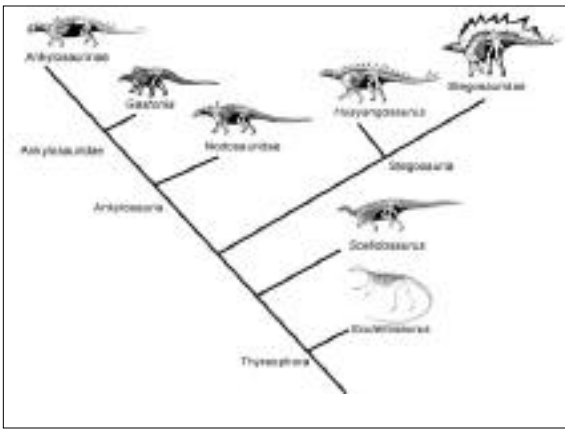


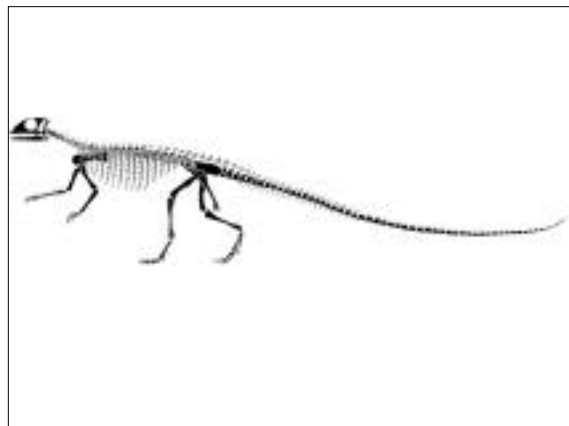
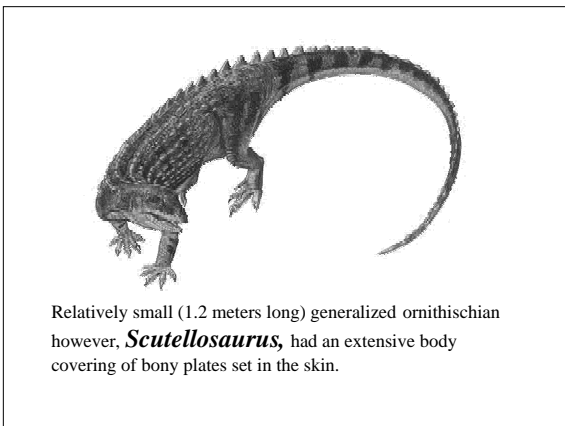
Thyreophora

- “shield bearer”
- Armored dinosaurs diagnosed by the presence of rows of dermal ossification
 - Primitive Thyreophora
 - Stegosauria
 - Ankylosauridae



Primitive Thyreophora

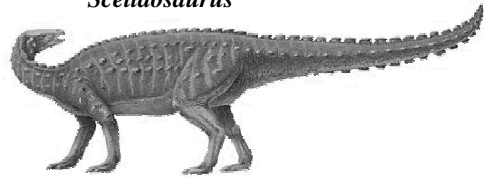
- Early thyreophorans small (1 m long) bipedal animals; later forms much larger and quadrupedal, with heavier armor
- Best known early of these is small bipedal *Scutellosaurus* (Early Jurassic, North America).



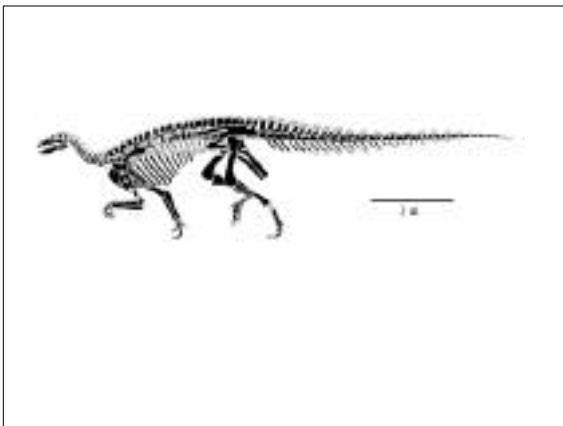
Primitive Thyreophora

- *Scelidosaurus* (Early Jurassic, Europe (maybe North America, China). Larger than *Scutellosaurus*, about 4 m long. Armor was proportionately much larger. Heavy armor required it to be an **obligate quadruped**.

Scelidosaurus



small head with leaf-shaped teeth which run to the snout, massive limbs of nearly equal length, no armor on skull but its back was covered with numerous bony plates broad sacrum



Stegosauria

- “Plated-lizards”
- medium sized (up to 9 meters long)
- quadruped
- herbivorous
- small heads
- short massive forelimbs
- long, columnar hind limbs
- short stout feet with hooves

Stegosauria

- Key evolutionary novelty
 - vertical bony plates and spines arranged in single or double rows along the neck, back and tail
- Stegosauria - May be defined as all thyreophoran ornithischians closer to *Stegosaurus* than to *Ankylosaurus*.

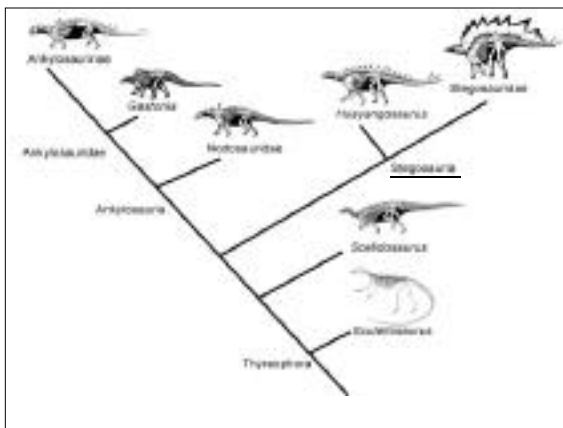
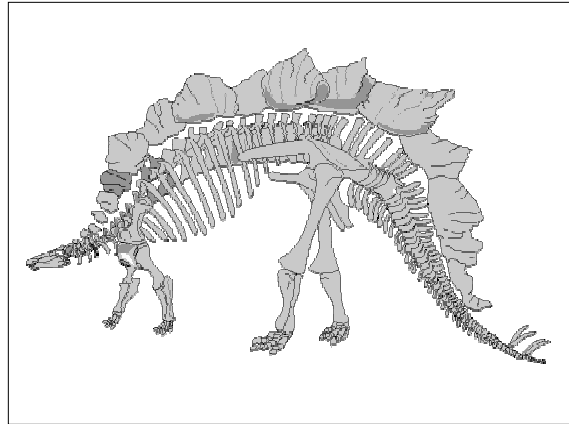
Stegosauria

- First appear in Middle Jurassic, common in Middle and Late Jurassic, rare in Early Cretaceous, die out at or before Early-Late Cretaceous boundary
- Reduce the size of most of the scutes on the body relative to *Scelidosaurus*

scute - A horny, chitinous, or bony external plate or scale

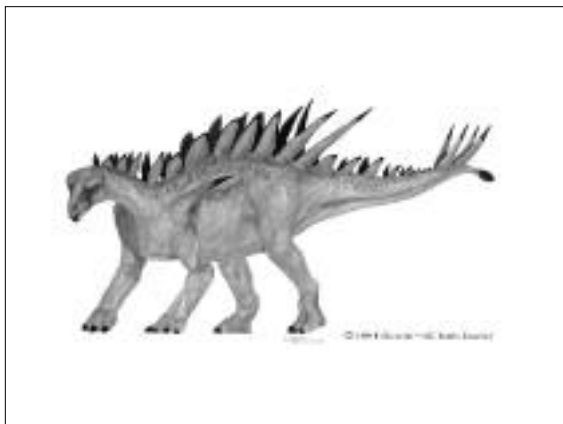
Stegosauria

- However, some scutes become much larger and highly specialized:
 - **Plates** (flat sided) and **Spines** (round cross-section) in pairs down the the back (derived stegosaurs such as Late Jurassic North American *Stegosaurus* had alternating plates rather than pairs)
 - **Shoulder spines** in the more primitive forms
 - **Thagomizers** (pairs of laterally facing spines) on the end of the tail, used as an active defense, swung from side to side



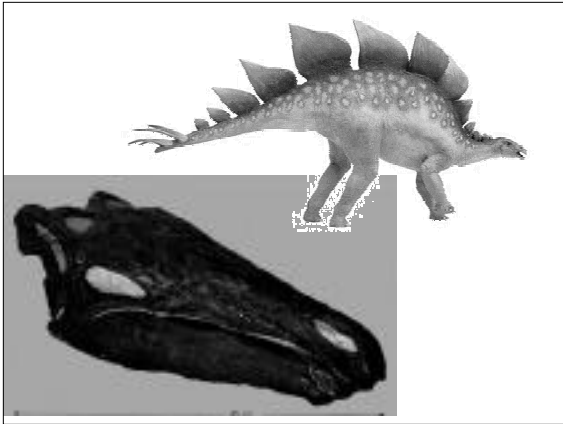
Huayangosaurus

- most primitive stegosaur
- from middle Jurassic of China
- 4.3 meter-long
- spike-shaped armor along the midline of the body and additional rows of small armor plates along each side of the row of spikes



Stegosauridae

- All stegosaur other than *Huayangosaurus*
- low skulls (distance between eyes greater than depth of skull)
- long snout
- posteriorly located eye sockets
- larger size
- massive
- relatively long hind limbs



Stegosaurus

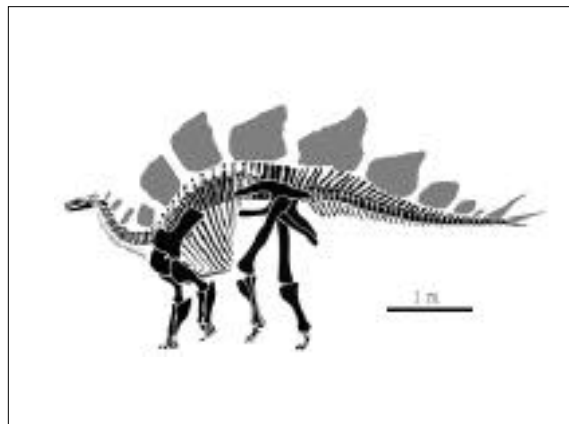
- had only a midline row of armor plates
- very small head
- tip of snout formed narrow toothless beak
- cheek teeth leaf-shaped
- no dental battery
- long neck and tail
- big shoulder blades

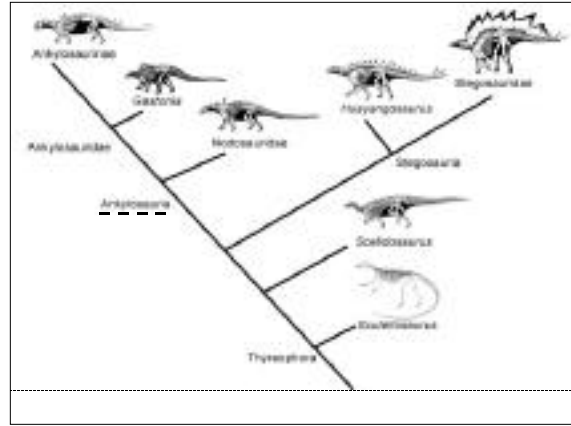
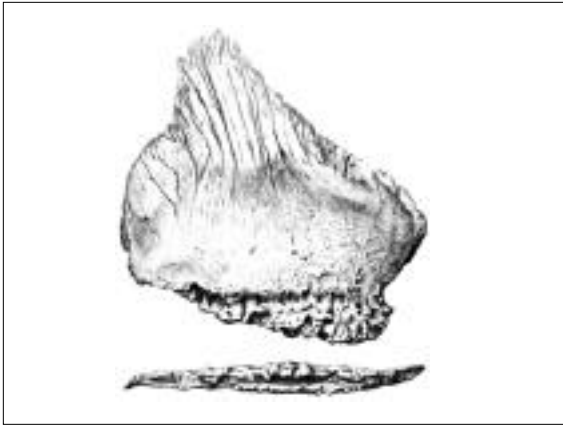
Stegosaurus

- possible semi-sprawling posture with front limbs
- forelimb had five short broad toes with hoof-like tips
- hind limb extremely long and pillar-like
- hind limb had three toes with hooves

Stegosaurus

- numerous small knob-like plates distributed over skin of most of the body
- prominent plates along backbone
- two pairs of spikes located on tail





Ankylosauria

- “fused lizards”
- rod of fused vertebrae in their backs
- medium-sized (up to 9 meters)
- quadruped
- plant-eating

Ankylosauria

- small heads
- leaf-shaped teeth
- non-interlocking teeth (not occluding)
- broadly arched ribs - very wide body
- body covered in small round or square armor plates
- some had spikes or spines
- some had a tail club
- forelimbs about 2/3 to 3/4 the length of the hind limbs

Ankylosauria

- Also first appear in Middle Jurassic, are present but rare in Late Jurassic, but become extremely common in Cretaceous

- Low skulls
- hoofed toes
- low skull
- Are more heavily armored than *Scelidosaurus* including:
 - **Scutes fused directly to skull roof**
 - **Rings of fused scutes** on neck and front of shoulders
 - **Fused scutes over hip region**
 - **Laterally-facing spines** in all but the most advanced forms
 - closure of fenestra in front of orbit and on top of skull

- Are more heavily armored than *Scelidosaurus* including:
 - **Small triangular hornlets** sticking out from the rear of the dorsal surface of the skull
 - Large shoulder spines in some forms
 - Scutes down arms, and even over eyelids and cheeks of some species!
 - Were most likely passive defenders: hunker down and absorb attacks (although probably pushed back with their spine as well)
 - Ankylosaur hips are **very wide**, and the ilia **flare out to form shelf**

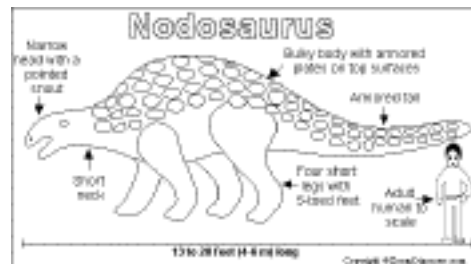
No antorbital or supratemporal fenestra



- Ankylosaurs have been divided into two clades: **Nodosauridae** and **Ankylosauridae**. However, "nodosaurids" as traditionally imagined are a paraphyletic grade.

"nodosaurid"

- *Hylaeosaurus* is an Early Cretaceous European "nodosaurid"; *Edmontonia* is a Late Cretaceous North American one
- Distinguished by narrow skulls which lacked armor and horns, presence of spines in their armor and the lack of ossified tail tendons or a tail club



Ankylosauridae

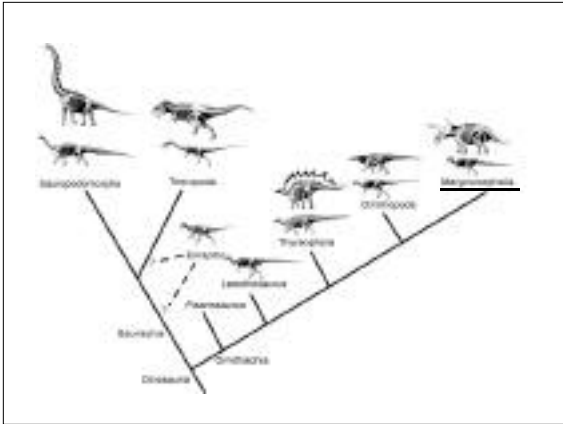
- o Characterized by **shorter, deeper, triangular skulls** with **small triangular hornlets sticking out of the ventral surface of the back** and by **complex nasal passageways**
- o *Gastonia* is an Early Cretaceous North American primitive ankylosaurid



Ankylosauridae

- o The most advanced ankylosaurids were the **Ankylosaurinae** of the mid-Cretaceous of Asia and the Late Cretaceous of Asia and western North America
- o Developed a **bony tail club** for active defense against predators (tyrannosaurids)
- o *Ankylosaurus* is an ankylosaurine, and the largest ankylosaurine, ankylosaurid, ankylosaur, and one of the largest thyreophorans (are some very large stegosaurs, too)



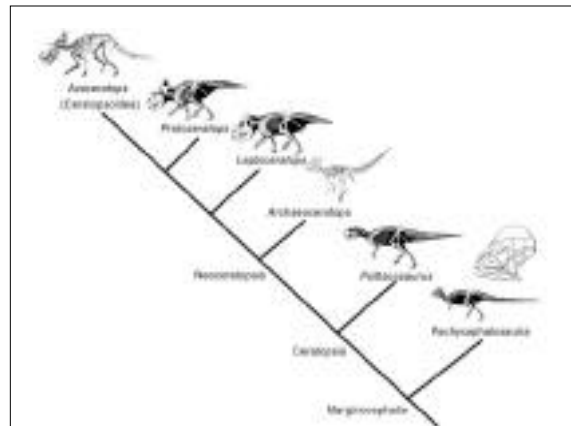


Marginocephalia

- a group characterized by the development of at least a small frill (a shelf of bone projecting from the back of the skull)
- plant eating

Marginocephalia

- Name means "ridge head"
- Characterized by **shelf of bone extending back over occipital region of skull**
- Absent from fossil record until Middle Jurassic, and all but one known are Cretaceous
- Primitive forms are bipedal; in one branch derived forms become very large and obligate quadrupeds
- **Marginocephalian skulls show a lot of suggestions of display and/or combat**



- Except for a few fragmentary specimens, all marginocephalians known fall into one or the other of two clades: the thick-skulled **Pachycephalosauria** or the deep-beaked (and often frilled (and sometimes horned)) **Ceratopsia**.

- Oldest known ceratopsian is from the Middle Jurassic of China (*Chaoyangosaurus*)
- Next oldest, and much better known, is Early Cretaceous *Psittacosaurus*, the "parrot dinosaur"
- Early marginocephalians were bipeds (possibly facultative bipeds), with bodies like heavily build hypsilophodonts

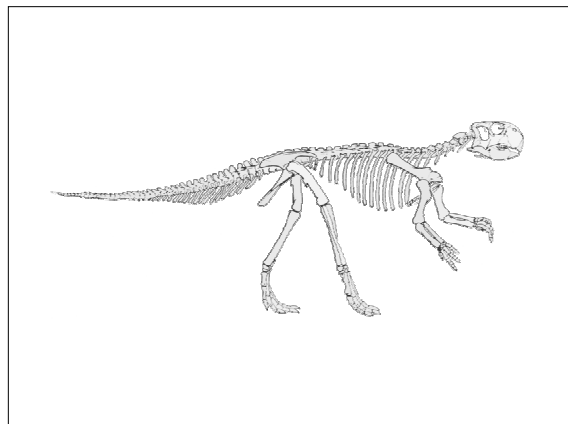
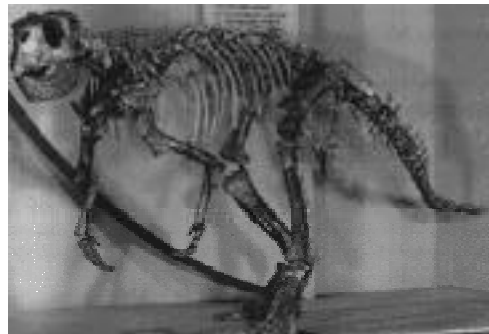
- Synapomorphies of Marginocephalia:
 - o **Rostral bone**, a bone unique to Ceratopsia
 - o A single, non-paired bone
 - o Attached in front of the premaxillae (and so it is a pre-premaxilla!)
 - o Forms the upper part of the beak, mirror image of the premaxilla
 - o Jugals form **pointed "cheek bones"**
 - o Ceratopsians have very deep and powerful jaws, with strong shearing bite

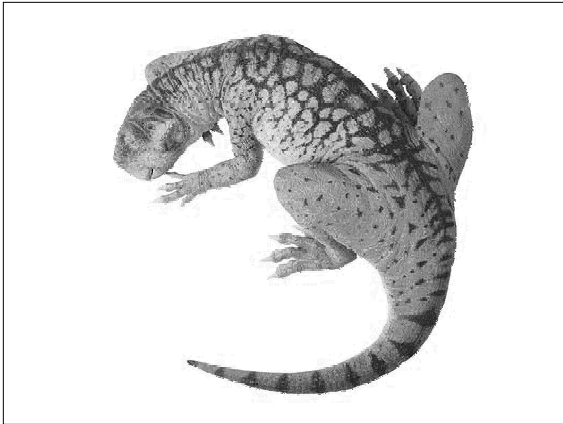
Ceratopsia

- one of the most diverse groups of the Late Cretaceous
- Two groups
 - Psittacosaurus
 - Neoceratopsia

Psittacosaurus

- “parrot dinosaur”
- primitive Ceratopsia
- rudimentary frill
- short snout
- high nostrils
- tall rostrum
- superficially resembles parrot beak





Neoceratopsia

- At the end of the Early Cretaceous, the first of the more advanced **Neoceratopsia** appears:
- Neoceratopsians characterized by a **frill**
 - Frill formed by extensions of the parietal and squamosal
 - Served in part as increased surface attachment for jaw muscles
 - Very likely was also used as a visual display

Neoceratopsia

- Neoceratopsians also have **enlarged heads** (that is, their heads are 20% or more the length of the postcranium)
- Early neoceratopsian, such as late Early Cretaceous *Archaeoceratops* were still bipedal
- More advanced neoceratopsians had **larger frills and heads**, forcing them to become **obligate quadrupeds**
 - *Protoceratops* of the Late Cretaceous of Mongolia and *Leptoceratops* of the Late Cretaceous of western North America represent this grade of neoceratopsians.

Neoceratopsia

- extremely large head
- broad and prominent frill
- pointed and sharply keeled rostrum
- obligate quadrupeds

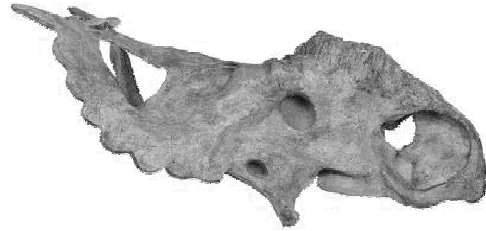
- Two clades
 - Protoceratopsids and Ceratopsids

Protoceratopsids

- small (1.2 meters)
- primitive group - intermediate between pitted ceratopsians and ceratopsids
- relatively larger skull but still small
- more pronounced frill
- fore and hind limbs equal length
- massive limbs and big feet
- no horns small nostrils

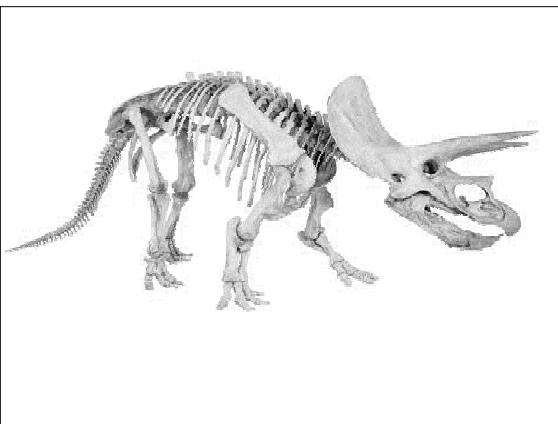
Pachyrhinosaurines

- relatively short high face
- shorter frill
- large nasal horns
- smaller postorbital horns



Ceratopsines

- long, low faces
- long frills
- large postorbital horns
- small nasal horns



Pachycephalosauridae

- Sometimes called **boneheads** or **domeheads** or **buttheads**
- Except for a possible Early Cretaceous form from Europe, are known only from the Late Cretaceous of Asia and western North America
- Obligate bipeds
- Postcranially resemble heavy hypsilophodonts

Pachycephalosauridae

- Most obvious derived feature: **thickened bone on skull roof**
- In primitive forms, the skull is still relatively flat
- In advanced forms, this thickened roof forms a **dome**
- Suggested behavior uses for these domes:
 - Used to butt theropod legs and bellies as defense
 - Used like the horns of bighorn sheep in dominance fights for females or territory

Pachycephalosauridae

- Some indication of sexual dimorphism, with bigger domed males and smaller domed females
- Pachycephalosaurs also have **rows of small dermal ossifications** around back of skull
- Some indication of strengthened cervical and dorsal vertebrae (for absorbing impacts?)
- Most were smaller than humans; only last and largest (*Pachycephalosaurius*) was bigger than a human
- Relatively unsophisticated jaws and teeth
- Relatively rare, seem to have preferred drier environments

