 kilograms without damaging the vertebrae. They authors also mention that another possible reason azhdarchids might require strong neck vertebrae is because they could do intraspecies "neck bashing" as giraffes do.

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Evidence that Shuvuuia Was Nocturnal

Bob Sheridan May 7, 2021

This paper involves the eyes and inner ears of the dinosaurs Shuvuuia and Haplocheirus. Some background is needed.

The scleral ring, or sometimes "sclerotic ring", is a bony ring made of many interlocking sclerotic ossicles embedded in the eyes of most reptiles and birds. This ring is centered around the lens. (One can think of the shape of the ring as a flattened donut or a pineapple slice.) The scleral ring can be flattish or somewhat domed, reflecting the shape of the eyeball. What function does it serve? One idea is that it helps maintain the shape of the eyeball where the shape is not a sphere, which would be the shape a fluid-filled sac would normally assume. As you might imagine, scleral rings are delicate and not often preserved as fossils, but enough exist that it is possible to infer something about the vision of extinct animals. This was the topic of an older paper by Schmitz and Motani (2011) who compared the scleral ring of dinosaurs and birds. There is a correlation between the ratios of the inner and outer diameters of scleral rings in living birds and reptiles and whether they do most of their activities during the day or night. Diurnal animals have a small inner diameter relative to the outer diameter, i.e. a wide ring. Nocturnal animals have a narrow ring, and also have a larger outer diameter, i.e. the size of the eye is large compared to the skull. This makes sense. If one normally has to have a very open pupil in dim light, one would need a very large inner diameter scleral ring to accommodate it. One point made by Schmitz and Motani is that there is strong evidence for nocturnal dinosaurs.

Shuvuuia

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There are two parts to the inner ear: the cone-shaped cochlea (which translates the vibration of the eardrum into a sensation of sound), and the vestibule, a sack-like pocket with three semi-circular canals sticking out from it. Fortunately for paleontologists, although inner ears are small, they are hollow spaces surrounded by a bony sheath called the "labyrinth", and so their shape, size, and orientation relative to the rest of the skull can be discerned by CT-scanning skulls, both of living and fossil animals. In reptiles, birds, and monotreme mammals, the cochlea is straight, as opposed to the coiled shape it has in advanced mammals. The length and diameter of the cochlea is thought to be related to the sensitivity of the animal to sound and/or the frequency range of hearing for the animal.

There is a family of small (2 ft long) theropod dinosaurs called the alvarezsaurids (named for Alvarezsaurus, which is in turn named after Walter Alvarez). One characteristic of (most) alvarezsaurids is that they have very short powerful arms ending in a single large claw. The most usual interpretation is that the arms are used for "scratch digging", although the animal would have to have its chest up against the surface it was digging for that to work. Interestingly, Haplocheirus is an unusual alvarezsaurid that has three fingers.

Choiniere et al. (2021), examine a number of birds and reptiles in terms of their scleral ring and the inner ear and compare them against two alvarezsaurids Shuvuuia and Haplocheirus. The scleral ring data is extended from that of Schmitz and Motani and supplemented with more data about extant birds. They confirm Schmitz and Motani's observations about the scleral ring configuration and whether living animals are nocturnal. The scleral rings of the dinosaurs Shuvuuia and Haplocheirus needed to be digitally reconstructed since most of the slerotic ossifIces are missing in the fossils. Given the reconstruction, the scleral rings for both dinosaurs are large compared to the size of the orbit and have a large inner diameter relative to the outer diameter. This is similar to the configuration of extant nocturnal birds. The particular example the authors use is the barn owl species *Tyto alba*.

The housing of the cochlea separate from the vestibule is called the "endosseus cochlear duct" (UCD). The authors note that nocturnal birds like owls have very long ECDs relative to braincase height.

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Shuvuuia Cont'd

Previous work on birds indicates that the ECD length correlates with increased sensitivity to sound; this makes sense: birds hunting at night would depend more on sound that sight. The ECD of Shuvuuia and Haplocheirus have ECDs similar, not to mentioned a slightly curved shape, to that of owls. Most dinosaurs have much shorter ECDs than nocturnal birds, although some predatory theropods like troodonts, dromaeosaurs, and tyrannosaurs have longish ECDs.

The conclusion of the authors is that at least some alvarezsaurids are nocturnal. In my opinion, the scleral ring argument is more solid here than the cochlea argument. The size of the pupil of the eye is clearly linked to the level of available light. In contrast, the length of the cochlea has a number of possible effects other than sensitivity of hearing in general, including sensitivity to higher-pitched sounds, and good hearing is an advantage whether or not an animal is nocturnal.

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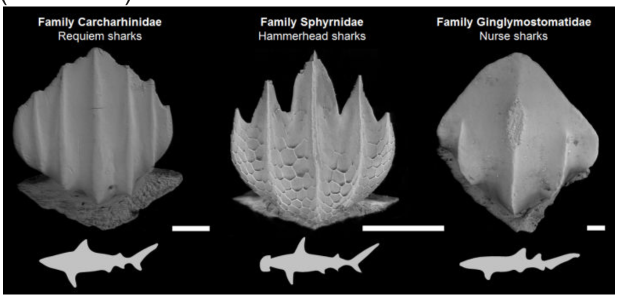
Possible Shark Extinction in the Miocene

Bob Sheridan Jun 8, 2021

Most fish are covered with scales. Sharks are covered with a particular type of hard scale (made of dentine) called denticles, which are typically less than 1 millimeter long. This makes shark skin feel much like sandpaper, especially if you move your hand from back to front. These denticles provide protection, of course, but the main function of these is to reduce drag in the water. For the purpose of this story, all that matters is that different sharks have different types of denticles. (I have not been able to discern whether any one shark can have different types of denticles.) Denticles, as microfossils in marine sediment, can be a proxy for the abundance and diversity of sharks.

A paper by Silbert and Rubin describe the abundance of shark denticles in core sediments from the Deep Sea Drilling Project, which ran from the 1960s to the 1980s. The goal of this project was to generate core samples of marine sediment from dozens of locations in the open ocean. The authors use data from two sites, one in the South Pacific and one in the North Pacific. The core samples cover time from 40Myr to the present. The authors identify a total of ~1200 denticles over this time period, which they divide into 63 morphotypes, i.e. shapes. Some of these morphotypes are "linear", i.e. have parallel fins or grooves, much like you would expect in a typical "fish scale". The rest are "geometric", i.e. like a diamond, star, or irregular shard. Modern sharks tend to have linear denticles. For any given time period, the abundance of denticles is compared to the abundance of other types of marine fossils like (non-shark) fish teeth.



About one-third of morphotypes span only a very short period of time. About 20% of morphotypes extend from 40Myr to the present. Interestingly, 70% of the morphotypes start at 40Myr but end abruptly at ~19Myr. There are no new morphotypes seen after ~19Myr. Also the abundance of denticles relative to other marine fossils falls 90% at 19 Myr. The interpretation of this is that there was a previously unsuspected crash in the diversity and abundance of pelagic sharks (i.e. swimming in the open ocean) in the Early Miocene. The timing seems unexpected because there are no known extinction or climate events at that time. Also, this is at least 4 Myr before the diversification of other open ocean fish and whales which could have produced competing predators.

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The Inner Ears of Archosaurs

Bob Sheridan May 7, 2021

This story concerns the inner ear of archosaurs, and terminology would be helpful at this point. There are two parts to the inner ear: the cone-shaped cochlea (which translates the vibration of the eardrum into a sensation of sound), and the vestibule, a sack-like pocket with three semi-circular canals sticking out from it. Each semi-circular canal is a tube that looks like part of a circle or a loop. The three loops are more or less perpendicular to each other. The vestibule detects the orientation of the head relative to gravity and detects acceleration. Fortunately for paleontologists, although inner ears are small, they are hollow spaces surrounded by a bony sheath called the "labyrinth", and so their shape, size, and orientation relative to the rest of the skull can be discerned by CT-scanning skulls, both of living and fossil animals. Studies of the inner ear of fossils (or more exactly the virtual models of them) are becoming more common since CT-scanners that can handle higher resolution and higher density materials are becoming more available.

Investigators try to infer behavioral information from the shape of the inner ear (independent of total size of the animal). Examples:

1. There is an expectation that the lateral semi-circular canal should be horizontal; therefore one can guess the habitual orientation of the head.
2. Investigators often try to relate the relative "loop-length" and diameters of the semi-circular canals to "agility" or being "aquatic".
3. The length and diameter of the cochlea is thought to be related to the sensitivity of the animal to sound or the frequency range of hearing for the animal.

If the inner ears of two animals are similar, does that imply more about their common ancestry or more about their common behavior? How much about behavior can we reliably infer from the anatomy of the inner ear, and does an inference for one group of animals apply to another group? How much of the shape of the inner ear is dictated by the overall shape of the skull? At present there is not a clear picture, and the work discussed below suggests that things are more complicated than formerly thought.

Now, a quick word about archosaurs. This is a particular branch of diapsid reptiles where there is an opening in the skull in front of the eye. Birds and crocodylians are the only living archosaurs, but there are many fossil varieties, including most famously dinosaurs and pterosaurs. Pseudosuchia ("false crocodiles") is a less well-known extinct group of carnivores from the Early Triassic. These are sometimes called "crocodile-like", but they had a number of different forms and sizes. Some were even bipeds, convergent on theropod dinosaurs, which came later.

Bronzati et al. (2021) compare the semi-circular canals of 82 of living and fossil archosaurs, plus more "primitive" diapsid reptiles like turtles and lizards. The size of the semi-circular canals is normalized relative to the skull length of the animal behind the snout. A common technique of analyzing objects that vary in many ways at the same time (here shapes of specific parts of the semi-circular canals) is due to principal components analysis. That is, one projects a high-dimensional object into two or three dimensions so that the placement of objects can be easily visualized. Usually, one looks for grouping of objects in the projection. In this projection one can see that birds, pterosaurs, modern crocodylians, pseudosuchians, and "bird-like" dinosaurs are separable groups. First of all, this means crocodylians are not "primitive" in their anatomy, i.e. they do not resemble pseudosuchians. Plus, the diversity of semi-circular canals in pseudosuchians is much larger than in modern crocodylians. The other important observation is that bird-like dinosaurs and pterosaurs have semi-circular canals much like those of modern birds, with longer, rounder, more perpendicular loops. These authors find a weak correlation between semi-circular canal shape and bipedalism or flight, but no correlation with being aquatic. There is an even stronger correlation with whether the entire skull is round or flattened, or how long the skull is in absolute terms. That is, most of the variation is not explainable by differences in lifestyle, in particular being aquatic or flying.

A paper by Hanson et al. (2021) has a similar goal, but come to somewhat different conclusions. Here they study 125 specimens, again consisting of living and extinct archosaurs, plus some non-archosaurian reptiles. Again the data is displayed via principal component analysis. Again, comparison is made between inner-ear anatomy and lifestyle, based on locomotion, diet, social behavior, etc. A major difference is that this study included the anatomy of the entire inner ear, not just the semi-circular canals. As with the previous study, there is a relationship between the overall skull shape and the inner ear, mostly in how tall the semi-circular canals are.

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As with the previous paper, there is a general trend for bird-like dinosaurs and true birds to have taller semi-circular canals than earlier reptiles. Pterosaurs show a similar condition (probably by convergence). Interestingly, the dinosaur Shuvuuia appears very primitive compared to most theropods. These authors find a reasonably strong signal having to do with "locomotor mode", contrary to the previous paper. The authors discuss three clusters in their space:

1. Quadrupeds (non-theropod dinosaurs, lizards, and crocodylians).
2. Bipeds, secondarily flightless birds, and birds that are "simple flyers". Pterosaurs are more like "simple flyers" in this scheme.
3. Flyers that engage in high maneuverability (all of which are modern birds and mostly predatory).

These authors also compare the cochlea. In reptiles, birds, and monotreme mammals, the cochlea is straight, as opposed to the coiled shape it has in advanced mammals. Primitive diapsid reptiles like turtles and lizards have short cochlea, and all other archosaurs have long cochleae. The cochleae of troodontids and Shuvuuia are especially long. Previous thought is that long cochleae correspond to more sensitive hearing and to hearing a larger range of frequencies. The authors find there is a statistically significant correlation between the length of the cochlea and (among extant reptiles and birds) whether or not the young make high frequency sounds, although the absolute correlation is fairly small. Crocodylians show some parental care, and the thought is that the cochlea elongated for that purpose just before the time crocodylians diverged from dinosaurs.

It is not unusual for two different investigators to do very similar studies in paleontology and come to somewhat different conclusions, in this case whether there is a strong correlation between the anatomy of semicircular canals and behavior. For this type of study I worry about the "Texas sharpshooter" effect, i.e. shooting first and then drawing the target around the bullet holes. This introduces a bias that makes perceived patterns appear stronger than they really are. For example, in Hanson et al. did the authors decide which birds were "simple flyers" before or after they saw their clusters.

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Oculudentavis Revisited

Bob Sheridan June 15, 2021

Here we are revisiting a topic from March 2020, namely Oculudentavis. To recap: In 2020

Xing et al. described a new specimen of Burmese amber (HPG-15-3) that contains an isolated skull, which was about 1.4 cm long. Burmese amber is ~99Myr, i.e. Middle Cretaceous. The authors give this specimen the name *Oculudentavis khaungraae* ("eye-tooth-bird" and after Khuang Ra who donated the specimen). Oculudentavis has a slender beak and very large eye sockets relative to the length of the skull. These sockets point clearly to the side. In birds and reptiles, scleral ring bones give rigidity to the eyes. In Oculudentavis, the individual scleral bones making up the ring are spoon-shaped instead of flat plates. Also, the scleral ring is quite wide in a radial direction, implying the maximum pupil size is small, which might also imply that Oculudentavis was active during the day. Oculudentavis has tiny conical teeth. The skull is totally fused, implying the specimen is an adult.

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The authors assigned Oculudentavis as a primitive bird based on phylogenetic analysis. However, there were very unusual things about it:

1. It is smaller than the smallest known adult bird, fossil or living.
2. It has a tooth row that extends under the eye socket. This has never before been seen in archosaurs (the reptile group that contains dinosaurs, birds, pterosaurs, and modern crocodilians).
3. The teeth are attached to the bone instead of being in sockets. Again, not characteristic of archosaurs.
4. The bones of the scleral ring have an unusual shape.

Almost immediately, another group Li et al. (2020) reexamined the original CT-scan of the specimen and made an alternative suggestion, that *Oculudentavis khaungraae* was not a bird but a lizard that happened to have converged on some bird-like characteristic such as a narrow beak and domed skull. Some points:

1. The attached teeth are characteristic of squamates, as are teeth that extend further back as the front of the eye socket.
2. Oculudentavis does not have an antorbital fenestra like archosaurs, but it does have a lower temporal fenestra, which occurs in squamates.
3. Oculudentavis has a few teeth on its palate, again characteristics of squamates.

This makes a lot of sense and eventually Xing et al. retracted their "bird" interpretation. This is a good example of how Science is supposed to work. BTW, by nomenclatural rules, the original name "Oculudentavis" stays, even though the "avis" part is probably wrong.

Another lesson here is that identification only from cranial remains can be problematical. Fortunately, Bolet et al. (2021) describe a new amber specimen GRS-Ref-28627 that contains the head, neck, and part of the scapula, clavicles, coracoid, and humerus of a tiny lizard-like animal. This specimen is from the same mine as HPG-15-3. The authors have decided this animal is the same genus as *Oculudentavis khaungraae*, given the common distinctive details in the skulls, but give it a distinct species name *O. naga*. (Naga are a historical Burmese tribe known for trading in amber.)

The major difference in skull shape is that *O. naga's* snout is broader and its skull is lower, making the overall shape more "crocodile-like" rather than "bird-like". The authors analyze how the skulls might have been compressed as an artifact of preservation; *O. khaungraae* probably has its snout compressed downward, while *O. naga* has its braincase pressed downward. Therefore the skulls of the two species may have looked more alike in life than they now appear. Also, it is possible that the bird-like snout of the *O. khaungraae* is due to lateral compression. (This type of analysis is new to me; I have not heard of specimens in amber being significantly deformed during fossilization.)

Phylogenetic analysis of Oculudentavis among a large set of squamates (reptiles that include lizards and snakes) and archosaurs (including theropod dinosaurs and birds) suggests that the Oculudentavis species are very closely related to each other. Both species are clearly nested among squamates, although exactly where among squamates dependent on which type of data (e.g. anatomy only vs. anatomy + molecular for living squamates) is included.

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The Story of Evolution in 25 Discoveries--A Review

Bob Sheridan June 20, 2021

Donald Prothero is a paleontologist at the Department of Vertebrate Paleontology at the Los Angelos County Natural History Museum. He has written many books, most of them aimed at correcting misconceptions about paleontology, and science in general. Pretty much anything he writes is worth reading, and I have reviewed many of his books in the Paleontograph. The first book I reviewed is "Evolution: What the Fossils Say and Why it Matters" (2007). His latest is "The Story of Evolution in 25 Discoveries. The Evidence and the People Who Found It." (2020). This is not to be confused with another of his recent books with a similar title "The Story of Life in 25 Fossils" (2018).

First, let me point out that while most books with titles like "The Story of X in N Somethings" will be filled with color pictures of fossils, with a page of text per picture. Prothero's books, including this one, are mostly text oriented, and the illustrations will be of diagrams, although there will be a few black-and-white photographs of fossils or animals.

This book does have 25 chapters, but despite the title, it does not key off of specific discoveries or discoverers. Instead, you can think of the chapter titles as summarizing arguments that living things as we see them now evolved instead of being designed, and that the mechanism of natural selection is almost certainly the cause. Of course, most of these arguments are those Charles Darwin's made in his book "Origin of Species". (Some points seem obvious to us today but are included because they are a counterpoint to many ideas current in 1850s England.)

1. Animals come in nested hierachies. For instance coyotes and wolves resemble each other, and these have anatomical resemblences to other carnivores such as cats, and collectively these animals are mammals, mammals have a lot in common with other vertebrates, etc. All this implies that all animals split off from common ancestors. BTW, this means all life is organized as a "branching bush", not a "chain of being."
2. Embryos of vertebrates resemble each other more than the adults do, once more indicating common ancestors.
3. Animals contain non-functional (i.e. vestigial) anatomical features, for example wings on an ostrich, the human appendix, etc. This is consistent with these animals evolving from ancestors where the features were functional. Also, this is inconsistent with an intelligent design model. For example, the designer of a nuclear submarine would not include a sail in the design.
4. There is much sub-optimal design in life, i.e. things work well enough, but not perfectly. This is similarly inconsistent with design.
5. There are no moral lessons to be taken from Nature; in many cases things work by means that seem to be cruel. One big example is the ichnemonid wasp, which lays its egg in a paralyzed caterpillar; the wasp larva eats the caterpillar from the inside out, leaving the vital parts for last.
6. "Biogeography", i.e. where certain types of animals live, is reflective of history, not suitability of organisms for particular habitats. For example, the "Noah's ark" model (diffusion of all animals from one central point) cannot explain why Australia is dominated by marsupials. Also it does not explain why different types of animals might inhabit very similar islands.
7. Artificial selection" (humans, deliberately breeding different varieties of dogs, chickens, etc.) works very well in practice, so Natural Selection should too.

Most of the rest of the book updates the arguments, given knowledge Darwin never had:

1. Nowadays, now that we know the DNA sequences of many organisms, the idea of common ancestry is astonishingly confirmed. Especially striking is the genetic similarity of humans and other apes. The idea of vestigial organs is astonishingly demonstrated at the level of genes. Specifically, most of our DNA is "junk" in the sense that it doesn't code for proteins. Also there appear to be many non-functioning versions of genes, including genes from viruses.
2. In Darwin's time there were not many known fossils that demonstrated transitions between classes of animals. Now we can demonstrate dozens of transitions using hundreds of fossils: dinosaurs to birds, fish to amphibians, land mammals to whales, reptiles to mammals, small hoofed animals to modern horses, apes to humans, etc. There is a separate chapter for some of these transitions.

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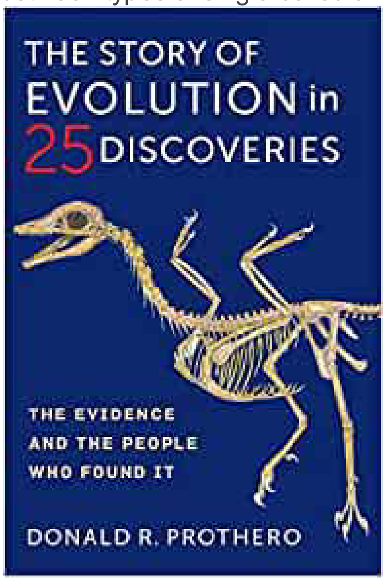
3. Darwin was insistent that evolutionary transitions would be too slow to be observable in a human lifetime. However, field observations of Galapagos finches show that large changes in beak shapes can take place in a year or two. Also, resistance of bacteria to antibiotics and insects to insecticides are observed to take place in only a few days in the lab and a few years in the field.

4. Darwin didn't know how heredity worked, and had entertained some vague idea of how "acquired characteristics" could be inherited. Fortunately, the idea natural selection does not require knowing how heredity works as long as characteristics are inheritable. Now that we know that germline cells (those that produce sperm or eggs) are separate from somatic cells (all other cells), there is no mechanism for acquired characteristics to be passed on. We also know that genes from mother and father are separate entities and that means at least some characteristics don't "average out" over time. Finally we know that in some genes (hox genes) that determine body structure in all types of animals, small mutations can make a big difference.

5. Darwin did not try to explain the origin of life, but today we can make educated guesses about how the molecules of life developed and have indisputable evidence that eukaryotes (animals with organized cell nucleae) are the results of symbiosis between types of single-celled animals.



There are three chapters that I will discuss in particular. One has to do with the evolution of the long neck in giraffes. (Most giraffe relatives like the okapi have fairly short necks.) This is a classroom example used to distinguish between "Lamarkian evolution" and "Darwinian evolution". In the former, giraffes stretched their necks to reach leaves in trees and through "acquired characteristics" passed on the long neck to their children. In the latter, giraffes that happened to have longer necks were able to reach more food and leave more children. (Larmark is given a bad rap with this story, since most of his evolutionary ideas are much less silly.) Ironically, it seems giraffes don't get the bulk of their food from treetops. An equally plausible explanation is "sexual selection", wherein male giraffes use their long necks to pummel rival males. This would make the neck of the giraffe the equivalent of a peacock's tail.

There is also a lesson in imperfect design. A particular nerve, the left recurrent laryngeal nerve comes from the base of the brain, loops around the aorta, and goes back up to the larynx. In fish, the path of the nerve is quite short. However in animals with necks the path includes a substantial detour, and in giraffes, the detour is 15 feet long!

Another chapter has to do with the quirks of human anatomy. Many of these difficulties are shared by most mammals. The retina in a vertebrate eye is "inside out" in the sense that the light-sensitive cells point away from the source of the light and that blood vessels block some the visual field. (Faults not shared by the octopus eye, for instance.) Our reproductive systems (both male and female) take long looping paths, giving much opportunity for things to go wrong. Humans have a number of special difficulties. The most notable is a spine that was optimized for quadrupeds is now upright, so that our weight squashes intervertebral disks and pinches spinal nerves. Babies can barely be born because our brain is almost too big for the pelvic canal. Our larynx seems to be in a position to maximize the possibility of choking on food. Our jaws are too small for the number of teeth in our mouths, resulting in impacted wisdom teeth. The example I did not know about: whereas in quadrupedal mammals the hole that drains the maxillary sinus is at the bottom of the sinus, given our upright stance, it is now near the top, making the possibility of infected sinuses much greater.

The final chapter asks whether humans are still evolving. Speculations in science fiction are quite ridiculous given our current knowledge. For example, there is no "orthogenesis", i.e. evolution working in one direction regardless of fitness. Most "man of the future" ideas involve getting a larger brain, assuming that the trend of a larger brain from a few million years ago to recently will always continue.

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Book review Cont'd

Actually, however, human brains have been getting smaller in the past few tens of thousands of years. Most human evolution is at the level of genes and is not visible. For example, the ability of adults to digest milk probably started about 8,000 years ago with the domestication of animals. Also, this chapter reviews that evidence that humans underwent a population bottleneck ~70,000 years ago and the result is that every human alive today is very closely related to all other living humans, the idea of "race" notwithstanding. The timing of the bottleneck corresponds to the eruption of the Toba volcano in Indonesia.

This book is an excellent, readable, summary for the evidence of evolution. I think of it as an updated version of "Evolution: What the Fossils Say and Why it Matters." The denial of evolution as a political ploy seems to have died down since 2007 (replaced by even more stupid beliefs!), but if it were around this book would be perfect for a popular audience. Prothero is an expert debunker, assuming facts can change minds. If you have taken biology in college and follow paleontology and biology as a hobby, as I do, you will find that most of the contents of this book aren't particularly new to you, but it is good to have them all in one place.

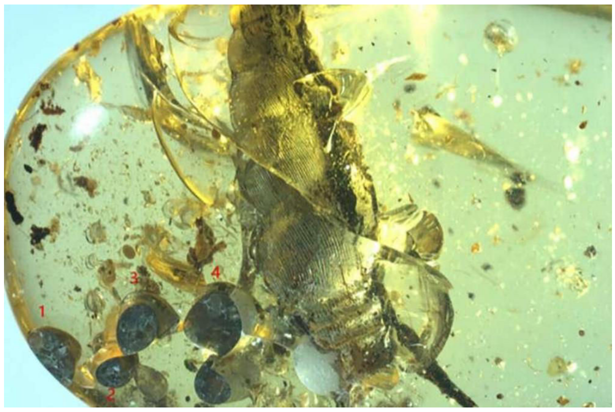
Sources:

Prothero, D.R.
"The Story of Evolution in 25 Discoveries. The Evidence and the People Who Found It."
Columbia University Press, New York, 2020, 360 pages.

Viviparous Snail in Amber

Bob Sheridan June 10, 2021

Snails are very rare as amber inclusions. Jochum and Neubauer (2021) describe a set of six small snails in Burmese amber (belived to be ~99 Myr). The authors name these *Cretatortulosa gignens*. (Other species of Cretatortulosa in Burmese amber have been described by others. The genus name means "Cretaceous Tortulosa", where Tortulosa is an extant land snail.) The amber specimen here was studied with optical microscopy and CT-scanning. The largest snail is about 11 millimeters long and 3.4 millimeters in width. The shell is "oblong" (or "turiform"), i.e. tall, with about 7 turns. Short tentacles are visible on a small head. Cretatortulosa is probably related to the "punids", which are modern land snails.



The most interesting thing about this amber specimen is that near the opening of the larger shell there are five smaller (1-2 millimeter) hemispherical objects that appear to be globular-shaped snails with only two turns. Parts of the smaller snails are missing because they are at the edge of the amber. The small number of turns indicates they are probably very young. There is also some amorphous "mucous-like" material linking the opening of the large snail to the nearest of the small snails. The authors' interpretation is that *Cretatortulosa gignens* was giving live birth while it was trapped and then engulfed in resin. Interesting, it is known that some extant snails eat resin, and it has been observed that Galapagos land snails often get trapped.

Vivipary is known for some living snails, although they are mostly aquatic. The usual evolutionary explanation for vivipary is that offspring can be better protected within the mother's body, compared to eggs laid on a branch. The drawback of that is the mother can fit only a small number of offspring in her body.

Sources:

Jochum, A.; Yu, T.; Neubauer, T.A.
"Mother snail labors for posterity in bed of mid-Cretaceous amber."
Gondwana Research 2021, 97, 68-72.

Locked in Time--A Review

Bob Sheridan June 29, 2021

Normally, the behavior of extinct animals is thought to be better demonstrated by trace fossils. There are many cases, however, where one can infer behavior of extinct animals from body fossils alone. These are not plentiful, in the sense that it usually requires very good preservation and/or special circumstances for behavioral inference to be made. The new book "Locked in Time." by Dean R. Lomax discusses such specimens in detail.

Dean R. Lomax is currently a visiting scientist at the University of Manchester. He is a professional paleontologists and scientific communicator and has written several books, some aimed at a younger audience. The illustrator Bob Nicholls is a commercial natural history artist. You should check out his website paleocreations.com.

This book is divided into five sections, and about 10 fossils are discussed under each section. The sections are:

1. Sex.
   This covers fossils of pregnant animals, not only mammals, but marine reptiles, fish, and invertebrates. Plus insects and turtles caught in the act of copulation.
2. Parental care and communities
   Fossils with juvenile remains (or eggs) associated with an adult. Also monospecific bone beds, indicating mass fatalities of large groups of animals..
3. Moving and making home
   Trackways, burrows, traces of motions just before death.
4. Fighting, biting, and feeding.
   Toothmarks or actual teeth embedded in fossil bones. Evidence of a meal inside a predator. Evidence in coprolites of what was eaten.
5. Unusual happenings.
   Evidence of parasitism, infections, injuries, and cancer. Plus miscellaneous unusual trace fossils.

As you can see from the list above, while the emphasis is on body fossils, trace fossils are not excluded where relevant. A number of these examples are fairly new (published as late as 2020), so the book is up to date. Illustrations are black-and-white photographs of each fossil in question, plus a restoration of the animals demonstrating the behavior implied by the fossil. If you follow paleontology as a hobby, as I do, you have probably heard of many of the examples in "Locked in Time": "fighting dinosaurs", "brooding Oviraptor", and "fish within a fish, etc.." However, I have not heard of at least one-third of the fossils. Here are five:

One normally does not think of dinosaurs as digging borrows. Oryctodromeus is a small hypsilophodontid dinosaur from the Cretaceous of Montana. Three individual specimens, an adult and two juveniles were found buried at the end of a tunnel not much wider than the bodies. The bones are jumbled, which suggests they died long before sand filled the burrow and buried them. At least a few additional burrows containing Oryctodromeus have been found, indicating that this represents real behavior and not an accident. Puzzlingly, the arms of Oryctodromeus do not seem especially adapted to digging. Similarly unexpected are burrows for giant ground sloths of the Pleistocene. In Brazil there are several burrows about 2 meters high and tens of meters long. The walls of the burrows have scratch marks that correspond to the claws of large (1-2 ton) sloths like Scelidotherium and Glossotherium. The skeleton of Scelidotherium was found in one such burrow. Given their claws and powerful arms, it is not surprising that extinct sloths could dig burrows.

Today giant clams play host to various fish. Specimens of the giant Cretaceous clam Platyceramus are often found in the chalk formations of Kansas. These clams are 1-2 meters in length. About nine unique types of fossil fish have been found within these fossil shells. Any given shell specimen may contain several dozen individual fish, which have presumably been trapped inside when the clam died.

Modern sharks are known to have nursery areas, a shallow part of the ocean where shark eggs are laid and where juvenile sharks can live without being attacked by the large predators, including other sharks. The Gatun Formation in Panama preserves many Miocene marine fossils, of which the most notable is large numbers of Megalodon teeth. One particular quarry contains a high concentration of very small Megalodon teeth and very few large teeth. Comparing these small teeth to Megalodon teeth from various developmental stages, investigators in 2010 concluded that these are teeth from juveniles, consistent with Gatun being a nursery area. In 2020 a similar site was discovered in Spain, confirming the idea of Megalodons using nursery areas.

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It is known that many wasps lay eggs inside the larvae or adults of other insects, such that the wasp larvae eats the victim from the inside out, leaving the vital organs for last. Vast numbers of cocooned fossil larvae from the Paleogene, about 3-4 millimeters long, were discovered in a phosphate mine in France. These specimens were described in 1940, but were not CT-scanned until 2018. Unexpectedly, dozens of these cocoons contain within them perfectly preserved wasp larvae and adults. These wasps were given the genus name Xenomorpha after the "Alien" movies.

As there are coprolites, there are also trace fossils called urolites, which are evidence of animals urinating. A particular trace fossil from the Early Cretaceous of Brazil shows a crater-like pit and ripple-like streamers. This type of mark can be produced by pouring liquid onto a sand dune. Urinating ostriches make similar mark. An even larger (3 meters long) similar urolite from Late Jurassic Colorado and may represent a urinating sauropod.

I would not call this book particularly detailed in its paleontological discussions, since it is aimed toward a general scientifically-literate audience, but not particularly toward serious hobbyists or students. However, I still learned about many unfamiliar fossils, and I recommend it highly.

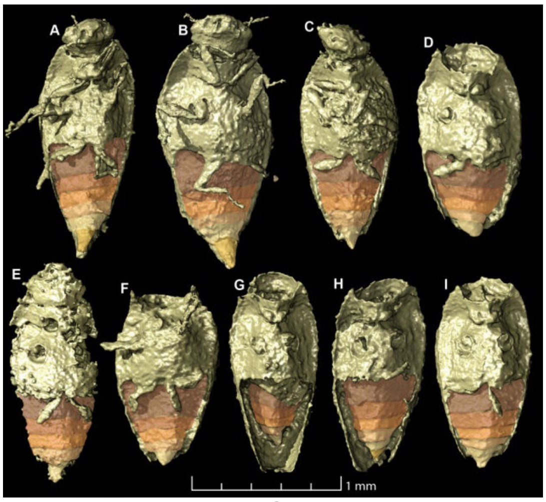
Sources:
Lomax, D.R.
"Locked in Time. Animal Behavior Unearthed in 50 Extraordinary Fossils."
Columbia University Press, New York, 2021, 286 pages $30 (hardcover).

Nearly Complete Beetles in a Coprolite

Bob Sheridan July 6, 2021

Most fossil insects are only a flattened film, for instance in limestones or shale layers. In contrast, insects in amber are usually preserved undistorted in three-dimensions. A new paper by Qvarnstrom et al. (2021) describes a new matrix in which the 3D structure of nearly complete insects can be preserved: coprolites.

The coprolite specimen in question is from a clay pit in Poland that is dated to the Late Triassic. The specimen is cylindrical, about 17 millimeters long and 21 millimeters in diameter. It appears to be broken, and it was probably much longer when complete. Micro-CT-scanning shows the coprolite is filled with dozens of beetle parts in disarticulation, mostly elytra, i.e. the hard wing covers of beetles, but some isolated heads and other parts. Most of the parts seem to belong to the same species, which the authors have given the species name Triamyxa coprolithica. The most unexpected thing is that there are two beetle specimens that are nearly complete. These are about 1.5 millimeter long and 0.5 millimeters wide, with obvious legs and antennae intact. The fact that nearly all the beetles are disarticulated probably means they were digested and excreted in feces, as opposed to a scenario where they invaded feces after it was excreted.



Phylogenetic analysis of Triamyxa shows it belongs within the large Myxophaga group of beetles, which has some living members, although the subfamily that the fossil belongs to is extinct. This is the origin of the genus name, which abbreviates "Triassic Myxophaga". Modern Myxophaga inhabit aquatic environments, including algal mats. It may be that the excreter of the coprolite was keen for algae and ate the beetles incidentally.

Of course, the source of any coprolite is never certain. However, other coprolite specimens with disarticulated elytra have been attributed to Silesaurus, also from the Late Triassic of Poland. Silesaurus is a dog-sized quadrupedal "dinosaurimorph", i.e. an advanced archosaur that is not yet a true dinosaur.

Sources:
Qvarnstrom, M.; Fikacek, M; Wernstrom, J.V.; Huld, S.; Beutel, R.G.; Arriaga-Varela, E.; Ahlberg, P.E.; Niedzwiedzki, G.
"Exceptionally preserved beetle coprolite of putative dinosauriform origin."
Current Biology 2021, 31, 1-8.

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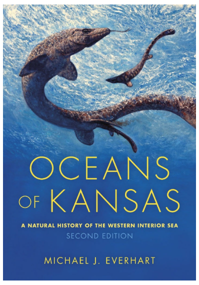

The 2nd Edition of *Oceans of Kansas – A Natural History of the Western Interior Sea* from Indiana University Press. The digital version is available from Amazon.The second edition is updated with new information on fossil discoveries and additional background on the history of paleontology in Kansas. The book has 427 pages, over 200 color photos of fossils by the author .

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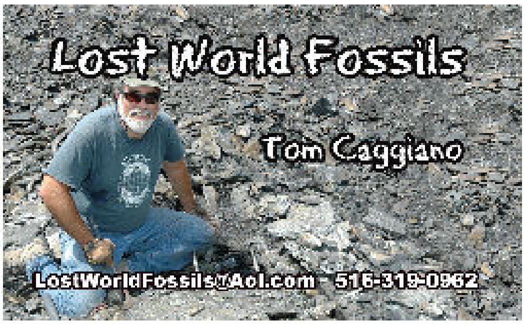
AAPS, The Association of Applied Paleontological Sciences was organized in 1978 to create a professional association of commercial fossil dealers, collectors, enthusiasts, and academic paleontologists for the purpose of promoting ethical collecting practices and cooperative liaisons with researchers, instructors, curators and exhibit managers in the paleontological academic and museum community.

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



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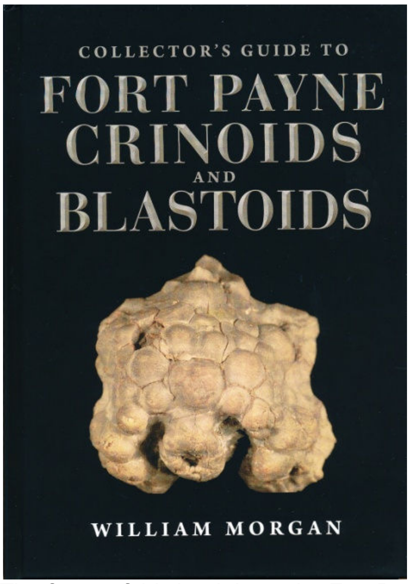

The focus of this book is on the Fort Payne Formation and the fossil crinoids and blastoids, which are found there. Although, it is not widely known outside of academic programs in geology and/or paleontology, the Fort Payne is one the largest Mississippian-age formations in the middle and southeastern 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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