THE BRODIE CLUB

Established 1921

Website: http://thebrodieclub.eeb.utoronto.ca

THE 1135th MEETING OF THE BRODIE CLUB

The 1135th meeting of the Brodie Club was held on Tuesday, 9 May, 2023 in Room 432 of the Ramsay Wright Laboratories of the University of Toronto.

Chair: Katie Thomas
Secretary: Ricky Dunn

The meeting was called to order at 7:32 pm and was attended by 10; 7 members and 3 guests.

Roll Call:

Present: Bertin, Dunn, Hussell, Kortright, Rising, Seymour, Stones.
Guests: Peggy Haist (guest of Bertin), Rachel Gottesman (Kortright), Tim Dickinson (Rising).
Regrets: Abraham, E. Addison, R. Addison, Beadle, Bell, Crins, Currie, DeMarco, N. Dengler, R. Dengler, Dunlop, Eckenwalder, Miller, Obbard, Pittaway, Sutherland.

Minutes: Minutes of the April meeting were approved with typos corrected. Gavin Miller had noted a misinterpretation in those minutes (apologies from the secretary) about the status of Speckled Alder in Canada. The tree present in Ontario is a subspecies of Gray Alder (i.e. *Alnus incana ssp. rugosa*). Speckled Alder as a species (*Alnus incana ssp. incana*) is native to Europe and does not occur in North America, at least not outside of cultivation.

Committee Reports:

Membership: Two prospects are in the works, but as older members who live at a distance are starting to drop out, we need to work on enrolling new members in the Toronto area. Bertin has agreed to join the Membership Committee.

Dunn presented a remembrance of Ron Tasker, which will be distributed with these minutes.

Field trip: Thomas reported two options suggested by the committee: Peter's Wood, and Happy Valley. Katie will investigate both further before a final decision is made. The probable date is Saturday 24 June, when Justin is available to lead.

Meetings: A suggestion was made to hold one of our meetings in Peterborough area to test effect on attendance. As people living west of Toronto would likely not attend, it should first be investigated whether attendance by those living to the east would actually increase.

The Faculty Club is tightening rules about requirement to have a UofT member of the Faculty Club present in each party dining there. We don't always have a qualifying person with us, and though we may inquire about a special status for the Brodie Club, we will look for an alternate place nearby to gather for pre-meeting meal. Nancy Dengler agreed to lead the search.

SPEAKER:

Kevin Seymour: **Why birds are dinosaurs**

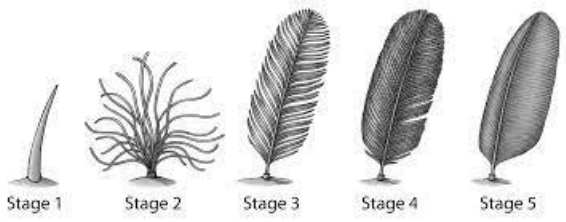
All discussion of fossil birds and dinosaurs usually starts with *Archaeopteryx lithographica*, a fossil from the Upper Jurassic (~150 million years ago), found in 1861 in lagoonal deposits of Solnhofen, Bavaria, Germany. *Archaeopteryx* means 'ancient wing,' and this specimen was commonly considered (until recently that is) as the first bird. This specimen and other beautifully complete fossils would never have been found if the rock wasn't already being carefully split and examined for slabs to be used for lithography (hence the species name of this fossil). Since this fossil was privately owned, it sold to the highest bidder--which happened to be the Natural History Museum in London, England. This was fortunate, as Charles Darwin had published his "Origin of Species" in England only two years earlier, in 1859, and evolution was a hot topic in scientific circles. However, not everyone was on board with his ideas. Interestingly there was a significant anti-evolution movement in Berlin at the time, led by Johann Andreas Wagner. Wagner refused to believe that this specimen was even real, as it supported Darwin's idea of evolution by appearing to be a transitional form between reptiles and birds. Without even seeing the specimen, Wagner called it G*riphosaurus problematicus*, which means 'problematic riddle-lizard', leaving all derivations of 'pteryx' (or wing) out of the name! This anti-evolution movement contributed to the specimen leaving Germany and going to England.

This first specimen of *Archaeopteryx* (incredibly, there are now 12) was headless. It was studied by Sir Richard Owen and later by Thomas Huxley, Darwin's defender. Owen figured that since it had feathers preserved, it must have had a beak, but Huxley thought that a small piece of jaw with four teeth in it, at the edge of the slab, may have belonged to this animal, meaning it was a toothed bird. Huxley published on this fossil in 1868 and later 1870, and it is worth reviewing his arguments as they are still valid today. His logic was as follows: Are there any fossil birds that are more reptilian than living birds? The answer was yes, *Archaeopteryx*. Then he asked: Are there any fossil reptiles that are more bird-like than living reptiles? And the answer was yes: *Compsognathus*, a small dinosaur also found in the Solnhofen deposits. Although a central fundamental principle of comparative anatomy at the time stated that animals with similar functions will show anatomical resemblances, Huxley realised that if evolution were true, then the *degree* of anatomical similarity may reflect evolutionary relationships *as well as* function. Furthering this logic is what comparative anatomists still follow today as a central tenet: the degree and complexity of anatomical similarities allows us to evaluate whether resemblances are deep or superficial. For example, although all vertebrates that can (or could) fly have wings (birds, bats and pterosaurs), these wings are not built the same way and hence are only superficially similar, implying no close relationships between these groups. In other words, their wings tell us about function but not ancestry, and we conclude that all three of these lineages evolved flight independently of one another.

The second specimen of *Archaeopteryx* was found in 1877 and it had a head, with teeth in both upper and lower jaws, vindicating Huxley. The transitional nature of this species is still quite obvious: it has good feathers on its wings and tail, and a bird-like structure of the hip, but it still had teeth, a long boney tail, and dinosaur-like claws on all its wing digits and feet. In fact, *Archaeopteryx* is so similar to the small dinosaur *Compsognathus* that some specimens preserved without feather impressions were initially identified as dinosaurs! A third specimen was found in 1951. For almost 100 years, these few specimens were studied intensively, and were the only story of bird evolution.

Finally, that changed with the discovery of the remarkable fossil deposits in the Liaoning province of China a little over twenty years ago. These deposits are Lower Cretaceous in age (121-125 million years old), or about 25 million years younger than the Solnhofen deposits. Although they represent ancient lake deposits, they are like the Solnhofen deposits in that they are very fine-grained and preserve tiny details such as feather impressions and insect wings.

First a review of feather structure. There are five growth stages of feathers which also may reflect evolutionary stages: stage 1, a simple elongated spike; stage 2, a branched structure (called plumaceous or downy feathers); stage 3, barbs and sometimes barbules on the plumaceous feathers, which may or may not form a vane; stage 4, hooklets on the barbules which allow the feather to form a vane; stage 5, asymmetry of the vane, reflecting aerodynamic function.



Liaoning discoveries came quickly one after another. I'll list them here in date order that they were discovered.

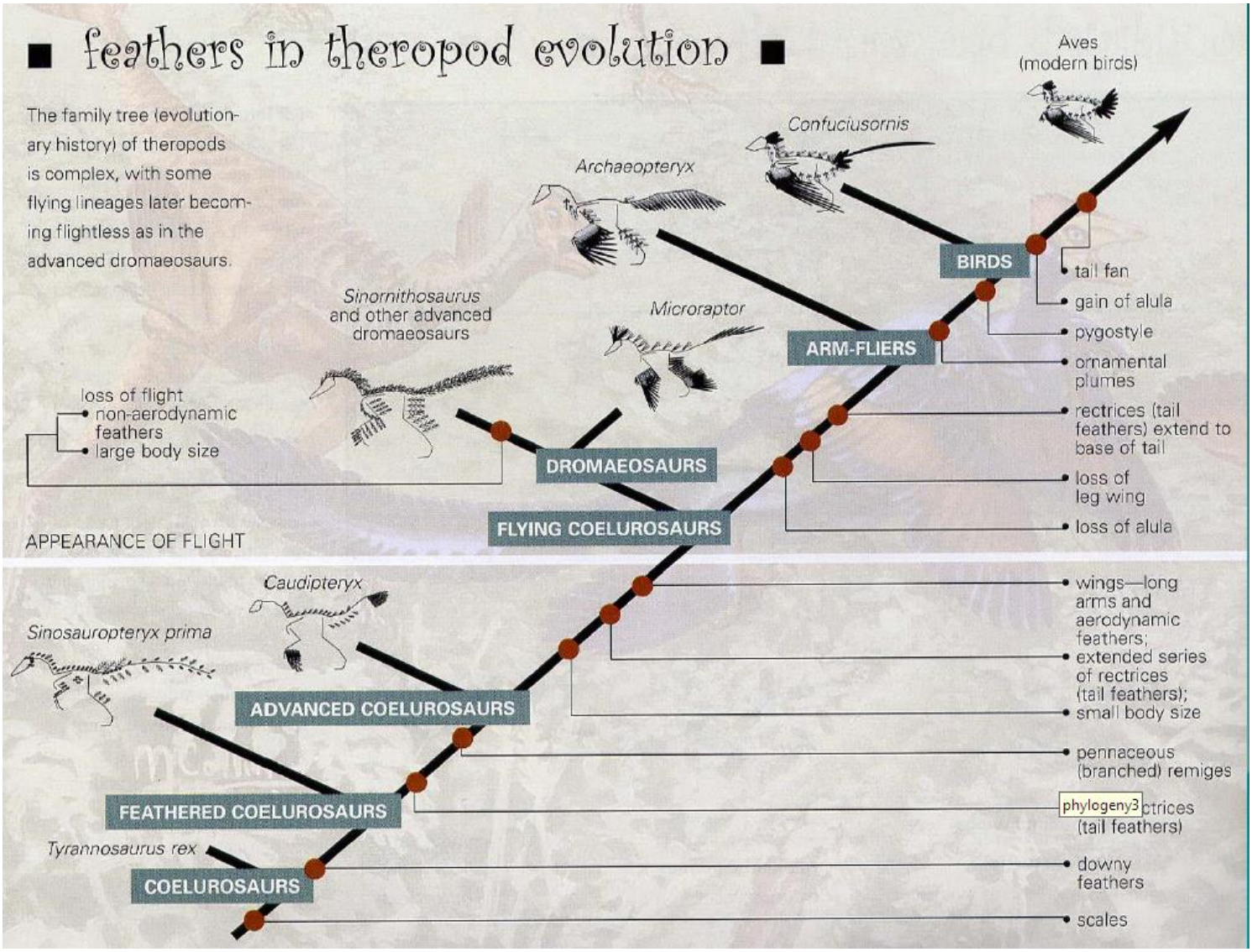
- 1996: *Sinosauropteryx*. This small compsognathid dinosaur had a fringe along its back and tail, which was interpreted as stage 1 and 2 feathers, with some stage 3 as well (not forming vanes). If these were proto-feathers, what were they used for? It was suggested may have provided some insulation for this small dinosaur.
- 1998: *Caudipteryx*. This large oviraptor dinosaur had a beak but also some teeth. It had feathers of the stage 3 variety, with vanes, but only on its tail tip and on its hand. These looked like primaries, but there were no secondaries, and the primaries were clearly not for flying, as the dinosaur was too large and the feathers too few and too small. So what were they used for? It was suggested that they may have been used for display.
- 1999: *Sinornithosaurus*. A small dromeosaur with type 1, 2, and 3 feathers, apparently without barbules, and a somewhat elongated hand. This was the first dinosaur for which fossil melanosomes were discovered, which enabled the colour of some of the feathers to be reconstructed.
- 2003: *Microraptor*. This small dromeosaur was the shocker, and many people had trouble believing it existed (sound familiar?). It had the full suite of kinds of feathers (from stage 1 to stage 5), including asymmetrical flying feathers on its wing AND its hind leg (so yes, it had FOUR "wings"). These wings had primaries, secondaries and coverts, and an alula was developed on the front wing. It also had long contour feathers on its body and head, the latter apparently forming a crest. Some argue it was only a glider, but this also is true of *Archaeopteryx*, and there is an abundant literature discussing whether or not it could fly.

The idea of a four-winged flying animal such as *Microraptor* was first proposed by William Beebe in 1915, which he called 'tetrapteryx' which simply means four-winged. It was nonetheless a

surprise to many when such a creature actually showed up in the fossil record! Yet an 1880 photograph of the Berlin *Archaeopteryx* shows that it too had feather impressions on the hind legs, but these had gone unnoticed because they had been scraped away during subsequent preparation of the fossil!

In case you haven't noticed, all of these animals I have listed are clearly dinosaurs skeletally. Without the superb preservation of the feather impressions we would have had no idea that they possessed these structures, so these deposits give us unique insight into the presence of both FEATHERS and FLIGHT (or at least gliding) in dinosaurs. But if dinosaurs possessed both feathers and flight, what then is a bird?

With only living birds to observe today, we have an inherent bias to call anything that flies and has feathers a bird. These fossils clearly show us otherwise and leave us struggling to define what is so unique about birds. If we call these dinosaurs "birds" then we dramatically broaden the definition of "bird", particularly because some later, derived dromaeosaurs such as *Velociraptor*, were clearly too big to be flying, and were therefore secondarily flightless—and may even have lost their feathers (although we know nothing about the covering in *Velociraptor* yet). How can a bird be flightless (OK, ratites) AND not have feathers?



To better define 'birds,' therefore, scientists have searched for derived boney characters that link all birds but separate them from dinosaurs. These could include the full developed bird hip, the uncinate processes on the ribs, the fused carpometacarpus in the hand, or the nubbin of bone on the end of the short tail of birds called the pygostyle. Some obvious birds from the Lioaning deposits, such as *Confuciusornis*, do not yet have the fully fused carpometacarpus or the uncinate processes, and the bird hip seems to have developed in dinosaurs. We are therefore left with the unique development of the pygostyle as the defining character. This has been widely (but not universally) accepted.

This has two broad implications: even though *Archaeopteryx* is far enough advanced along this evolutionary sequence to have stage 5 feathers and flight (or gliding), it still possesses a long boney tail, and therefore is on the "wrong side of the line" and must be a called a feathered dinosaur and not a bird. And second, the dividing line between birds and dinosaurs is becoming increasingly difficult to draw, demonstrating to us that birds indeed must have evolved gradually from dinosaurs, with different bird-like features evolving at different paces. Birds indeed ARE dinosaurs by the strict cladistic classification methods used by all scientists today.

Questions following the presentation:

Dunn – Does having a pygostyle contribute to active flight vs. gliding?
Answer: not sure. Its structure ensures that tail feathers form a flat fan, as opposed to being on either side of a long tail, so maybe.

Bertin – Noted that Thomas Huxley applied for job at UofT and was turned down… Dunn asked whether Huxley was an anatomist. Kevin wasn't sure, but according to Wikipedia, Huxley was indeed a comparative anatomist, and was regarded as one of best of his time.

Gottesman – does the scarcity of early bird fossils mean the sites have simply run out?
Answer: Solnhofen still produces large numbers of fossils, but just no more birds so far. The scarcity world-wide is mostly an issue of there being very few sites of the right age, and of the type that preserve high quality fossils. Ongoing erosion through geologic time has doubtless erased many fossil beds, and some lengthy time periods aren't represented by any rock layers at all. The fossil record will be incomplete no matter how much exploration is done.

Observations

Recent bird records were mentioned, including recent Willow Ptarmigan at Point Pelee, and a White Wagtail in Barrie area.

Rising asked whether Tree Swallows were suffering from the many cold wet days this spring. Seymour noted that swallows find insects in such weather by flying low over water bodies. Dunn said that swallows lay an egg a day, but when faced with wet cold days, they may skip a few days before completing the clutch.

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