Geo 302D: Age of Dinosaurs

LAB 8: Saurischian Dinosaurs

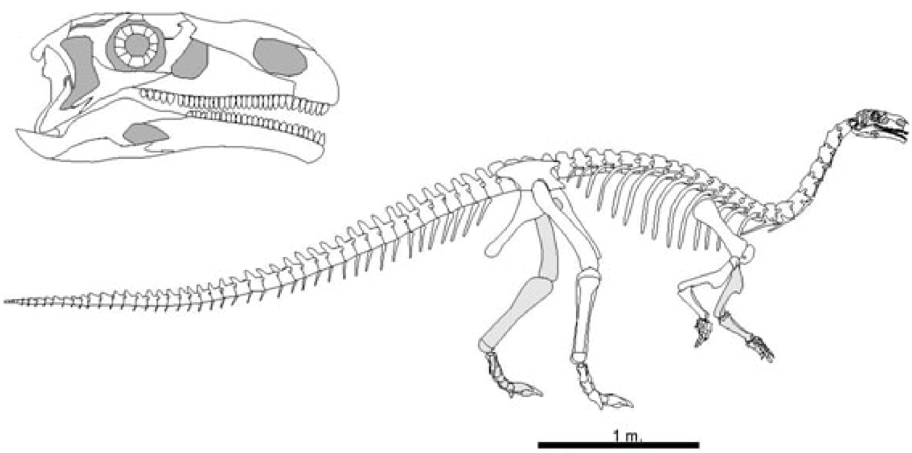
Last lab you were presented with a review of the major ornithischian clades. You also were presented with some of the types of plants that ornithischians faced on a daily basis. This lab takes a look at the other great dinosaur clade, the sister taxon to Ornithischia, **Saurischia**.

Saurischian Diversity

The ancestral saurischian possessed a derived suite of synapomorphies compared to the ancestral dinosaur. See the attached cladogram to review these and all synapomorphies of smaller saurischian groups. The ancestral saurischian, similar to *Herrerasaurus,* 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. 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 facing backwards, the deep ribcage probably contained an extensive gut system able to house quite a large bacterial colony to aid in breaking down cellulose.

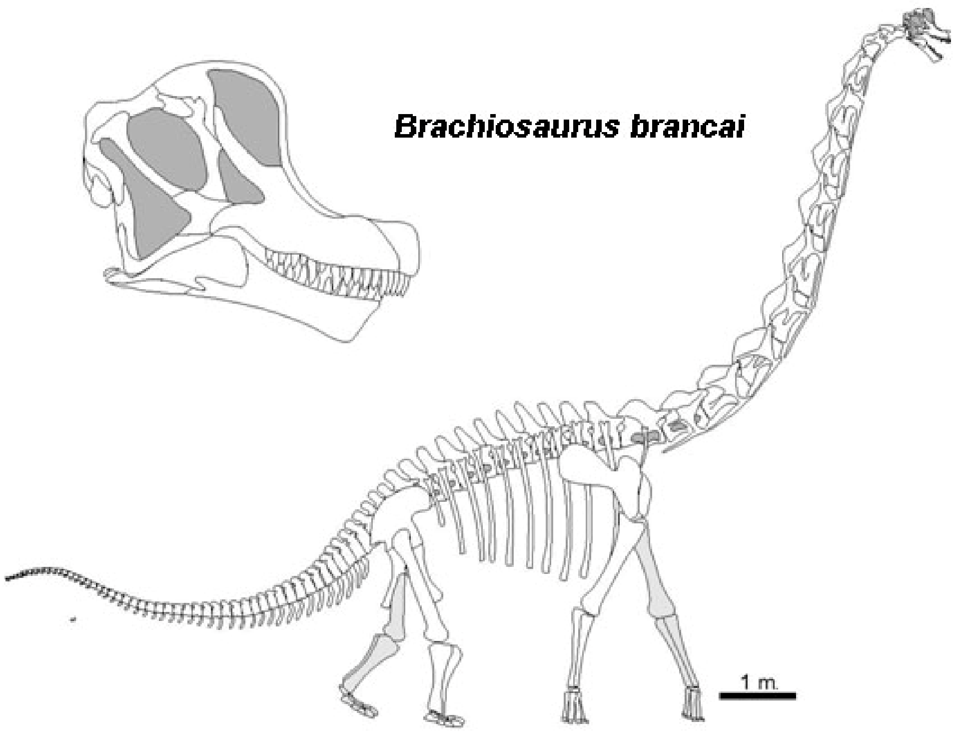
The earliest sauropodomorph fossils are known from Late Triassic sediments around the globe, but mostly from Europe and South America. These primitive forms probably retained the bipedal stance of their ancestors but show decreased size in skulls and teeth. *Plateosaurus* (the skeleton seen below) is one of the best known basal sauropodomorphs. It was a relatively large animal compared to modern animals (roughly six to seven meters in length).



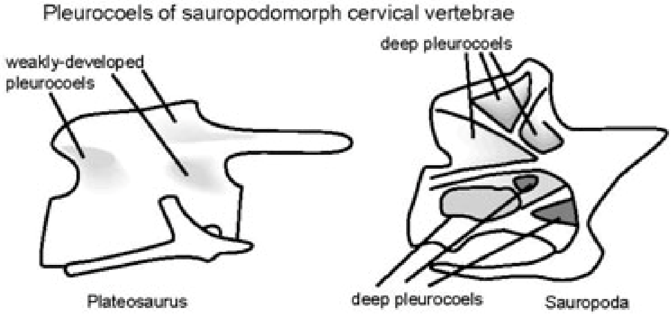
Plateosaurus sp.

As sauropodomorphs diversified into the more derived **Sauropoda**, they also increased in size. Sauropoda includes the largest terrestrial animals of all time. During much of the twentieth century 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. More recent analyses indicate that the sauropod skeleton was equipped to deal with the animals' great weight on dry land.

Like many saurischians, the vertebral column of sauropods is lightened by **pleurocoels (hollow excavations into the sides of vertebrae)**. Some modern paleontologists hypothesize that they were filled with pneumatic air sacs similar to the extensive air-sac-filled pleurocoels of modern birds. Sauropods take their pleurocoels to an extreme; the body of the vertebra is little more than an I-beam in cross section. This morphology provides great strength and weight reduction.

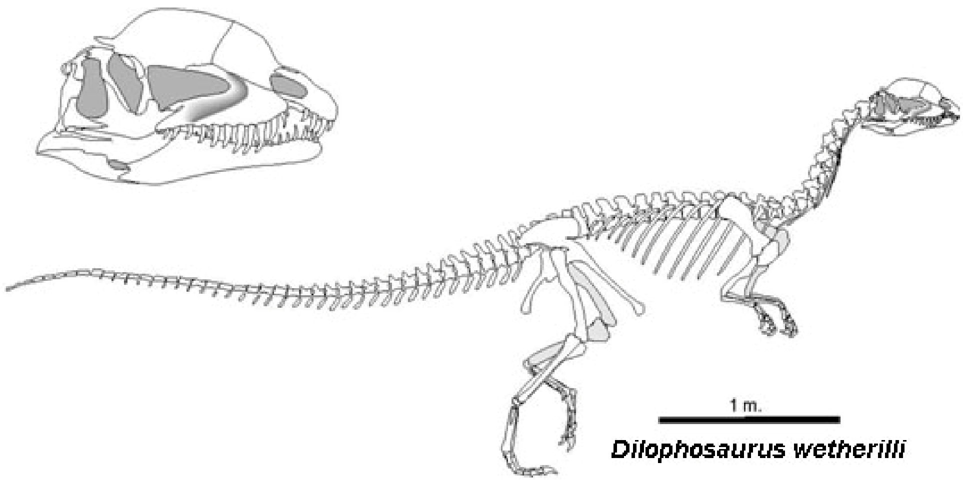


Pleurocoels of sauropodomorph cervical vertebrae

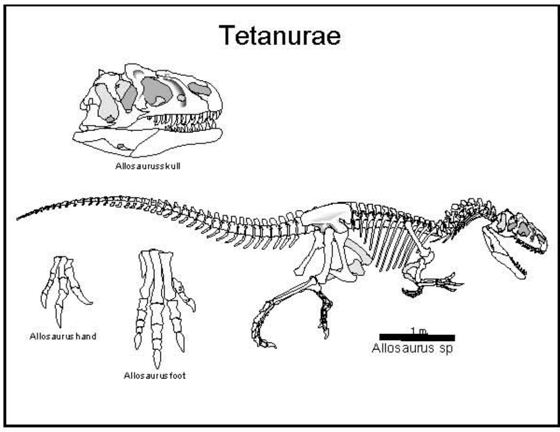


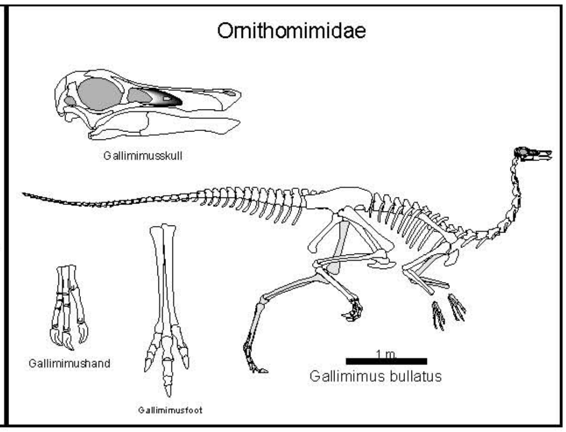
Theropoda is the sister taxon of Sauropodomorpha. There are many synapomorphies for this clade. Theropods retain the ancestral diet of meat. They range in size from a few grams to many tons, and they all retain a bipedal mode of locomotion. There are two main lineages within Theropoda: **Ceratosauria** and **Tetanurae**.

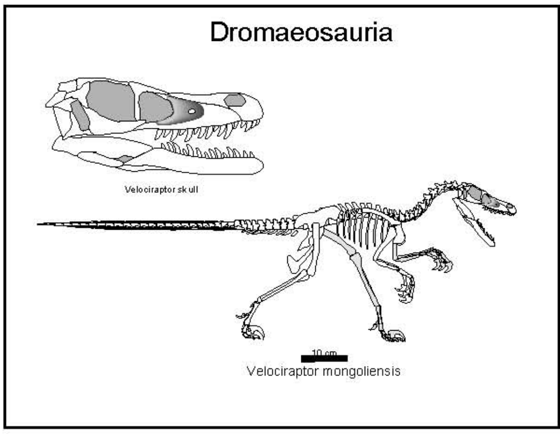
The fossil record of **Ceratosauria** begins in the Late Triassic and includes some of the oldest dinosaurs for which good fossils are known. *Coelophysis* is one of the best known of all Late Triassic theropods, and a cast of the skeleton of this taxon is on display in the hallway on the first floor. 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 ceratosaurian taxa sport elaborate cranial crests, horns, or knobs. You can see this clearly on the skull of *Dilophosaurus*, a six meter long ceratosaur from the 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 were extinct by the end of the Cretaceous Period.

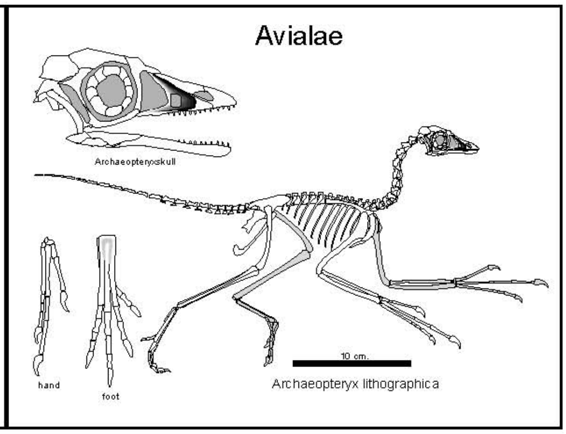


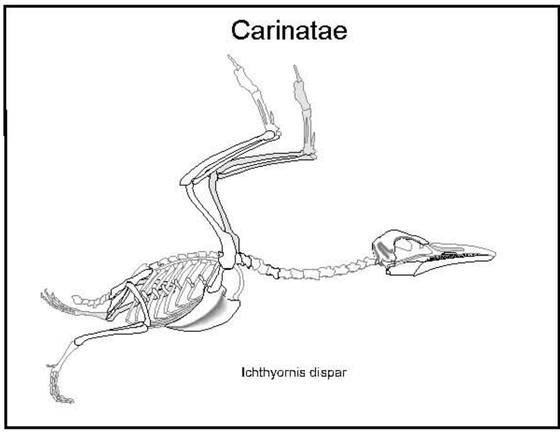
Tetanurae is the sister taxon to Ceratosauria. The earliest fossil record of this group occurs in the Early Jurassic, and the clade survives to the present day. Tetanurines include most of the more famous theropods, such as tyrannosaurs, dromaeosaurs, and allosaurs. Some tetanurines evolved slashing claws on the second toe of each foot, whereas others have an uncanny resemblance to modern paleognath birds (e.g., ostriches, emus, rheas). We now know that feathers appeared in some tetanurine groups before *Archaeopteryx*. There are a great many clades nested within Tetanurae, and you must be familiar with the relationships and synapomorphies diagnosing them all. The skeletons on the following page give you just a glimpse at the great diversity within Tetanurae.

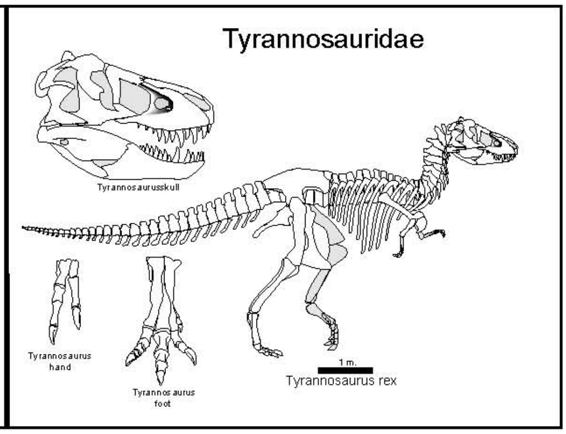

Tetanurae
Allosaurus skull
Allosaurus hand
Allosaurus foot
1 m.
Allosaurus sp


Ornithomimidae
Gallimimus skull
Gallimimus hand
Gallimimus foot
1 m.
Gallimimus bullatus


Dromaeosauria
Velociraptor skull
10 cm.
Velociraptor mongoliensis


Avialae
Archaeopteryx skull
hand
foot
10 cm.
Archaeopteryx lithographica


Carinatae
Ichthyornis dispar


Tyrannosauridae
Tyrannosaurus skull
Tyrannosaurus hand
Tyrannosaurus foot
1 m.
Tyrannosaurus rex

There was a large diversity of basal (occurring at the beginning of the clade history) tetanurines; however, we will only discuss **Spinosauroidea** and **Allosauroidea** in this class. Basal tetanurines have been found on every continent, including Antarctica. The spinosauroids were the most restricted in terms of distribution and age; they were present in Europe, South America, and north Africa from the Early Cretaceous to the early Late Cretaceous. These interesting tetanurines are highly derived in their feeding mechanism and most resembled modern crocodilians. Allosauroids are known from the Middle Jurassic to the early Late Cretaceous and had a global distribution. The sister taxon of Allosauroidea is Coelurosauria.

Coelurosauria includes the small Compsognathidae and the larger Tyrannosauroidea, Ornithomimosauria, and Maniraptora. **Compsognathids** were small in size. This clade is recognized by only a few taxa from the Late Jurassic of Europe and Early Cretaceous of China, and therefore its phylogenetic position has varied.

Tyrannosauridae is known from Late Jurassic to Late Cretaceous sediments with the most derived, and well-known, forms found in the Late Cretaceous deposits of North America and Asia. The relatively large fossil record of tyrannosaurids preserves taxa that possess both a variety of synapomorphies of derived members of the clade and taxa with more transitional morphologies that retain plesiomorphies; this allows for a better understood history of the group compared to that of other tetanurines.

Ornithomimosaurs are found in Cretaceous sediements of North America and Asia; they are lightly built with delicate skulls and elongated forelimbs. The sister taxon to Ornithomimosauria is Maniraptora.

Maniraptora includes Oviraptorosauria and a **polytomy** (unresolved branching relationship) between Dromaeosauridae, Troodontidae, and Avialae. Maniraptora is characterized by having a tail that is stiffened for most of its length, long, pinnate arm feathers, and brooding behavior. **Oviraptorosauria** includes smaller bodied forms with highly specialized skulls, large head crests, and toothless jaws. This group is known only from the Northern Hemisphere in the Cretaceous. There are well-known specimens from Mongolia that are preserved sitting on nests of eggs.

Dromaeosauridae includes the familiar *Velociraptor*, as well as many other taxa from the Createaceous of North America and Asia with possible specimens from Europe. They had long forelimbs, long, stiffened tails and evidence of the presence of primary feathers.

Troodontidae includes small theropods from the Cretaceous of North America and Asia. This group has a highly specialized skull with an enlarged cranial cavity, large orbits, and well-developed middle ear.

The third clade in the polytomy is **Avialae**, which includes *Archaeopteryx*, all modern birds, and many other taxa with various morphologies. The oldest recognized true bird is *Archaeopteryx*, found in the Late Jurassic Solnhofen Limestone of Germany.

Exercises

Some of the questions on these exercises require you to recall material from lecture and lab. **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.**

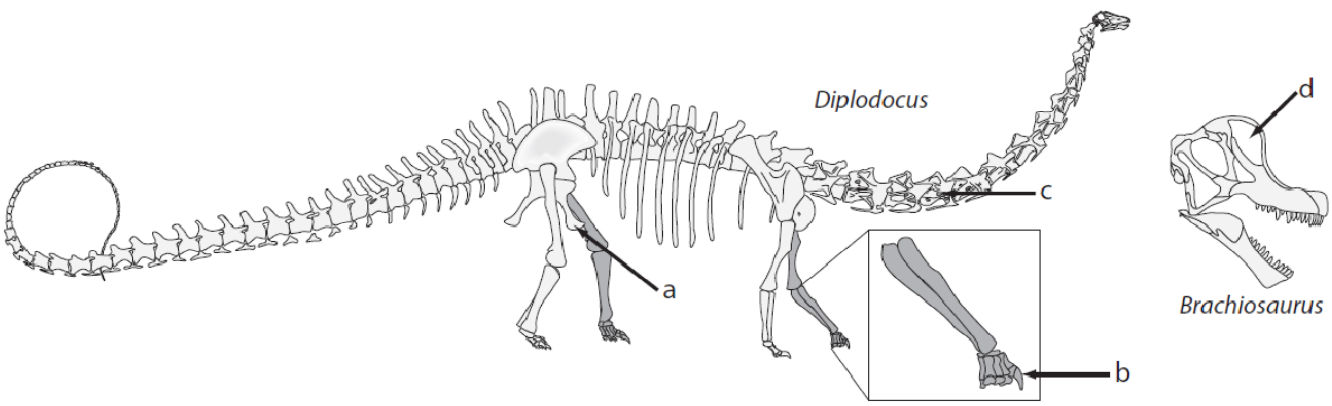
1. Identify the labeled elements on the figures of *Diplodocus* and *Brachiosaurus*.

a.

b.

c.

d.



2. Ornithischians adapted their morphology in response to an herbivorous diet by evolving complex dentition and reorienting the pubis backwards. What morphological features do sauropodomorphs have that are associated with herbivory?

3. Many coelurosaurians are known only from deposits in North America and Asia. What does this suggest about the history of the Earth's surface during the Cretaceous?

4. We know that modern crocodylians and modern birds both lay eggs in nests and exhibit parental care. Before we found the oviraptor fossils sitting on nests, would you have inferred that dinosaurs laid eggs and had parental care? Why?

5. Examine the bones before you and determine what they are. Identify features on these elements that you recognize as synapomorphies of the following groups and write them down below.

a) Dinosauria:

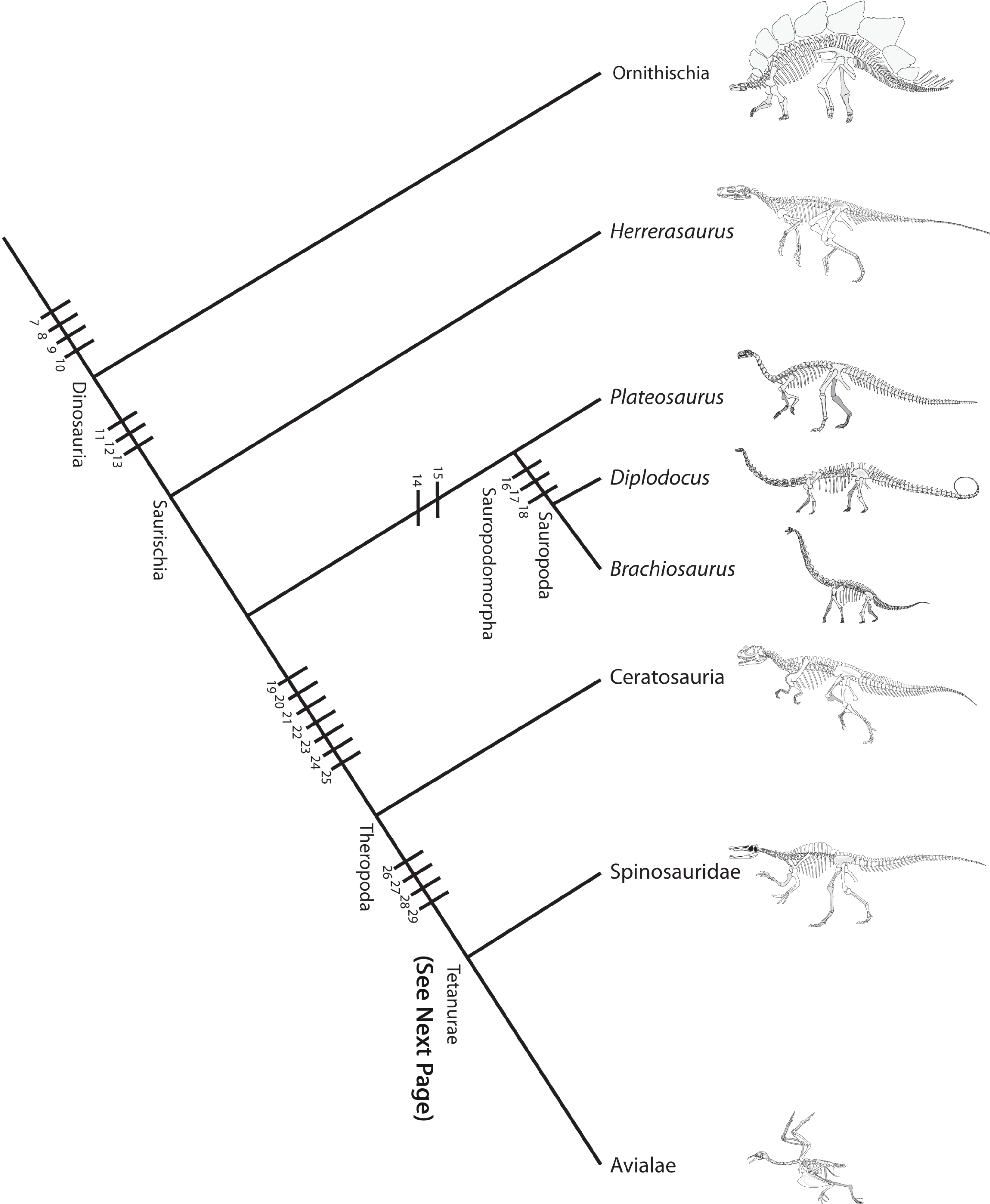
b) Theropoda:

c) Tetanurae:

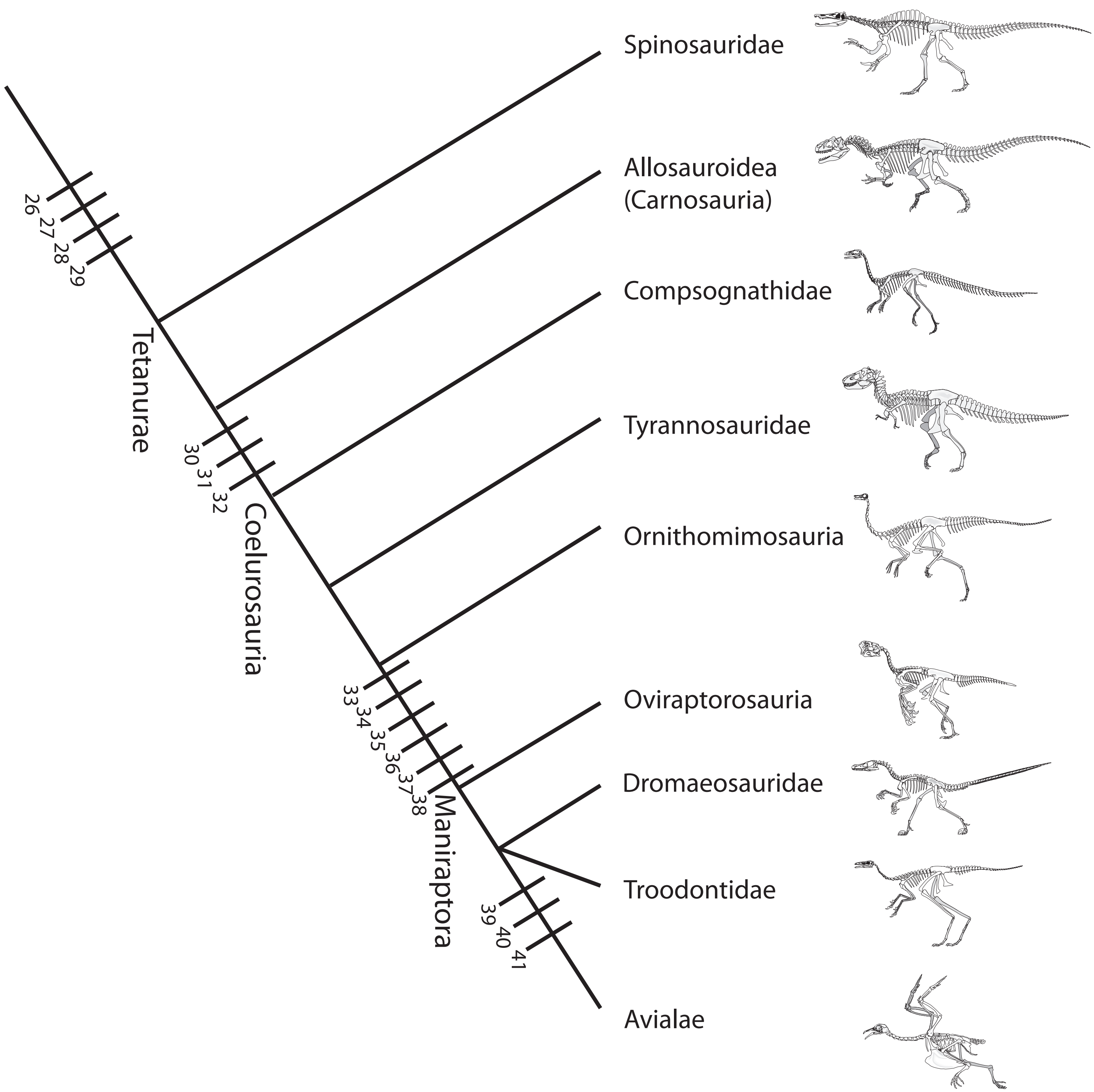
d) Maniraptora:

e) Avialae:

6. In Linnaean biological classification birds were traditionally separated into their own class, Aves, because they possessed such different features as feathers, lightly-built bones, a furcula (fused clavicles), and the ability to fly. Many of these features have been subsequently found in more basal theropod fossil taxa. What does this suggest about the origin of flight?



Ornithischia
Herrerasaurus
Plateosaurus
Diplodocus
Brachiosaurus
Ceratosauria
Spinosauridae
Avialae
Dinosauria
Saurischia
Sauropodomorpha
Sauropoda
Theropoda
Tetanurae
(See Next Page)
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29



Spinosauridae
Allosauroidea
(Carnosauria)
Compsognathidae
Tyrannosauridae
Ornithomimosauria
Oviraptorosauria
Dromaeosauridae
Troodontidae
Avialae
Tetanurae
Coelurosauria
Maniraptora
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41

Saurischian Synapomorphies

<u>Archosauria</u>
1. Diaphragm
2. Palatal teeth lost
3. Four-chambered heart
4. Enlarged brain
5. Nest building behavior
6. Parental care of young

<u>Dinosauria</u>
7. In-turned femoral head
8. Opposable thumb
9. Perforate acetabulum
10. S-shaped neck

<u>Saurischia</u>
11. Long cervical vertebrae
12. Long hand, with digit II the longest
13. Large claw on thumb (digit I)

<u>Sauropodomorpha</u>
14. Blunt, closely packed teeth
15. Tibia shorter than femur

<u>Sauropoda</u>
16. Nares shifted to dorsal surface of skull
17. Presacral vertebrae greatly lightened by pleurocoels
18. Great reduction in number of phalanges of hand; only digit I retains a claw

<u>Theropoda</u>
19. Kinetic, flexible jaw
20. Deep ball-in-socket joint between head and neck
21. Digit V lost from hand (4-fingered hand)
22. Phalanges of digit V of foot lost
23. Digit I of foot reduced and no longer in contact with ankle joint
24. Hollow, thin-walled, tubular bones
25. Fused clavicles (furcula)

<u>Tetanurae</u>
26. Tooth row positioned entirely in front of orbit
27. Maxillary fenestra present
28. Digit IV lost from hand of adults (3-fingered hand)
29. Astragalus overlaps tibia

Coelurosauria

30. Semilunate carpal present
31. Long, slender hands
32. Protofeathers present

Maniraptora

33. Distal ¾ of tail stiff
34. Forelimb at least ¾ length of presacral vertebral column
35. Ossified sternal plates
36. Front part of pubic boot absent
37. Brooding behavior
38. Long, pinnate arm feathers present

Avialae

39. Flight
40. Forelimb longer than hindlimb
41. Asymmetrically veined wing feathers