Natural History of Vertebrates
Lecture Notes
Chapter 16 - Mesozoic Diapsids

These notes are provided to help direct your study from the textbook. They are not designed to explain all aspects of the material in great detail; they are a supplement to the discussion in class and the textbook. If you were to study **only** these notes, you would not learn enough to do well in the course.

Be sure to study the List of Terms

Diapsida

The Diapsida are considered to be monophyletic (figures 16-1 and 16-2). The diapsids have two temporal openings; one high between the postorbital and the squamosal, and a second one low between the quadratojugal and the jugal (figure 16-3). In addition, there is a suborbital or antorbital fenestra and a **Jacobson's organ**, which is are ventromedial outpockets of the nasal cavity that are lined with vomeronasal epithelium and innervated by the olfactory bulb. The Jacobson's organ is found in squamates and tuatara (Sphenodonita), and is seen embryologically in birds and crocodiles, but not in adults.

Diapsida is split into two groups (figures 16-1 and 16-2);

- Archosauromorpha - crocodiles, birds, dinosaurs
- Lepidosauromorpha - tuatara, squamates, mosasaurs

Archosauria

- antorbital fenestra
- orbit of eye is triangular
- teeth are laterally compressed
- trend towards bipedalism
- advanced archosaurs semiaquatic to marine forms (phytosaurs and crocodiles), flying forms (pterosaurs and birds), and terrestrial forms (dinosaurs)

Crurotarsi includes the **Phytosauria** and the **Crocodilia**
These two groups are sister taxa relative to each other, though the Crocodilia replaced the Phytosauria in the fossil record. The Phytosauria were common in the Early Triassic while, by the Late Triassic, the Crocodilia were dominant and had replaced the phytosaurs. The Crocodilia reached their most abundant, most diverse in terms of species, and the largest sized species in the Cretaceous. Many extinct species of Crocodilia were strictly terrestrial, however all extant species are semi-aquatic. In the Cretaceous, the largest species was 12 to 15 meters in length, and perhaps weighed as much as *Tyrannosaurus rex*. Perhaps the Crocodilia were following Cope's Rule through the Cretaceous.

Extant Crocodilia

- 21 species survive today
- most have long snouts with numerous pointed teeth, some have extremely long snouts and specialize in eating fish that are caught with a sideways swipe of the jaw.
- three families: Alligatoridae (alligators and caimans, western hemisphere) Crocodylidae (crocodiles, marine and freshwater, worldwide) Gavialidae (single species, fish specialist, eastern hemisphere)
- in general, have legs splayed somewhat to the sides, however they can pull the legs inward and gallop, can move quite fast if the need arises.
- advances relative to the phytosaurs include:
- four-chambered heart
- socketed teeth (thecodont)
- secondary palate that separates the mouth from the nasal cavity

Circulation

Blood flow through the heart is variable and has great implication for the physiology and activities of crocodiles. There is a 4-chambered heart, which is similar to the mammalian heart, in that blood from the systemic circulation flows into the right atrium, then to the right ventricle. There are also a series of valves which keep the blood flowing in only one direction. However leaving the right ventricle are two arteries, one to the lungs (pulmonary artery) and one to the posterior part of the body (left aortic arch going to the systemic circulation, primarily the viscera). Blood from the lungs returns to the left atrium, then to the left ventricle, and from the left ventricle into the right aortic arch that supplies blood to the head and the posterior part of the body. One additional feature is an opening (**foramen of Panizza**) that connects the right aortic arch from the left ventricle to the left aortic arch from the right ventricle that goes to the posterior body. A valve allows blood to flow in only one direction through the foramen, from the right aortic arch to the left aortic arch.

At rest, blood pressure in the right and left ventricles is equal. Thus blood does not flow through the foramen of Panizza and blood from the right ventricle flows into the systemic circulation. This carries deoxygenated blood to the viscera, however this blood, which is high in CO2 also has a low pH. The extra hydrogen ions aid in the digestive process and allow a very low pH to be generated in the stomach.

When active, blood pressure is greater in the left ventricle than in the right. Thus blood flows through the foramen of Panizza from the aorta to the left aortic arch and no blood from the right ventricle enters the left aortic arch as the increased blood pressure keeps the ventricular valve closed.. Thus only oxygenated blood is carried to the posterior part of the body and the exercising muscle of the trunk and limbs. This is called a right to left shunt as blood is moved from the right aortic arch to the left aortic arch. Thus when active, the heart of a crocodile functions like a mammalian heart in that blood from the systemic circulation is kept separate from the blood in the pulmonary circulation.

Reproduction and parental care

All crocodilians lay eggs with a leathery covering and thus fertilization must be internal. This implies a complex courtship ritual and advanced behavior patterns. The eggs are laid in a nest and the nest is guarded by one or more parents. In alligators, of the of the best known, the mother constructs a nest of matted. wet vegetation. The eggs are laid in the nest and then covered with more vegetation. The heat from the rotting vegetation incubates the eggs.

When the babies are close to hatching, they begin making noises which attracts one or both parents who then open the nest and free the hatchlings. The hatchlings are then picked up in the mouth of the parent and carried one or two at a time to the water and released. The young alligators stay near their mother for two years. This period is longer in some other species of crocodilians. If the young feel threatened, they will emit a distress call which causes the parents to rush to their defense.

Crocodilians share this nesting and guarding behavior with birds. As these taxa are both within the archosaurs, we can conclude from a cladistic analysis that all archosaurs exhibited some type or nesting behavior and parental investment in the young after hatching.

Pterosaurs

- sister taxon to the Dinosauria (figure 16-1)
- flight evolved twice (convergent evolution) within the archosaurs, pterosaurs and aves
- wing structure is very different from birds as the radius and ulna are short and the phalanges (especially the fourth) are very long and support the wing (more similar to a bats wing).
- hollow bones
- well developed sternum for flight muscles
- reduced olfactory bulb (less reliance on smell)
- large eyes (more reliance on vision)
- large cerebellum for coordination of sensory and muscles.
- possibly endothermic (possibly possessed "hair" as insulation)
- capable of sustained flapping flight, likely slow maneuverable flight
- could climb well using claws on the forelimbs
- placed the hind foot on the ground in a manner similar to birds
- a variety of dentition patterns which indicates a variety of feeding niches (figure 14-8)

Dinosuaria

two groups: Ornithischia and the Saurischia

There is a trend towards a bipedal stance and thus we see a change in the hip structure. Early archosaur had the three hip bones (**ilium** (dorsal), **ischium** (posterior), and **pubis** (anterior)) all about equal in size and arrayed around the joint with the femur. The femur projects sideways almost parallel to the ground (figure 16-8).

In the saurischians, the ischium is elongated and extends posteriorly, while the pubis is elongated and extends anteriorly. The flexor of the femur originate on the ischium and the extensors of the femur originate on the pubis (figure 16-8).

In the ornithischians there are two configurations. In both the ischium is elongated and extends to the posterior. In one group the pubis also extends posteriorly and the flexors originate from both the pubis and the ischium, while the extensors originate from an anterior projection of the ilium. In the second group the pubis is elongated posteriorly and anteriorly, so that extensors originate off an anterior projection of the pubis and flexors from a posterior projection of the pubis and the ischium (figure 16-8). In both the saurischians and the ornithischians the head of the femur is rotated so that the femur projects straight down from the hip.

Saurischia

Sauropodomorpha

- abundant in the Late Triassic and Early Jurassic
- prosaurapods were long-necked forms (figure 16-16)
- advanced sauropods of Jurassic and Cretaceous were very large with lengths of 25 to 30 m and weights up to 100,000 kg (figure 16-16)
- Diplodocids such as camerasurids and branchiosaurids had long necks and long tails, teeth at the front of the jaws. Both were enormously heavy. Had massive bones and special support for the vertebral column, which consisted of a very thick ligament that ran along the dorsal surface of the spinous processes of the vertebrae. This ligament also supported the neck (figure 16-17)
- Heart was probably 4-chambered as this seems to be primitive for the clade (found in birds and crocodiles).
- Blood pressure would likely present some problems that would need to be overcome
- primarily herbivorous and probably used gastroliths to aid mechanical digestion

Theropoda

- all were bipedal (figure 14-18)

ceratosaurs or carnosaurs

- large predators such as *Tyrannosaurus* were 15 m long and 6 m tall.
- had large hindlimbs, very small front legs, 2 small fingers in front, teeth were 15 cm long

coelurosaurs (ornithomimids and birds)

- bipedal
- ate small prey, some were probably omnivores
- 3 fingers on front hand
- fused boy sternum
- had a furcula (wishbone)
- were convergent on ostriches, probably lived in herds and possibly omnivores

deinonychosaurs

- *Deinonychus* and *Velociraptor* were two genera from the Cretaceous
- small theropods
- greatly enlarged claw on the 2nd toe of the hindlimb of *Deinonychus* which was used to kick and disembowel prey (figures 14-19 and 14-20)
- in other genera the 3rd toe is largest
- 1st toe is backwards as in birds, 5th toe is gone as in birds.

birds and theropods share several characters in common

- elongate, s-shaped neck
- skull and neck with one occipital condyle
- intertarsal ankle joint
- hollow pneumatic bones
- epidermal scales

earliest bird is *Xiaotingia* or *Archaeopteryx*

- had feathers, both primaries and secondaries
- no keeled sternum
- limbs are elongated
- except for feathers, it is very similar to the deinonychosaurs (small bipedal theropod)
- possess a furcula
- fused clavicle
- sternum is unossified and lacks a keel
- humerus has the processes and tubercles similar to theropods and not at all like modern birds
- probably could not fold the wings along the body.
- coracoids are thin
- foot design has a reverse hallux (1st digit), which is also found in several theropods
- conclusion is that *Archeopteryx* had a life similar to other theropods (fast runner, insectivorous, and catches fast moving prey)

Ornithischians (the other group of Dinosauria)

- Gave rise to no living descendants.
- many bipedal forms (figure 16-12), such as hardrosaurs (duck-billed dinosaurs) (figure 16-13)
- quadrupedal forms such as *Stegosaurus* (figure 16-11)
- all had horny beaks with no teeth, forelimbs better developed, even in bipedal forms.
- fossil evidence of parental care (nesting) and social behavior based upon assemblages of fossils

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