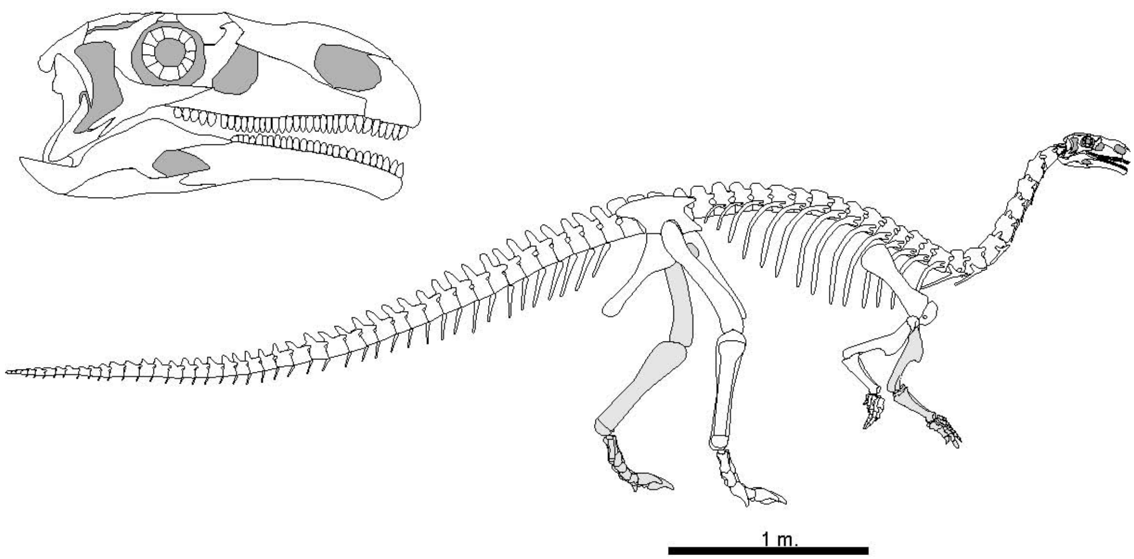
Geo 302D: Age of Dinosaurs

LAB 8: Saurischia

Last lab you were presented with a review of the major ornithischian clades. You also were presented with some of the types of plants that ornithischians faced on a daily basis. This lab takes a look at the other great dinosaur clade, the sister taxon to Ornithischia, **Saurischia**.

The ancestral saurischian possessed a suite of synapomorphies derived over the ancestral dinosaur. See your CD to review these and all synapomorphies of smaller saurischian groups. The ancestral saurischian gave rise to two distinct lineages, **Sauropodomorpha** and **Theropoda**.

Sauropodomorpha differs from its ancestors in that members of this clade adapted to an herbivorous diet. As a result, they shared the same advantages and disadvantages as their ornithischian cousins. Like ornithischians, sauropodomorphs developed small, blunt teeth better suited for dicing plants than for tearing meat. Unlike ornithischians, sauropodomorphs never evolved complex, efficient grinding teeth. Evidence suggests that they compensated for this by using **gastroliths** to mechanically break down large volumes of plant material. Although the pubis of sauropodomorphs is not backturned, the deep ribcage probably contained an extensive gut system able to house quite a large bacterial colony to aid in breaking down cellulose.

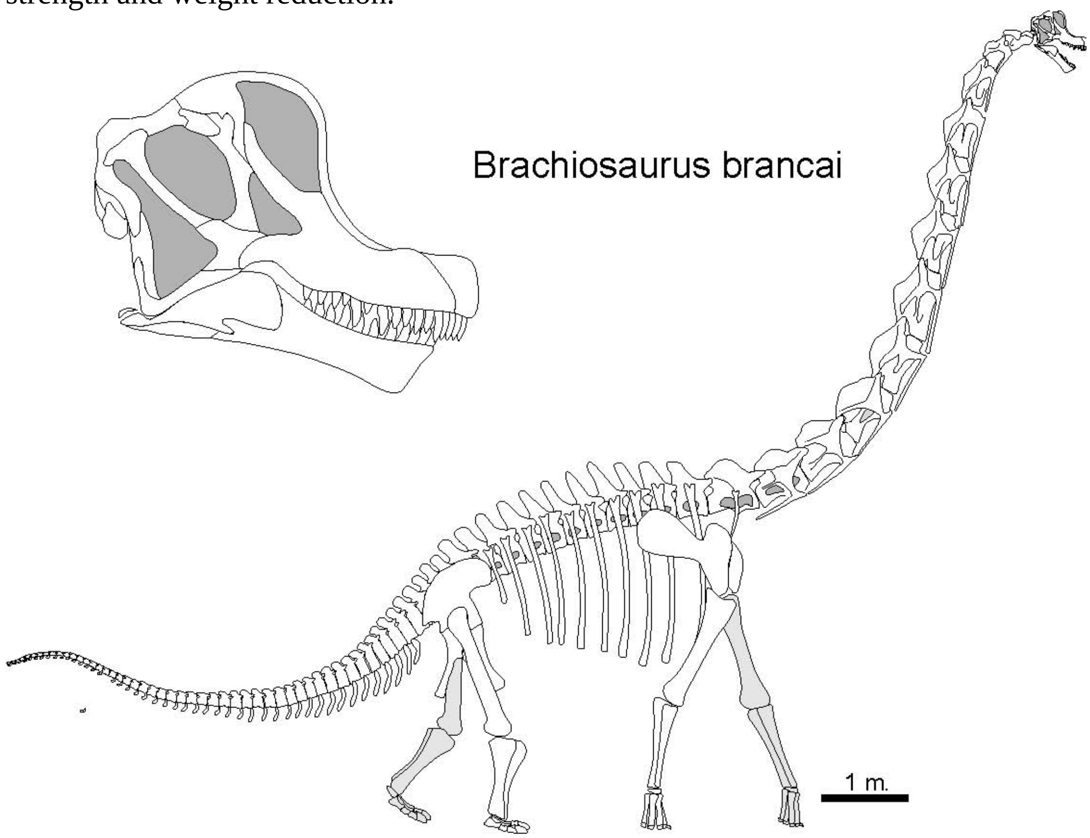


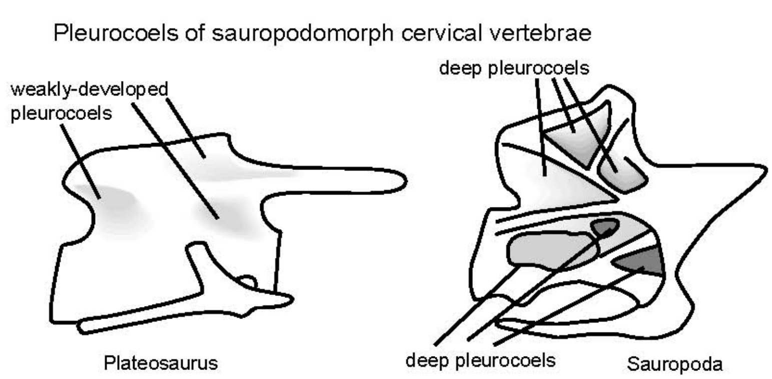
Plateosaurus sp.

The earliest sauropodomorph fossils are known from Late Triassic sediments around the globe. These primitive forms retained the bipedal stance of their ancestors, but decreased the size of their skulls and teeth. The hands no longer bore large claws for grasping prey. *Plateosaurus* (the skeleton above) is one of the best known primitive sauropodomorphs. It is a relatively large animal by today's standards, roughly six to seven meters in length.

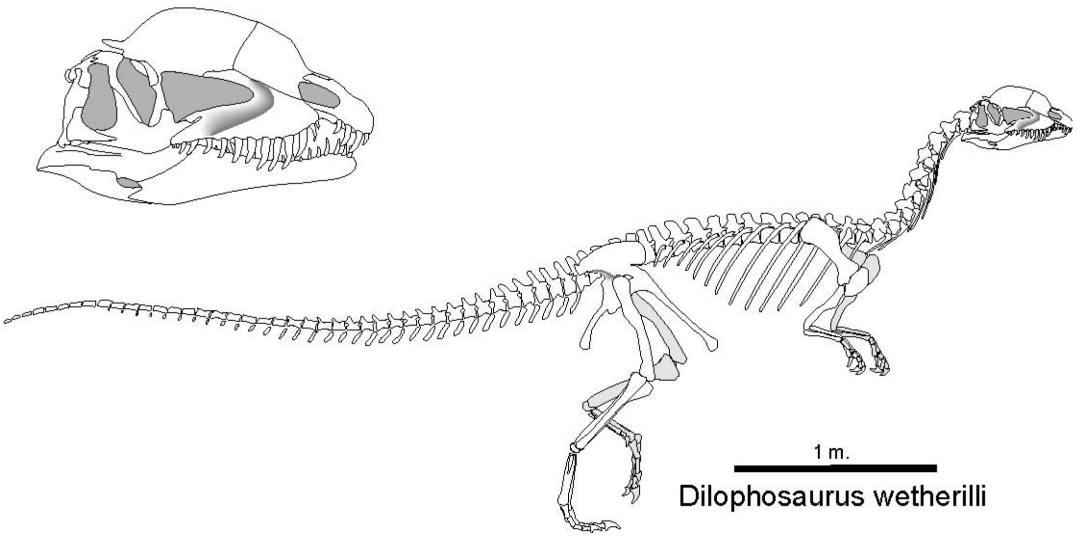
As sauropodomorphs diversified, they also increased in size. From basal sauropodomorphs like *Plateosaurus* arose members of **Sauropoda**. Sauropods include the largest terrestrial animals of all time. During much the twentieth century many paleontologists assumed these animals were too large to have effectively supported their weight on land. That is why many older textbooks show huge sauropods standing chest or head-deep in water, wallowing about like giant hippos. Today we know that the sauropod body plan was superbly designed to bear the animal's great weight on dry land.

Like many saurischians, the vertebral column of sauropods is lightened by pleurocoels. Pleurocoels are hollow spaces excavated into the sides of a vertebra. Some modern hypotheses suggest they were filled with pneumatic air sacs. Modern birds have extensive air-sac filled pleurocoels. Sauropods take their pleurocoels to an extreme. The body of the vertebra is little more than an I-beam in cross section. This affords great strength and weight reduction.



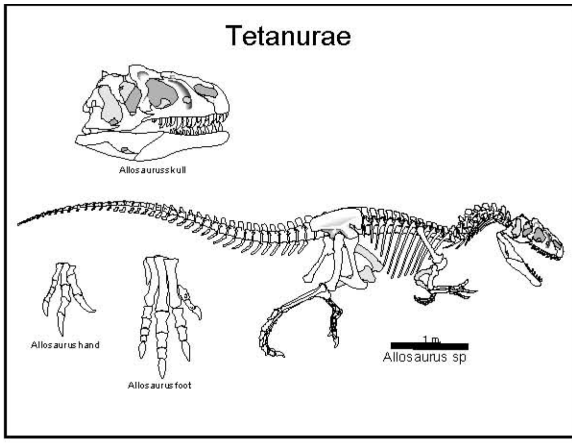


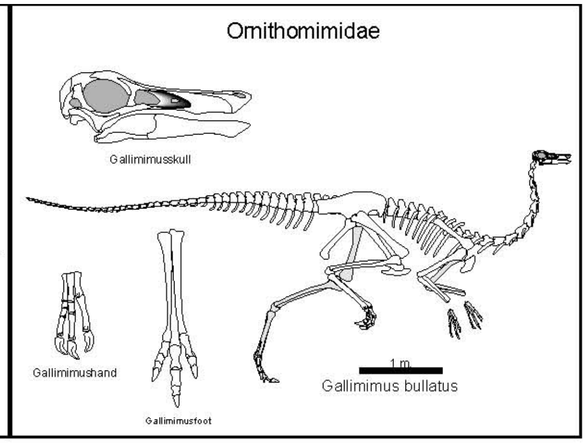
Theropoda is the other saurischian lineage. There are many synapomorphies for this clade, and you must know them all. Theropods retain their ancestral diet of meat. They range in size from a few grams (hummingbirds) to many tons, and even though some are larger than many quadrupedal dinosaurs, they all retain their bipedal mode of locomotion. There are two main lineages within Theropoda: **Ceratosauria** and **Tetanurae**.

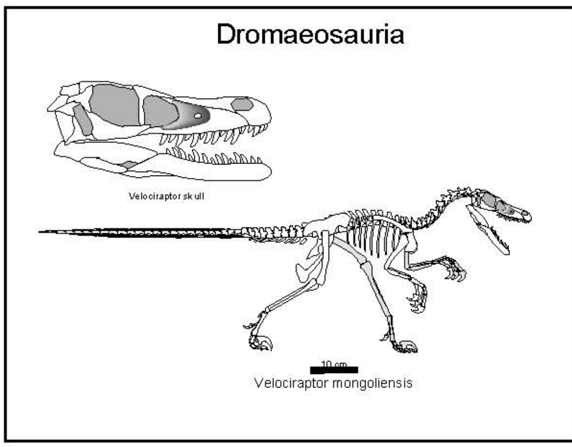


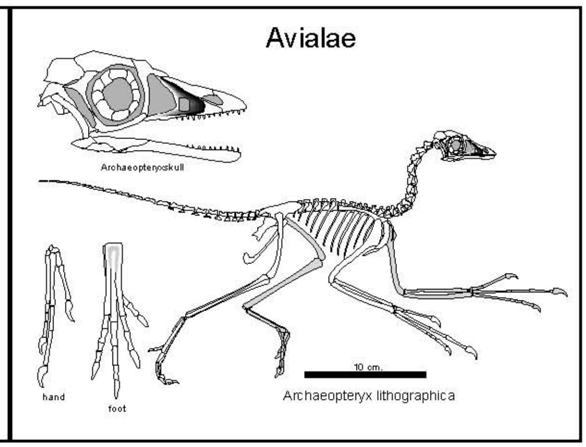
The fossil record of **Ceratosauria** begins in the Late Triassic, and includes some of the oldest dinosaurs for which good fossils are known. *Coelophysis* is the best known of all Late Triassic theropods. A cast of the skeleton of this taxon is on display in the hallway on the first floor. Ceratosaurs ranged in size from lightly built individuals little more than a meter in length, to very large forms measuring ten or more meters long. Ceratosaurs are recognized by extensive **fusion of bones in the ankle, hips, foot, and sacrum**. These same features are converged upon millions of years later by another theropod lineage, birds. Many species of ceratosaurs sport elaborate cranial crests, horns, or knobs. You can see this clearly on the skull of *Dilophosaurus*, a six meter long ceratosaur from Early Jurassic rocks of Arizona. Some derived ceratosaurs survived in Gondwana until the end of the Cretaceous. One that exhibited extensive cranial ornamentation was *Carnotaurus*, from the Late Cretaceous of South America. Instead of delicate crests, *Carnotaurus* had two massive pre-orbital horns. All ceratosaurs became extinct by the end of the Cretaceous Period.

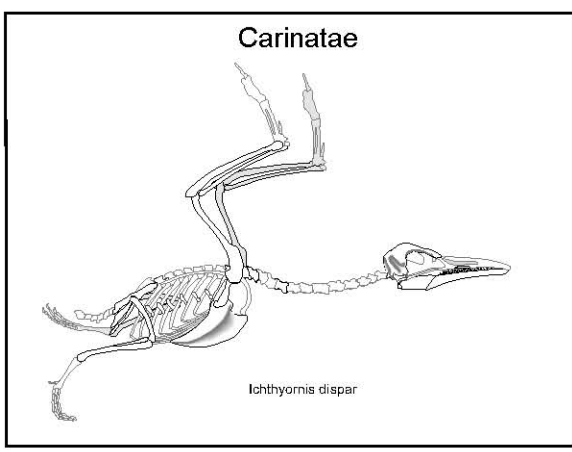
Tetanurae is the sister taxon to Ceratosauria. The earliest fossil record of this group extends back into the Early Jurassic, and the clade survives to the present day. Tetanurines include most of the more famous theropods, such as tyrannosaurs, dromaeosaurs, and allosaurs. The tetanurine lineage shows several trends as it proceeds to more and more derived forms. Some tetanurines evolved slashing claws on the second toe of each foot. Others have an uncanny resemblance to modern paleognath birds (ostriches, emus, rheas, etc.). We now know that feathers appeared in some tetanurine group phylogenetically before the appearance of *Archaeopteryx*. There are a great many clades nested within Tetanurae, <u>and you must know the relationships and synapomorphies diagnosing them all</u>. The skeletons on the following page give you just a slight glimpse at the great diversity of tetanurines.

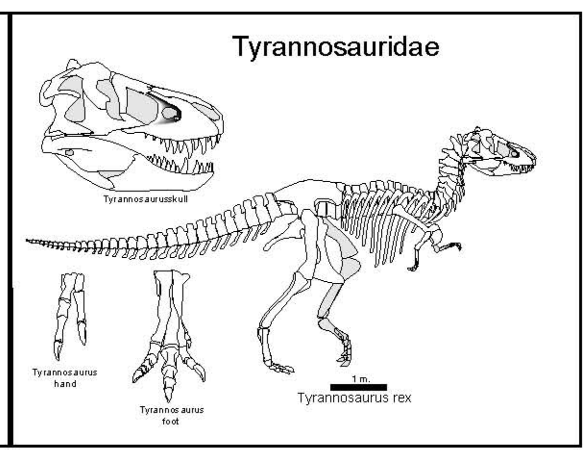

Tetanurae
Allosaurusskull
Allosaurus hand
Allosaurus foot
1 m.
Allosaurus sp


Omithomimidae
Gallimimusskull
Gallimimushand
Gallimimusfoot
1 m.
Gallimimus bullatus


Dromaeosauria
Velociraptor skull
10 cm.
Velociraptor mongoliensis


Avialae
Archaeopteryxskull
hand
foot
10 cm.
Archaeopteryx lithographica


Carinatae
Ichthyornis dispar


Tyrannosauridae
Tyrannosaurusskull
Tyrannosaurus hand
Tyrannosaurus foot
1 m.
Tyrannosaurus rex

Exercises

Some of the questions on these exercises require you to recall material from lecture and your CD. **You are responsible for knowing the synapomorphies of dinosaur clades, as well as the phylogeny of Dinosauria, even if the lab handouts do not explicitly spell them out.**

1. Identify the labeled elements on the model of *Apatosaurus* and the picture of *Brachiosaurs brancai*.

   a.

   b.

   c.

   d.

   e.

2. Ornithischians solved the problem of adapting to herbivory by reorienting the pubis backwards to make room for a longer gut. How did sauropodomorphs solve the herbivory problem?

3. Examine the cast of *Archaeopteryx*. See if you can identify any of the synapomorphies of the following groups in its skeleton:

   Archosauriformes:

   Archosauria:

   Saurischia:

   Theropoda:

   Coelurosauria:

4. Look at the skeleton of *Gallus gallus* (chicken) on the last page. Identify **one** synapomorphy that you can see in this skeleton from each of the groups listed below. Label each synapomorphy on the skeleton as well.

a.) Archosauriformes

b.) Saurischia

c.) Theropoda

d.) Coelurosauria

e.) Maniraptora

f.) Avialae

g.) Ornithurae

h.) Ornithothoraces

i.) Carinatae

j.) Aves

5. It has been noted in the vertebrate paleontology literature that there is evidence for nest building behavior amongst Archosauria, as well as the development of brooding behavior and incubation within Saurischia, and particularly of note within Theropoda. Below is a phylogeny showing the development of some reproductive characters within Saurischia (Grellet-Tinner et. al., 2006).

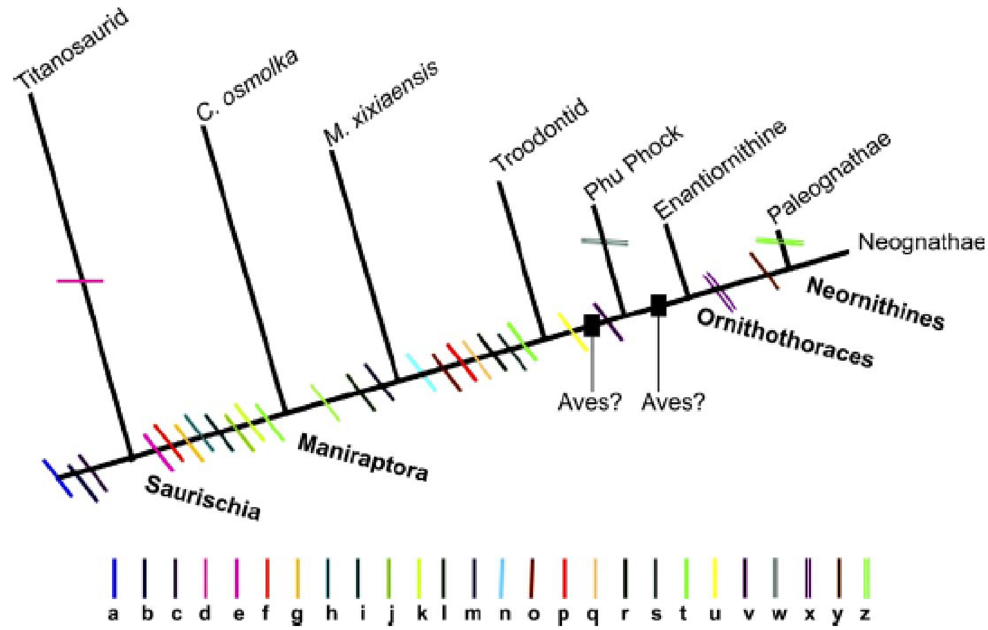
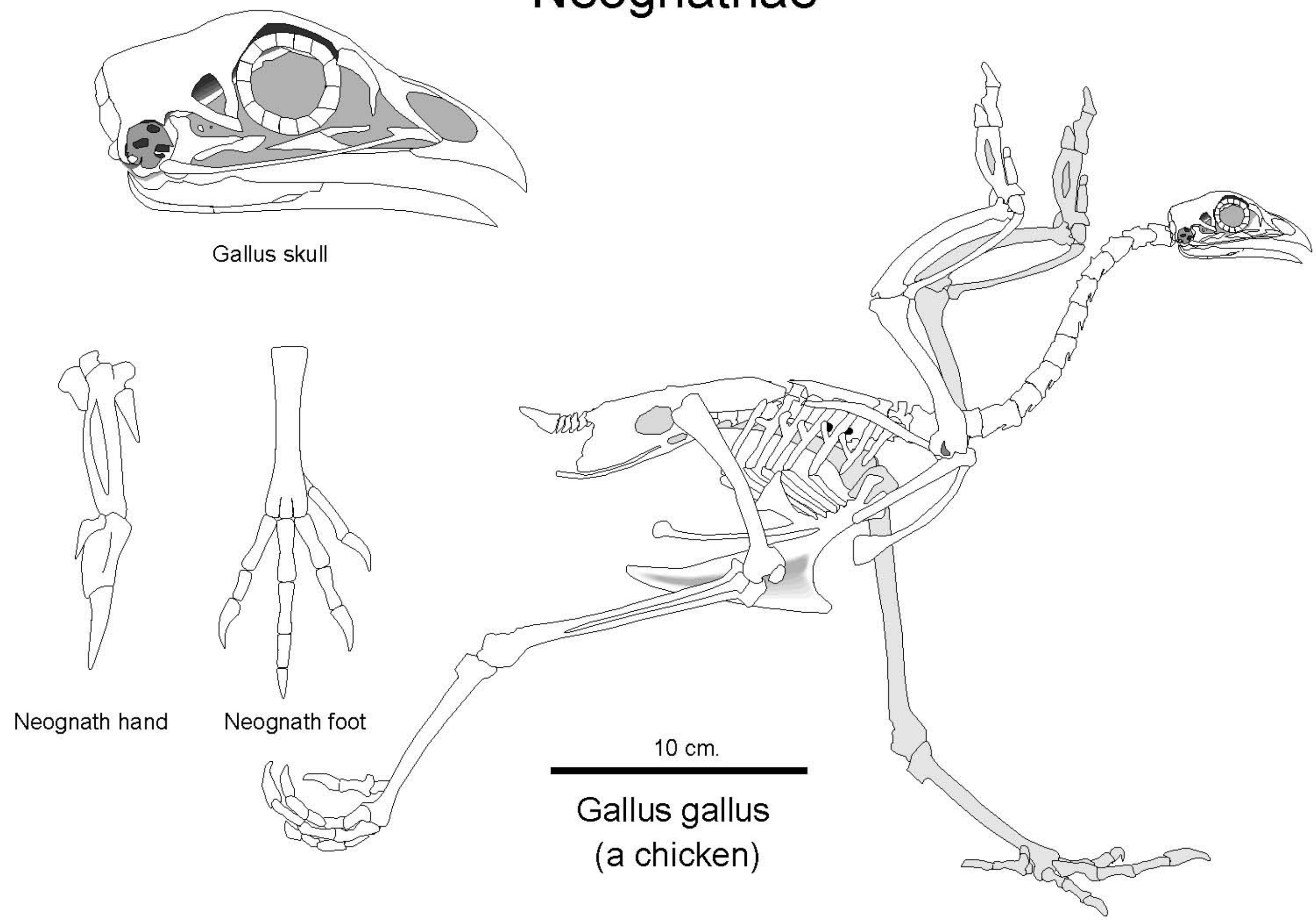


Fig. 10. Cladogram solely based on the optimization of oological and reproductive characters of the studied taxa. Note the coeval appearance of brooding behavior with a change in the architecture of the nest, egg, and eggshell in oviraptorids and a second similar advent at the level of troodontids when incubation developed a) presence of surficial ornamentation; b) acicular crystals as building blocks of the eggshell structure; c) eggs contained within a rimed nest; d) nodular ornamentation in titanosaurids; e) presence of two aprismatic layers; f) presence of acicular crystals limited in layer 1 and crystal orientation of layer at 90 from that of layer 1; g) linearituberculate ornamentation; h) elongated eggs; i) presence of a proto-air cell; j) appearance of a monoautochronic ovideposition as indicated by the eggs arranged in pairs; k) eggs are laid on the perimeters of circles that superposed in 2–3 layers and with an empty space in the center of the clutch; l) presence of brooding behavior; m) differentiation of organic lines within layer 2, creating 2 sub-divisions; n) presence of blade-shaped crystals in layer 1; o) presence of a single circle of eggs; p) presence of a fully developed air cell; q) no space devoid of eggs in the center of the clutch; r) reduction from two to one functioning ovary; s) presence of two prismatic eggshell structural layers; t) eggs are vertically oriented in the substrate with air cell up; u) absence of eggshell surficial ornamentation; v) Presence of proto-avian incubation; w) presence of bi-modal nodular ornamentation; x) presence of three prismatic eggshell structural layers; y) layer 1 wider than layer 2; z) presence of aerial nests; s-1) character reversal for the Paleognath clade: prismatic eggshell boundaries reverse to an aprismatic character state.

a) In this class, we have primarily discussed morphological characters and their use in creating phylogenies. What other characters were used in creating this phylogeny of Saurischia?

b) What issues might paleontologists face in dealing with these types of characters?

Neognathae



Gallus skull
Neognath hand
Neognath foot
10 cm.
Gallus gallus
(a chicken)