

Geo 302D: Age of Dinosaurs

LAB 7: Ornithischian Dinosaurs

By the end of this class you should have a clear idea of what is a dinosaur, and what is not. This assumes that you know the unique synapomorphies that diagnose Dinosauria and can identify them in a skeleton. **From this point on, 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.** Dinosauria is divided into two major clades, Ornithischia and Saurischia. This lab and the following lab will focus in greater detail on the diversity and form of members of these two clades, as well as some of their biology and lifestyles.

Ornithischia

Ornithischian dinosaurs represent a diverse lineage of highly successful taxa. The lineage diverged from the ancestral dinosaur and became highly modified for an herbivorous diet. The ancestral dinosaur, and most other archosaurs for that matter, was probably a carnivore. Meat is easy to digest and is high in nutritional value, yet ornithischians adopted a completely herbivorous diet. Keeping these advantages and disadvantages in mind, consider the kinds of plants early ornithischians had available to them in the early Mesozoic Era.

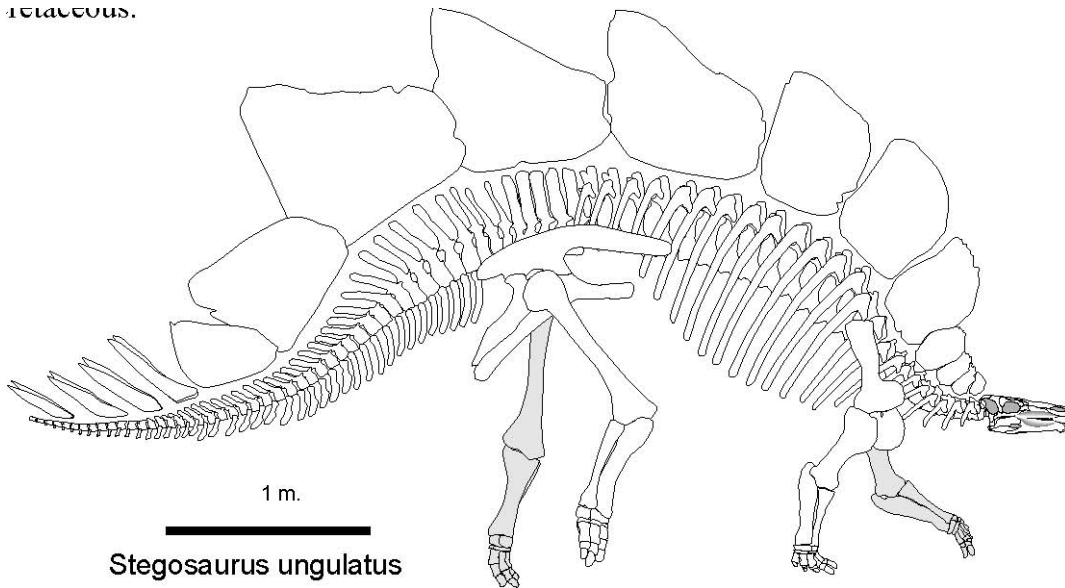
Ornithichian Diversity

The earliest ornithischian fossils known are Late Triassic in age. By the Early Jurassic the group had diversified into two main lineages: **Heterodontosauridae** and **Genasauria**. **Heterodontosauridae** is a group of primitive ornithischians with heterodont dentition. This type of dentition, where different regions of teeth in the skull are specialized for specific functions, is unique among ornithischians and has contributed to uncertainty about the group's phylogenetic position. **Genasauria** is a group containing **Thyreophora** and **Cerapoda**, and it is characterized by expanded crowns of their premaxillary teeth.

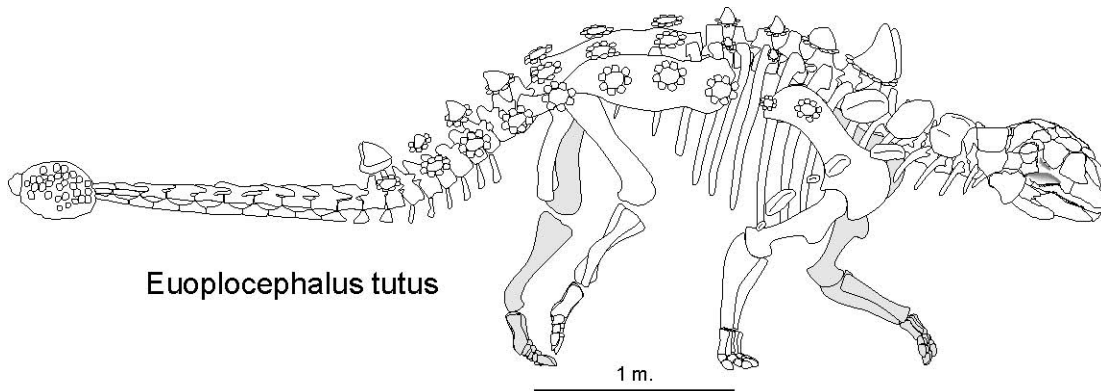
Thyreophora is characterized by extensive osteoderms set in the skin on the body. The earliest member of this group is *Scelidosaurus*, a small animal known from Early Jurassic rocks of Arizona. *Scelidoosaurus* had numerous small osteoderms adorning its sides, back, and neck. From an ancestor similar to *Scelidosaurus*, the two main thyreophoran lines developed, **Stegosauria** and **Anklyosauria**.

Stegosaurs are among the most publicly recognized dinosaurs. Instead of scattered, circular osteoderms found on primitive thyreophorans, the osteoderms are aligned in a double row along the back of the animal. Different taxa of stegosaurs have various combinations of flattened plates or large spikes along the back. Many also have some arrangement of spines near the tip of the tail. The fossil record of stegosaurs is most diverse during the Jurassic, but the group declined and finally went extinct in the Cretaceous.

Cretaceous.



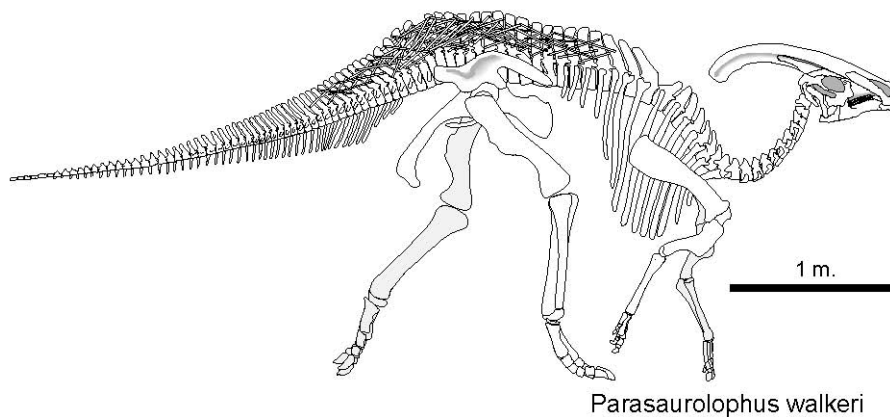
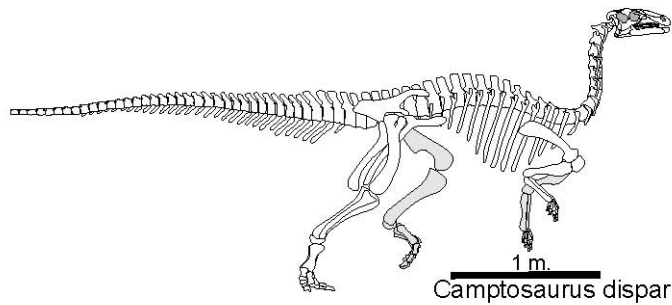
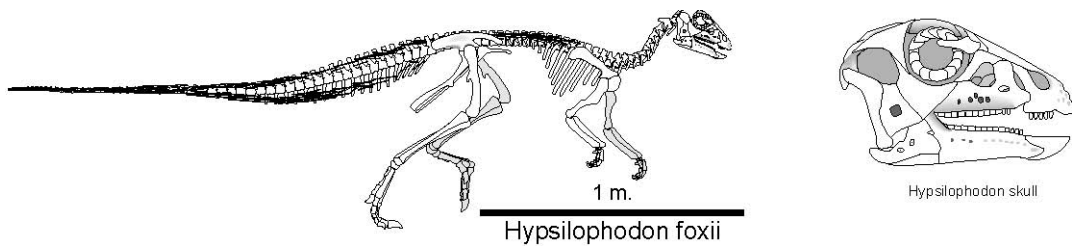
Ankylosaurs take a different approach to their osteoderms. The number and size of the osteoderms is increased until they form a mosaic of bony plates covering the dorsal surface of the body. Even the skull gets added layers of bony armor, including an osteoderm within the eyelid. In some forms, the osteoderms on the tip of the tail are enlarged and fused to form a huge club. Ankylosaurs first appear in the Early Cretaceous, and their fossils are found in rocks until the end of that Period.



Cerapoda is made up of two main lineages, **Ornithopoda** and **Marginocephalia**. **Ornithopods** have a long fossil record, extending from at least the Middle Jurassic to the end of the Cretaceous. Ornithopods look somewhat dull when compared to their thyreophoran and marginocephalian cousins. They lack osteoderms, horns, or spikes. However, ornithopods are far superior to other ornithischians in the degree of development of their chewing apparatus. Unlike the simple slicing and dicing motion used by most other ornithischians, ornithopods evolved a unique hinge in the upper jaw, a **pleurokinetic hinge**. This allowed the tooth-bearing bone in the skull (the maxilla) to flex laterally when the jaw closed. This created a degree of shear in the chewing and was far more efficient at mechanically breaking down the cellulose walls of plants. In the Late Cretaceous, the most diverse ornithopods were the hadrosaurs. Hadrosaurs represent the most derived of ornithopods in terms of their dental batteries. Additionally,

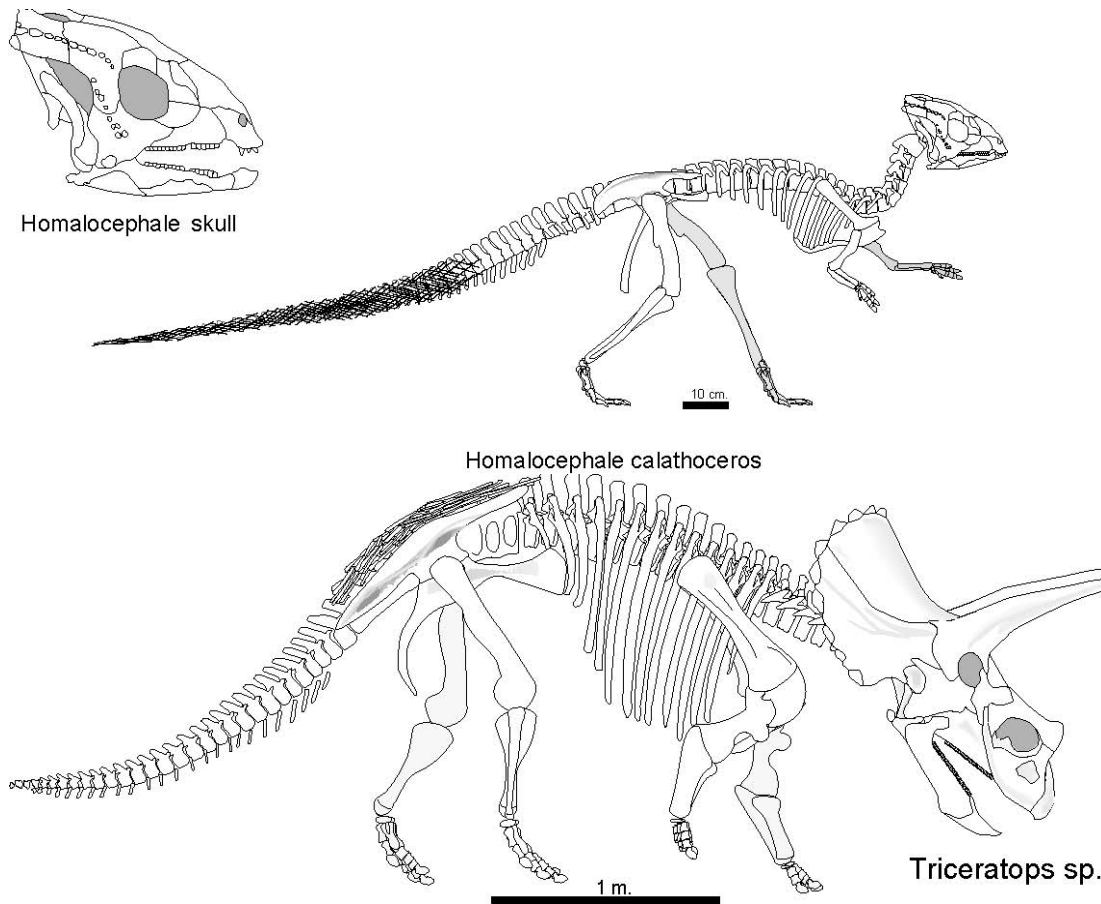
some hadrosaurs evolved elaborate crests on their skulls. Most of these crests were hollow structures connected to the nasal passageways. Over the years, numerous hypotheses have been raised to explain the function of these crests.

Marginocephalians sport some of the most garish headgear of any dinosaur. The group is composed of two smaller clades, **Pachycephalosauria** and **Ceratopsia**. You saw a cast of the skull of *Pachycephalosaurius* at the museum. The most distinctive feature of pachycephalosaurs is the massive thickening of the skull roof. In addition to the thickened skull dome, the rear margins of the skull are often marked by stout knobs, bumps, or spines. A popular hypothesis concerning these animals is that they used their thickened heads as battering rams, much as bighorn sheep butt heads today to vie for harems of females. This hypothesis is not universally accepted. Pachycephalosaurs are relatively rare fossils, and are known only from the Late Cretaceous.



Ceratopsians are well represented as fossils from the Cretaceous Period. Some of the earliest and most primitive members of this clade are known from the Late Jurassic of Asia, and they increased in diversity and size until the end of the Cretaceous. Both ceratopsians and hadrosaurs had dental batteries (a convergent character). Instead of the large horizontal grinding surfaces present in the jaws of hadrosaurs, ceratopsians tackled

their food with a one-two punch. First, the tip of the upper jaw was narrow and downturned to form a massive, parrot-like beak. They did this with the addition of a **rostral bone**. Second, the teeth were arranged to create a scissor-like slicing edge when the jaws closed. Ceratopsians were probably able to snip through and slice up even the toughest of plants. The back of a ceratopsian skull is greatly expanded to form a large frill that projects dorsally and posteriorly from the head. Often the frill is ornamented with knobs or spikes. Also, many ceratopsians have additional horns or knobs projecting from their snouts and/or over their orbits.



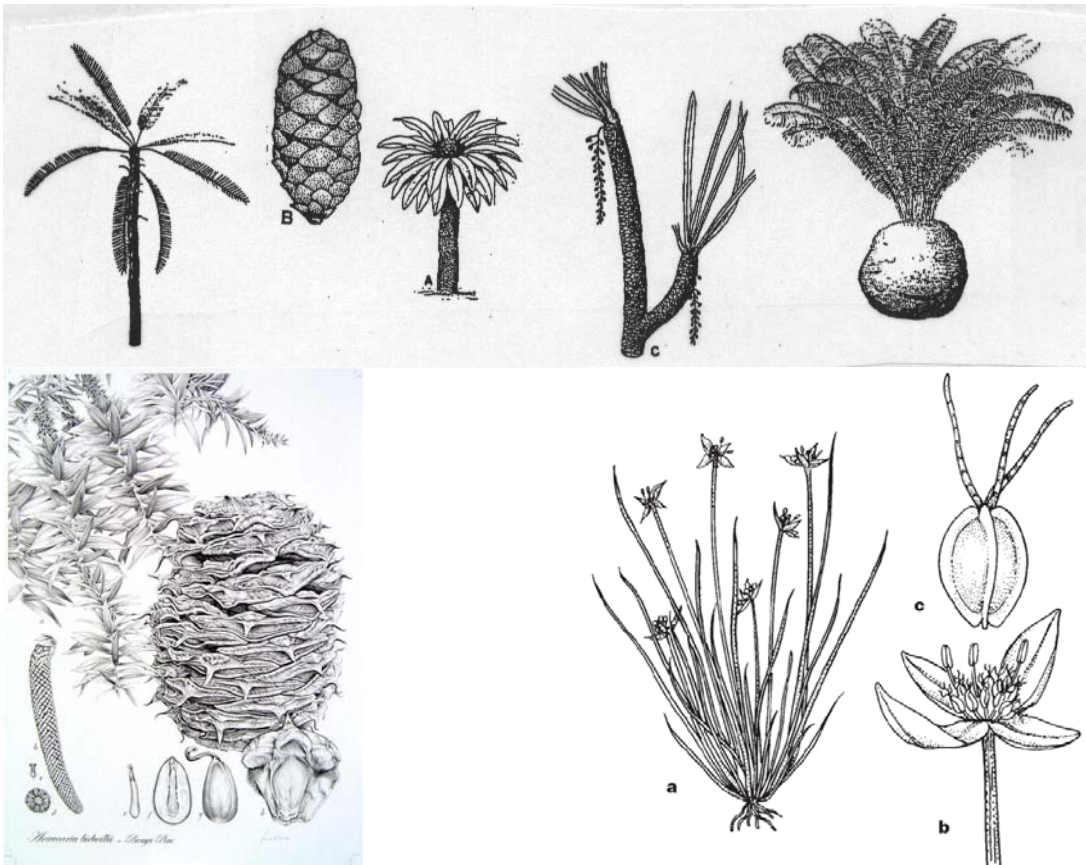
Mesozoic plants

When dinosaurs first appeared (probably Early Triassic) the terrestrial flora of this planet was quite different from what you are familiar with today. Flowering plants, the angiosperms, had not evolved and would not appear for nearly a hundred million years. Grasses (a very successful group of angiosperms) would not evolve for over 200 million years. In the time up until the appearance of angiosperms, the terrestrial megafloa (big plants) was dominated by gymnosperms (the classical group “Gymnosperma” is paraphyletic in the context used by most people and grade school textbooks). Gymnosperms are characterized by having relatively exposed, naked seeds. A couple of types constituted the majority of large plants at this time.

Conifers are familiar to most of us. They include pines, spruces, junipers, and their kin. Conifers are characterized by having very narrow, reduced leaves with a thick waxy outer layer called a cuticle. We commonly refer to these tough, narrow leaves as needles, and they probably evolved to withstand dry, windy, or cold environments. Conifers reproduce using cones that dangle from the tips of branches. Today there are approximately 300-400 species of conifer, and they are most diverse in relatively cooler or higher altitude environments.

In the Mesozoic, **cycads** were abundant, but they have declined in diversity and range since then. Now they are mainly restricted to the tropics and subtropics. Cycads also reproduce with cones, but the cones are nestled in the center of the plant with large frond-like leaves radiating outward from the central hub. Each cycad plant is either male or female, unlike conifers. A few species of cycads are hardy enough to withstand the climate of southern North America and are used as ornamental plants.

The first **angiosperms** appeared in either the latest part of the Jurassic or the Early Cretaceous. Angiosperms differ from their gymnosperm cousins in that they reproduce with flowers, and the seed is usually enclosed or covered by some sort of fleshy layer, or fruit. Angiosperms quickly spread across the globe during the Cretaceous and became the dominant type of terrestrial plant on Earth. There are thousands of species alive today, and there is a long fossil record for some groups.



Exercises

Some of the questions on these exercises require you to recall material from lecture and your CD. **From this point on, 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. Name the two sister taxa that together with their most recent common ancestor make up Ornithischia.

2. Closely examine the plant specimens in the room. Be sure to handle the specimens. Identify each as a conifer, a cycad, or an angiosperm.

A)

B)

C)

D)

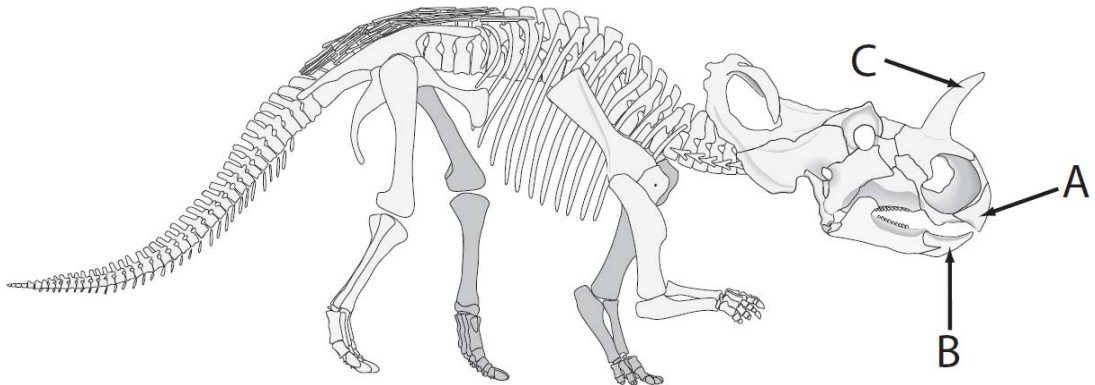
3. What synapomorphies of Ornithischia would indicate modifications for biting off and chewing plants like those in question #2?

4. Some stegosaurus sport very large, flat plates along their backs. What are some possible functions of these large plates?

5. The headcrests of some hadrosaurian ornithopods are highly complicated in form, and the air passages within them are complex. What is a possible function of the hollow head crests of hadrosaurs? How might you investigate this hypothesis?

6. A) List one synapomorphy for Ceratopsia.

B) Which letter on the diagram below corresponds to the synapomorphy?



7. A) In the Late Cretaceous of western North America, in the swamps and river deltas that bordered the Cretaceous Intercontinental Seaway, remains of several species of ceratopsians are found in the same place from rocks of the same age. With so many different kinds of ceratopsians wandering the area, can you think of a potential problem faced by individual ceratopsians during mating season?

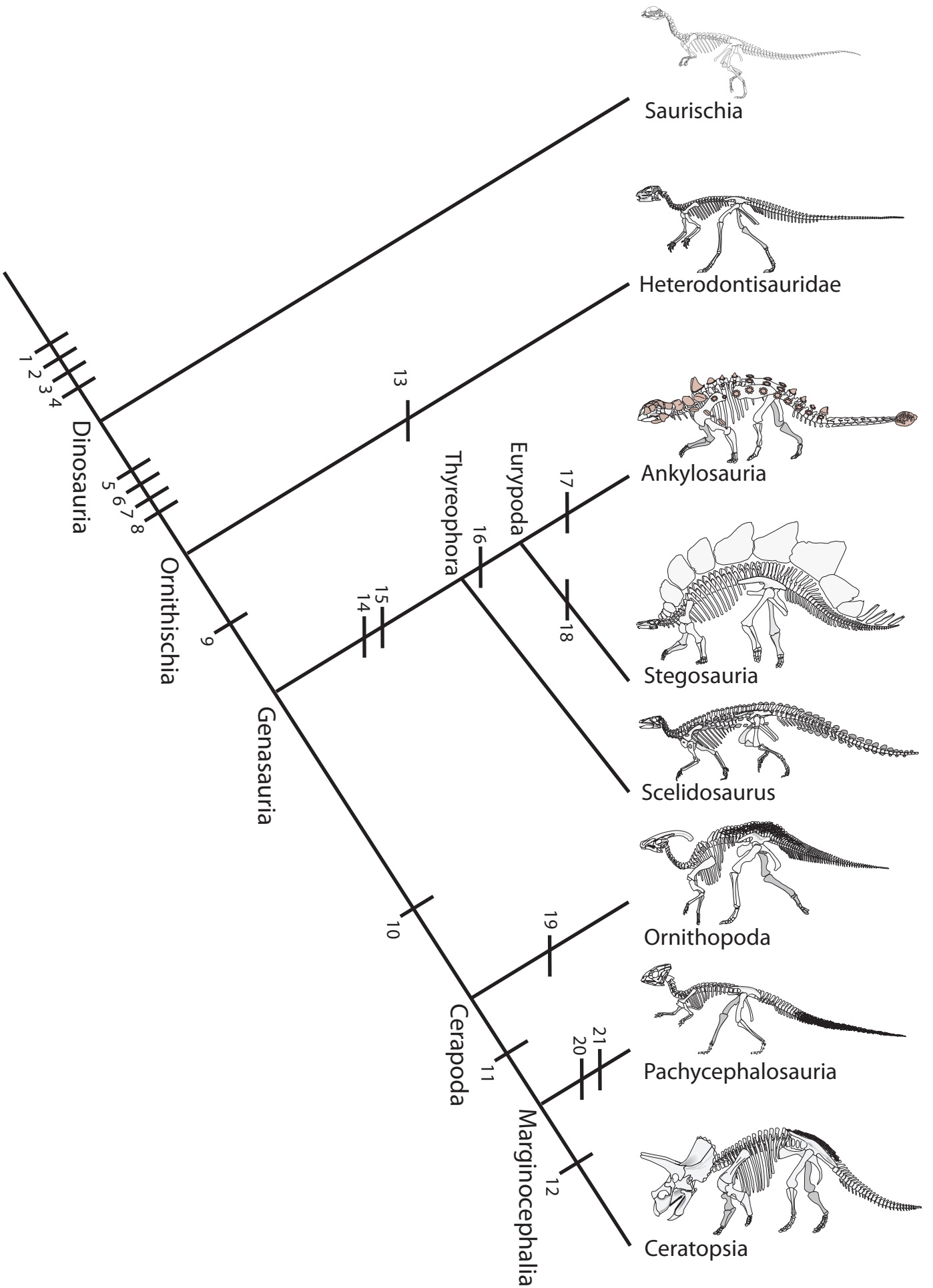
B) Given what you know about ceratopsians, list as many possible reasons why each species of ceratopsian appears to exhibit a different arrangement of frills and horns.

8. Look at all of the ornithischians we have discussed.

A) List two features that aid in passive defense.

B) List two features that aid in active defense.

C) Choose a form of active and passive defense and discuss the energetic costs of each.



Ornithischian Synapomorphies

Dinosauria

1. In-turned femoral head
2. Opposable thumb
3. Perforate acetabulum
4. S-shaped neck

Ornithischia

5. Characteristic pelvis with back-turned pubis
6. Predentary bone in lower jaw
7. Ossified tendons along part of vertebral column
8. Teeth inset from margin of jaws (indicating the presence of muscular cheeks)

Genasauria

9. Expanded crown in premaxillary teeth

Cerapoda

10. Asymmetrical distribution of tooth enamel

Marginocephalia

11. Expanded shelf at back of skull

Ceratopsia

12. Rostral bone present on upper jaw to form sharp beak

Heterodontosauridae

13. Large, spike-like caniniform tooth in dentary bone

Thyreophora

14. Armor made of bony scutes that cover back and/or flanks
15. Tibia shorter than femur

Eurypoda

16. The anterior portion of the ilium is much longer than the posterior portion

Ankylosauria

17. Scutes form interlocking mosaic that covers most of body

Stegosauria

18. Scutes enlarged to form two rows of large plates extending along vertebral column

Ornithopoda

19. Articulation of skull and jaw well below the level of the tooth row

Pachycephalosauria

20. Skull roof greatly thickened to form solid “dome” that is usually surrounded by various bumps and tubercles
21. Occipital plate rotated beneath skull