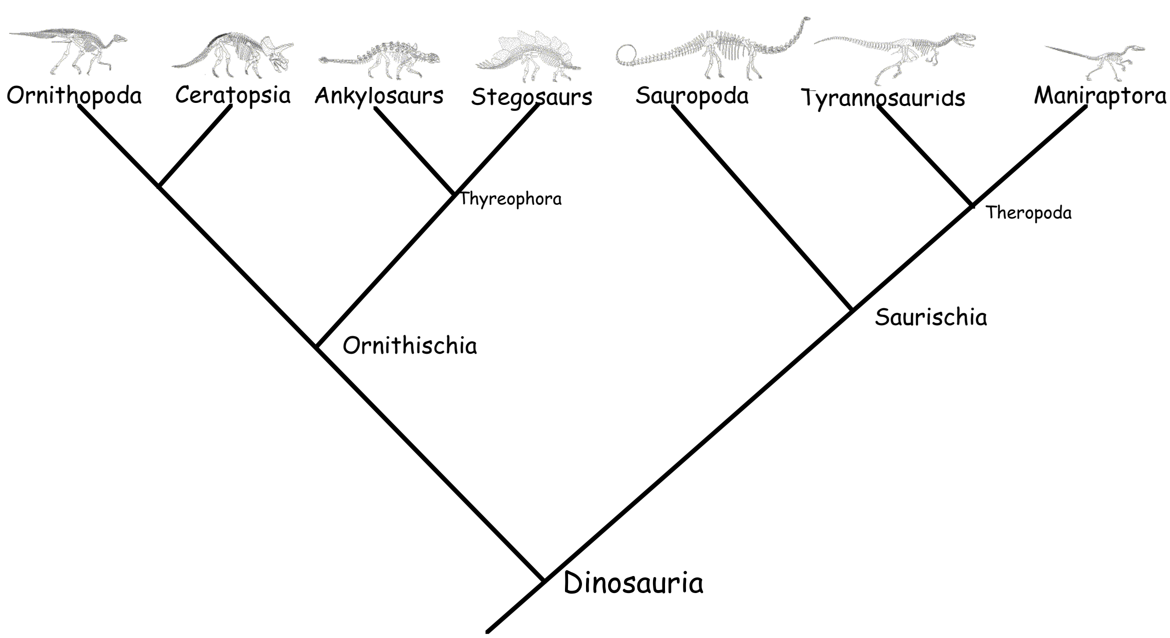
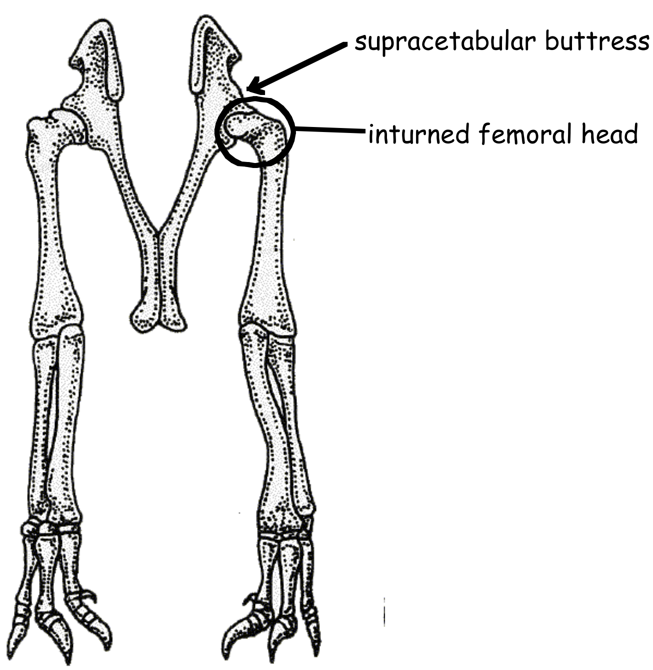
012:004 – Evolution and the History of Life
Lab 11 – Dinosaurs

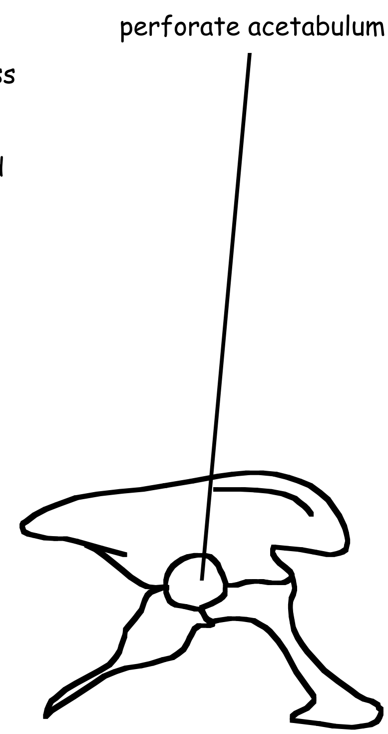
Dinosaurs were a hugely successful group of archosaurs that lived during most of the Mesozoic. The first dinosaurs appeared during the Late Triassic and these early forms were mainly small bipedal (they walked on two legs) carnivores. By the Jurassic, dinosaurs had evolved into a wide variety of forms. These ranged from the now large carnivorous Theropods, the giant herbivorous Sauropods and to the well-armored Thyreophorans (stegosaurs and ankylosaurs). During the Cretaceous we see the rise of the Tyrannosaurids and Maniraptorans—these are the so-called "raptors" made famous by *Jurassic Park*. Also, during the Cretaceous we see the diversification of the Ornithopods (the duck-billed dinos) and the Marginocephalians (Pachycephalosaurs and Ceratopsian—*Triceratops* and its kin). And of course, as we known all the dinosaurs then meet their tragic fate at the end of the Cretaceous Period in one of the major mass extinctions of life…all the dinosaurs that is, except for the avian kind. These dinosaurs (birds) showed up in the Jurassic and are still alive and kicking today with over 9,000 known species—but we will leave birds for another lab.

THE DINOSAURS



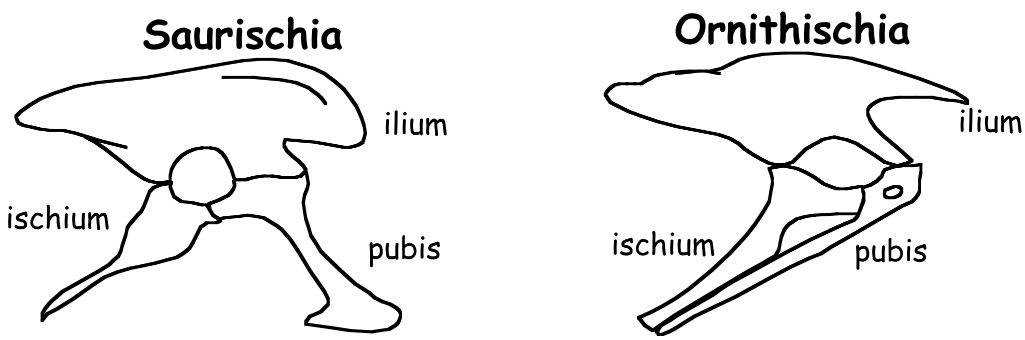
Dinosaurs differ from other archosaurs due to their fully upright and primitively bipedal posture. Dinosaurs possess a number of features related to the evolution of the dinosaurs' upright gait. Unlike many other diapsids, dinosaurs walk fully upright—that is, they carry their legs directly underneath their body as opposed to sprawling their legs out to the sides like most lizards. In order to keeps one's legs underneath one's body you need to have a couple of things going for you in the hip region. This is because you don't want your leg bones to slip out of the hip socket and jab into your abdomen puncturing internal organs and killing you (not exactly an adaptive trait, huh?) Dinosaurs solve this problem three ways. First, they have a ridge of bone over their hip socket. This is called a **supraacetabular buttress** and it helps to keep the femur from sliding up and out of the hip socket. Next, their hip socket becomes a completely open hole. This is called a **perforate acetabulum.** The good thing about a perforate acetabulum (a completely open hip hole) is that it allows the head of the femur (the top part of the femur closest to the body) to sit all the way inside of the hip socket. Finally, the third adaptation was that the head of the femur is turned inward towards the body. This is called an **inturned femoral head** and this allows the femur to fit all the way inside the hole in the hip socket but still keeping the rest of the femur point down at the ground. A supraacetabular buttress and an inturned femoral head are characteristics of all Ornithodirans. Only dinosaurs possess a perforate acetabulum. This is the major synapomorphy for the group.



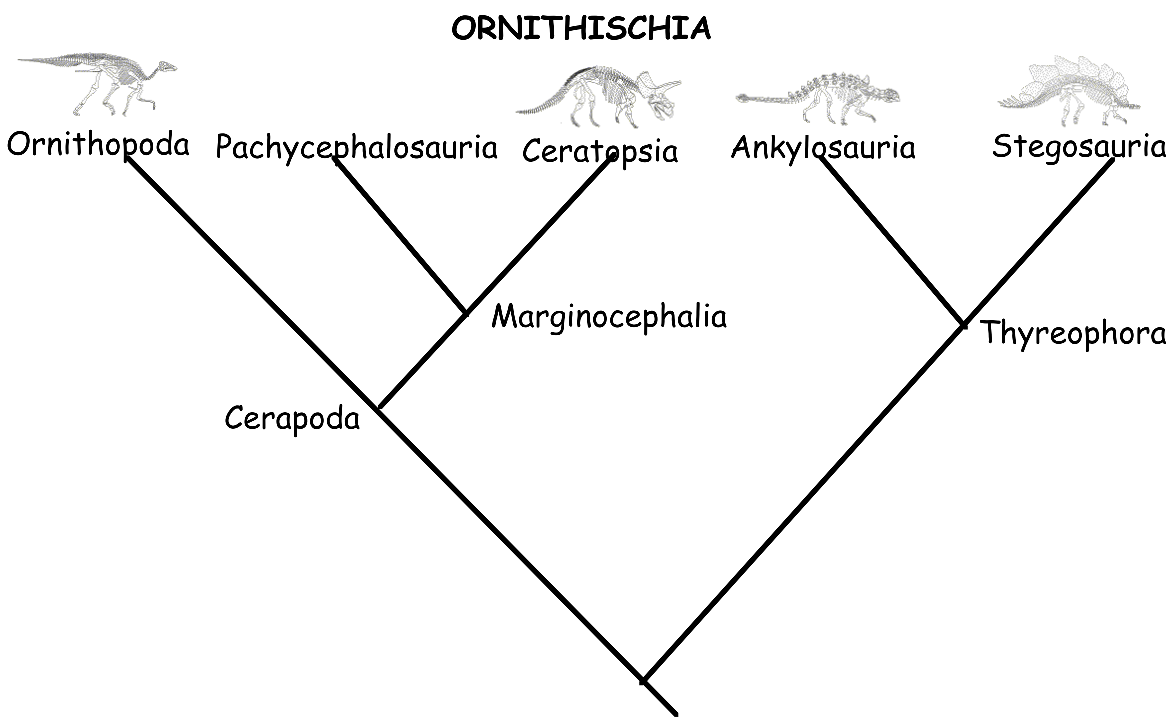


The Various Groups of Dinosaurs

There are two major groups of dinosaurs. These are the **Ornithischia** and the **Saurischia**. Ornithischia means "bird-hipped" and Saurischia means "lizard-hipped". The way to distinguish between these two groups is by the orientation of the bones in the hip. There are three bones that make up the hip. They are the **ilium, ischium,** and the **pubis.** In Ornithischian dinosaurs both the pubis and the ischium point backwards. In Saurischian dinosaurs the pubis points forward and the ischium points backwards.



Now we will look at the different groups within Ornithischia and Saurischia:



Ornithischians are strictly herbivorous and in addition to their hip structure, they share another unique trait. They have a small bone at the front of the lower jaw called a predentary bone. This is thought to be an adaptation to their herbivorous lifestyle. There are two major groups within **Ornithischia**—the **Thyreophora** and the **Cerapoda**. Cerapoda is made up of the **Marginocephalians** and the **Ornithopods**.

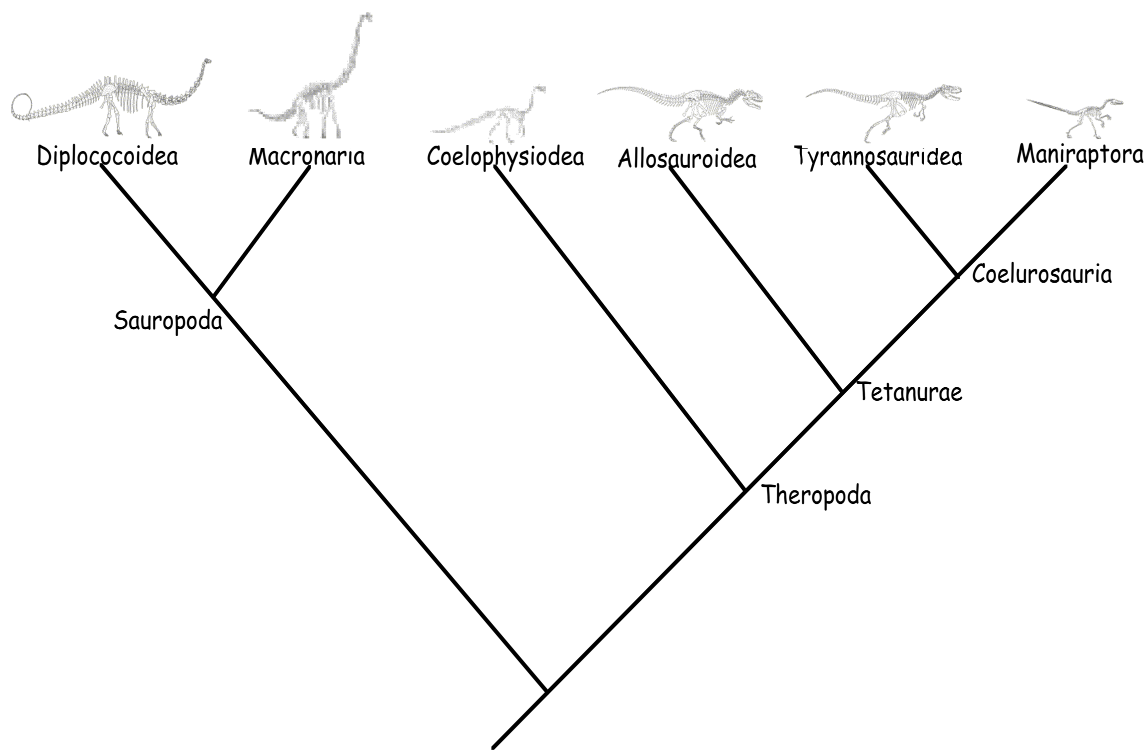
Thyreophora—this group includes the **stegosaurs** and the **ankylosaurs** and is characterized by the possession of numerous large osteoderms (bony-armor within the skin) along their backs.

Cerapoda—this group is characterized by the presence of ossified ligaments along the spine right above the hip.

Marginocephalia—this group of cerapods includes the **ceratopsians** and the **pachycephalosaurs**. This group is characterized by the presence of a shelf of bone along the base of the skull. In ceratopsians this shelf of bone forms their bony frill while in pachycephalosaurs it helps to form their enormously thickened skull roofs.

Ornithopoda—these are the so-called duck-billed dinosaurs. Aside from their characteristic skull shape, all ornithopods take their ossified tendons to an extreme with them running from in front of the hip to nearly the tip of the tail.

SAURISCHIA



Two major groups of Saurischians exist—the **Sauropodomorpha** and the **Theropoda**. Sauropodomorphs include the sauropods and their closest relatives.

Sauropoda—these were huge quadruped animals that are characterized by adaptations of their teeth and skull to their herbivorous diet as well as large column-shaped legs used to support their massive weight and very elongate necks and tails. Sauropoda is divided into two groups. The **Macronaria** and the **Diplodocoidea**.

Macronaria—these sauropods generally have tails shorter than their necks and necks that are directed up into the air. The most apparent synapomorphy of the group, however, is the greatly enlarged nasal opening which forms an almost handle shaped structure directed upwards (dorsally) off of the skull.

Diplocoidea—this group differs from Macronaria three major ways. First, in diplocoids both the neck and the tail are elongated. Second, diplocoids have spatula-shaped teeth as opposed to the peg-shaped teeth of the macronarians. Lastly, diplocoids do not posses the greatly enlarged nasal opening like that of macronarians.

Theropoda—this group of saurischians continue to possess the primitive bipedal posture of early dinosaurs. Theropods have sharp, recurved, laterally-compressed teeth with serrations running along one edge—a design ideal for tearing through flesh. Additional characteristics of theropods are sharp claws on the hands and feet as well as an opposable thumb. All of these are adaptations for their carnivorous diet. Trends in theropod evolution are seen in the reduction in the number of digits on the hand and feet, hollowing of the bones to reduce weight and the elongation of the forearms (especially within Maniraptora).

Coelophysoidea—this is a very basal group of theropods and in that respect they show many of the primitive theropod traits. These traits are five digits on the foot and four digits in the hand. Coelophysoids tend to develop crests along the length of their snouts (the *Dilophosaurus* of *Jurassic Park* is a good example of this).

Tetanurae—this group is characterized by the loss of the fourth digit in the hand, so tetanurans have only three fingers. Tetanurae includes the Allosauroids, the Tyrannosaurids and the Maniraptorans.

Tyrannosauroidea—this group includes theropods like *Albertosaurus* and the famous *Tyrannosaurus rex*. These animals are characterized by the reduction of the forearm and the loss of all but two digits in the hand.

Maniraptora—this group includes animals such as *Deinonychus, Velociraptor,* and birds. These animals are characterized by the stiffening of the tail, the pubis begins to become back-turned, digit 5 is lost on the foot and the arms and digits of the hand become greatly elongated (often being as long as the hindlimbs). Often present in maniraptorans is a large sickle claw on the second digit of the foot.

1.) What is the major synapomorphy for Dinosauria?

2.) What major adaptation is this synapomorphy associated with?

Specimen 1: Here is a cast of a *Coelophysis*. A and B are labeling two of the bones that make up the hip.

3.) Name which bones A and B are pointing to.

4.) Is *Coelophysis* a Saurischian or an Ornithischian? HOW do you know?

5.) Is *Coelophysis* a Theropod or a Sauropodomorph? HOW do you know?

Specimen 2: Here are some teeth from an *Albertosaurus*.

6.) Sketch one of the teeth and indicate two features that make it useful in a carnivorous life-style.

Specimen 3: This is an endocast (essentially an artificial internal mold) of the braincase of a T-rex. The arrows are pointing to the two large circular depressions towards the front of the brain. These areas are where the olfactory bulbs originate. The size of these depression indicate extremely large olfactory bulbs (perhaps as large as an orange).

7.) The olfactory bulbs are where smells are processed in the brain. Based on the size of T-rex's olfactory bulbs what kind of quality of sense of smell do you think T-rex had?

Specimen 4: This is a big nasty recurved claw!

8.) What group of theropods would the animal that possessed this claw belong to?

Specimen 5: This is the skull material of a *Deinonychus*.

9.) To what group of theropods does this animal belong?

10.) The arrow is pointing to one of the fenestrae on the skull. What fenestra is it pointing to and for what group is this fenestra a synapomorphy?

Specimen 6: This is a cast of the skull of a *Velociraptor.* Unlike the velociraptors of *Jurassic Park*, real *Velociraptors* were much smaller.

11.) Make a sketch of this skull and indicate what feature on the skull indicates its theropod ancestry.

Specimen 7: Here is a dino trackway that you all have seen before.

12.) What kind of dinosaur made this track? Was the animal a biped or a quadruped?

Specimen 8: Here is a big-honkin' vertebra….isn't it cool?

Specimen 9: This is a cast of a skull of a *Diplodocus*, a type of sauropod.

13.) Does this skull belong to a Macronarian or to a Diplodocoid? How could you tell?

14.) Compare the teeth of *Diplodocus* to the teeth of a horse. How do the teeth compare with one another?

15.) Horses use their front teeth to nip and slice grasses and other vegetation. What do you think this says about how a *Diplodocus* might have fed?

Specimen 10: Here you are looking at some fragments of a rib and an osteoderm of a dinosaur.

16.) What group of dinosaurs does this material likely belong to? How do you know this?

Specimen 11: This is a cast of a *Protoceratops* egg. *Protoceratops* is a type of ceratopsian dinosaur.

17.) Based on the accompanying picture, how much parental care do you think these animals showed?

Specimen 12: Cast of dinosaur skull

18.) What group of Ornithischians did this belong to?

Specimen 13: These are cross-sections through the jaw bone of a ornithopod dinosaur. Slower growing cold-blooded animals such as lizards and crocs tend to develop bone in a layered fashion with very few blood vessels passing through the bone. Warm–blooded animals tend to have bone that is full of holes for blood vessels to pass through. The debate over whether dinosaurs were warm-blooded or cold-blooded is still unsettled, but bone structure is one of the things scientists look at in order to help answer these questions.

19.) Look at the acetate peels and the cross-sectioned bone. What types of bone do you see there (layered bone, bone full of holes, or both)?

20.) What might this say about whether dinosaurs were warm-blooded or cold-blooded?

Specimen 14: Here is a picture of an Ornithischian dinosaur.

21.) What group does this dino belong to and how do you know? Name the synapomorphy.

Specimen 15: This is a cast of a pterosaur, a flying reptile that lived during the time of the dinosaurs. Pterosaurs belong to the group Ornithodira along with dinosaurs.

22.) Why isn't a pterosaur a dinosaur?

23.) How does a pterosaur's wing differ from a bird's wing or a bat's wing?

Specimen 16: Look at the picture and answer the following question.

24.) Is this a dinosaur? Why or why not? Hint-look at the skull.