Systematics

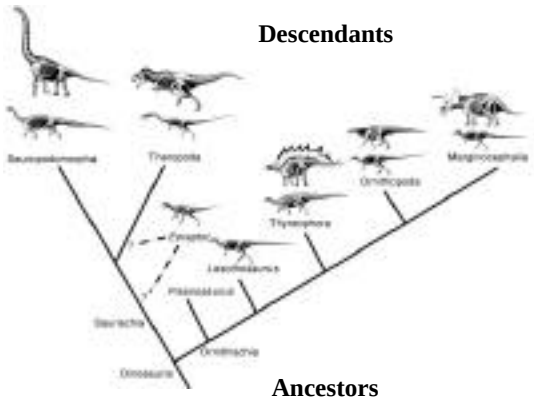
- the scientific study of the diversity of organisms within and among **clades** (genetically related groups of organisms)
  - Taxonomy = naming organisms / groups
  - Systematics = identifying evolutionary significant groups

Evolutionary Systematics

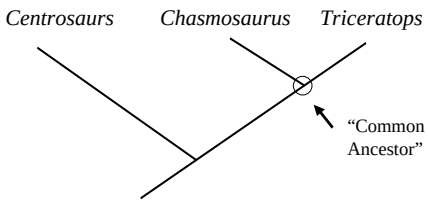
- an eclectic system of classification based on morphological similarity and the Linnaean taxonomic hierarchy (K,P,C,O,F,G,S)
- It turns out that to classify organisms there need to be an unmanageable number of sub- and super- groups (superorder, suborder …)

Phylogenetic Systematics

- Also known as Cladistics
- **Phylogeny**: a "family tree" of taxa
- Designed to show closeness of ancestry between groups

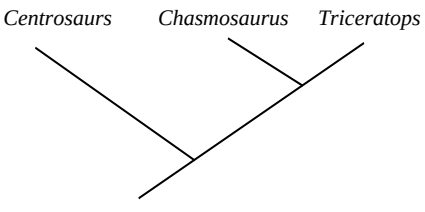


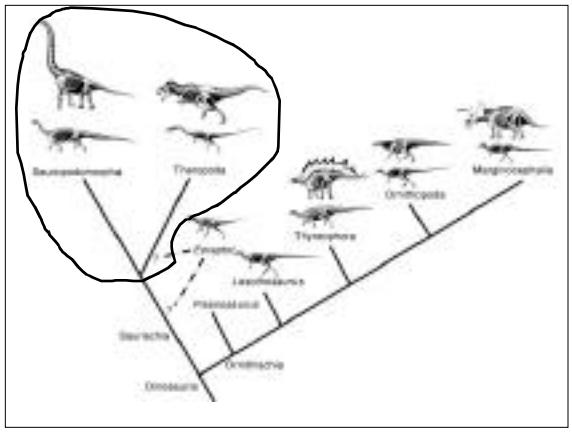
Chasmosaurus and *Triceratops* **share a more recent common ancestor with each other** than either does with *Centrosaurs*

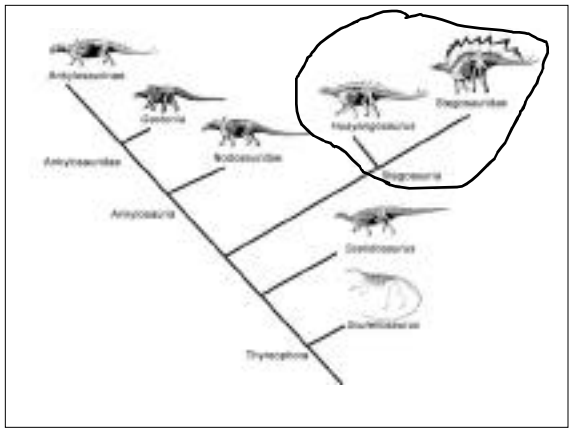


Sister Taxon - taxon which share a splitting event, like *Chasmosaurus* and *Triceratops.*

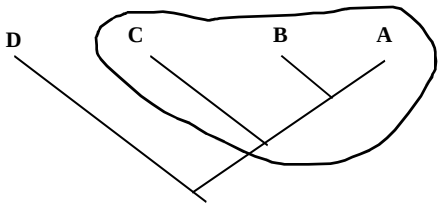
Centrosaurs is a sister group with *Chasmosaurus* plus *Triceratops.*



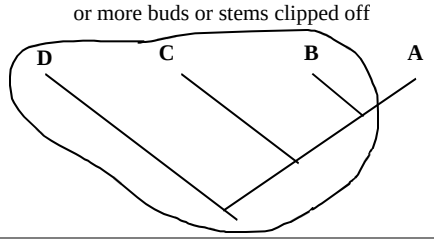




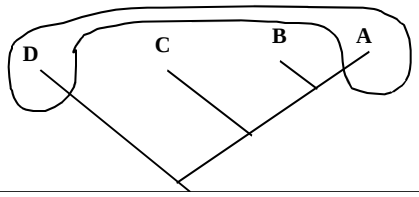
- **Monophyletic** ("single branch"): all descendants of a common ancestor
  - o Most recent common ancestor of the members of a monophyletic group is also a member of that group
  - o Represents a complete branch of the tree of life



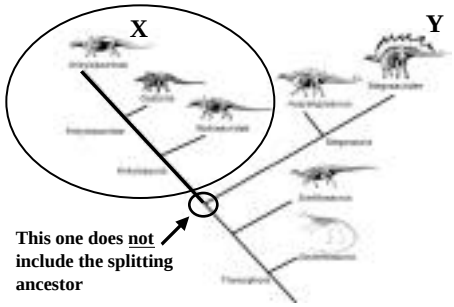
- **Paraphyletic** ("nearly a branch"): some, but not all, descendants of a common ancestor
  - o Most recent common ancestor of the members of a paraphyletic group is also a member of that group
  - o Represents a branch of the tree of life with one or more buds or stems clipped off



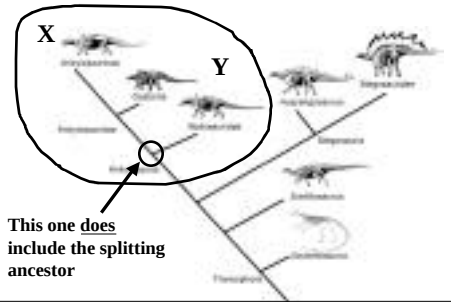
- **Polyphyletic** ("many branch"): two groups that do not share a direct common ancestor which is also part of the group
  - o Most recent common ancestor of the members of a polyphyletic group is **not** also a member of that group
  - o Represents two or more separate branches of the tree of life



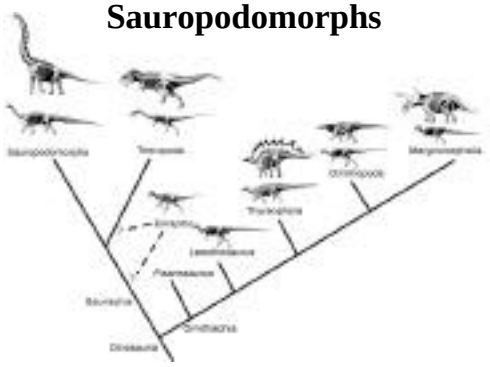
- <u>Stem-based taxon</u> - "Taxon X and all organisms sharing a more recent ancestor with Taxon X than with Taxon Y"



- Node-based taxon - "The most common recent ancestor of Taxon X and Taxon Y, and all descendants of that ancestor"



Sauropodomorphs



Saurischia

("lizard-hipped" or "reptile-hipped")

Ornithischia

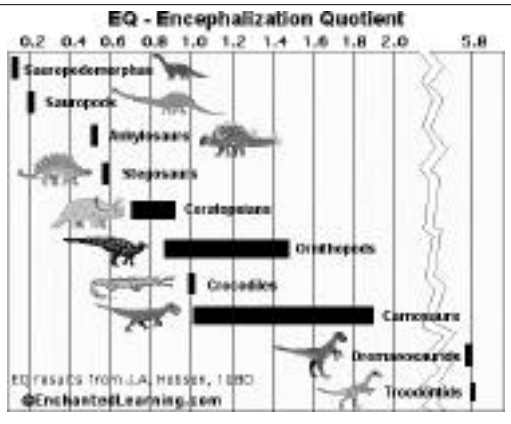
("bird-hipped")

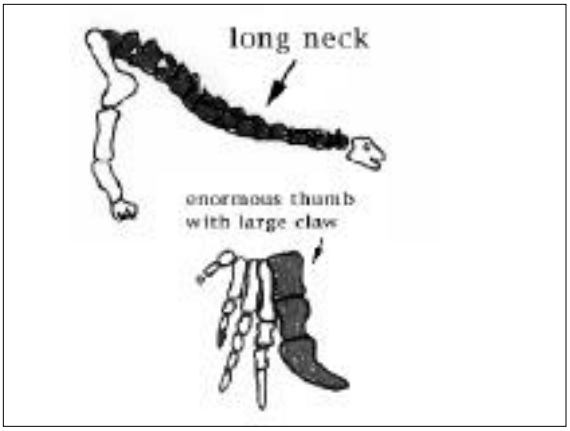
Sauropodomorphs

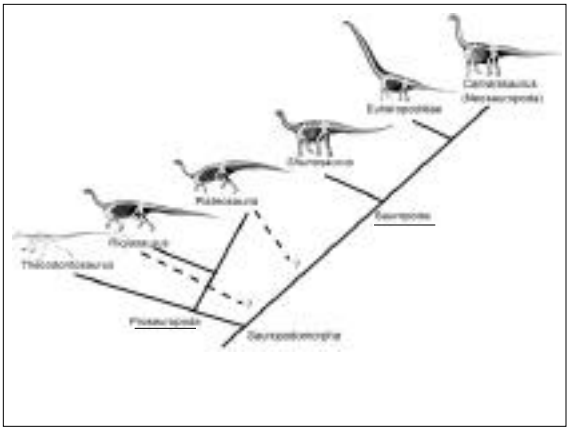
- Name means "sauropod form"; Sauropoda means "lizard feet", even though their feet do not look much like lizard feet!
- Characterized by:
  - **Enlarged nares**
  - An **elongated neck**
  - **Leaf-shaped teeth**
- Herbivores (early forms maybe omnivores)
- Primitive forms are facultative bipeds; later forms were so large they were obligate quadrupeds
- Were the **largest herbivores ever to live on land**; by the end of the Late Triassic had surpassed all previous land living animals in size, and kept on going…

Sauropodomorphs

- Evolutionary novelties
  - heads that were very small compared to body
  - spatulate teeth
  - at least 10 elongated vertebrae in the neck
  - short feet
  - very large claws on the I digit of the forefoot
- Composed of two groups: Sauropods & Prosauropods







Prosauropods

- one of the first evolutionary diversifications of plant-eating dinosaurs
- Range from Late Triassic to Early Jurassic
- They may form a paraphyletic grade leading to the **Sauropoda**; they may form their own monophyletic group **Prosauropoda**; or there may be a combination of both.
- Typically thought of as closest relatives but not direct ancestors of sauropods

Prosauropods

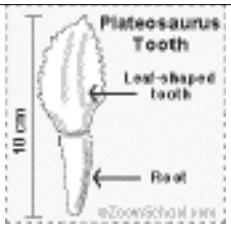
Evolutionary novelties

- Originally small size (1.5-2 m long), but eventually reaching 10 m or more
- Originally obligate bipeds, but as size increases they become **facultative bipeds**
- Retention of a big thumb claw and grasping hands
- Some prosauropods may have a beak, although this is uncertain

Prosauropods

Evolutionary novelties cont.

- Simple **leaf-shaped teeth** with no occlusion
- Only two or three sacrals: lower than almost all other dinosaur groups
- Prosauropods were the most common herbivorous dinosaurs from the Late Triassic to the Early Jurassic; no prosauropod survived into the Middle Jurassic, though

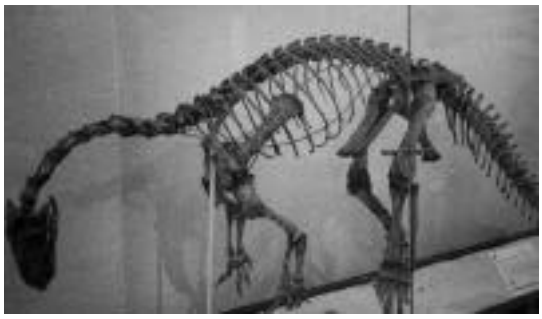


- Prosauropods were the first large-bodied dinosaurs. Their long necks would allow them to **browse higher in trees** than any contemporaneous herbivores. Also, larger size would give them **bigger guts to digest more plants** and **defense against predators**.

Plateosaurus, **based on Galton (1990).**

fairly large (about 6-8 m long)

Long neck, long tail, saurischian pelvis



Jaw joint below the tooth row

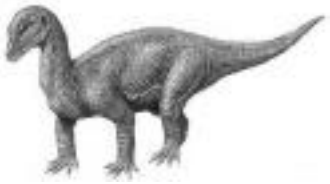
Claw from digit I

- have a body plan like a biped, but the trackways suggest that they usually walked quadrupedally
- forelimbs were at least two-thirds the length of the hind limbs
- digit I of the hand was much larger than the others and bore a large claw
- could rear up on hind limbs to reach vegetation higher in trees

- Herbivores
  - long necks to extend vertical feeding range
  - had cheeks - allows food to be retained while chewed
  - jaw hinge below tooth line
  - tooth rows almost parallel
  - spatulate teeth - resemble teeth of modern Iguana - a plant eating lizard
  - discovery of gastroliths - gastric stones for grinding

Mussaurus

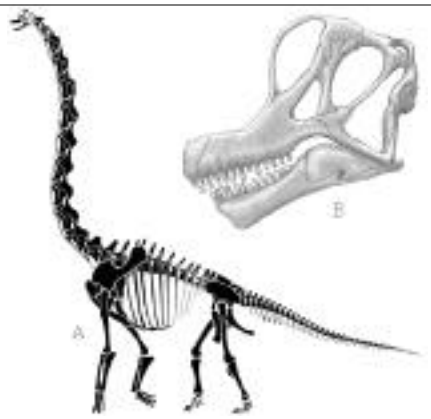
- "mouse-lizard"
- ~20 cm long probably a baby
- means Prosauropods laid eggs

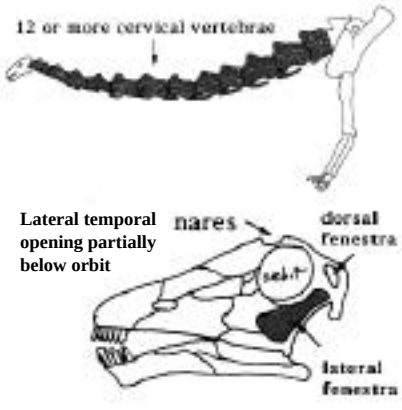


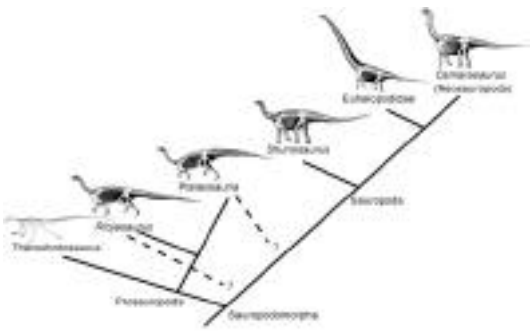
Sauropods

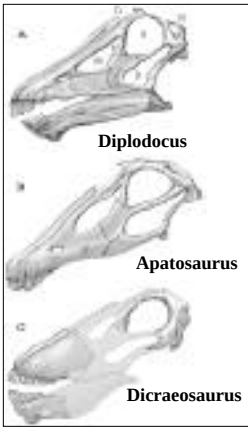
- Include the largest land animals of all time
- The oldest known sauropod is from the end of the Late Triassic, but sauropods do not become common until the Middle Jurassic.

- Evolutionary Novelties
  - **Extremely large size**: all sauropods were at least elephant-sized as adults, and many much, much larger
  - **Obligate quadrupedality**
  - **Reduced skull size**
  - **Nares placed at least as high dorsally as the orbits**
  - Tooth-to-tooth **occlusion** for precise bites
  - Extra cervical vertebrae
  - **Four or more sacrals**
  - **Reduced number of phalanges on manus**
  - Long necks and tails







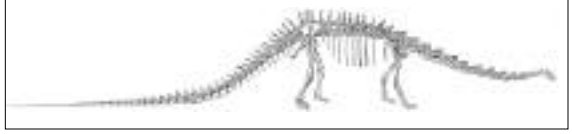


Diplodocidae

- skulls were long and slender with elongate muzzles
- the jaws bore peg-like teeth confined to the front of the mouth
- nostrils were on top of the skull in front and above the orbits

Diplodocus

- Bodies were long and relatively lightly built (including the longest, but not heaviest)
- necks were extremely long with an increased number of vertebrae
- fewer vertebrae in the back



Diplodocoids:

- **Pencil-shaped teeth** only at very end of snout
- Nares are **placed together above the orbits**
- Tails ended in **very narrow and long caudals**
- **Forelimbs much shorter than hindlimbs**

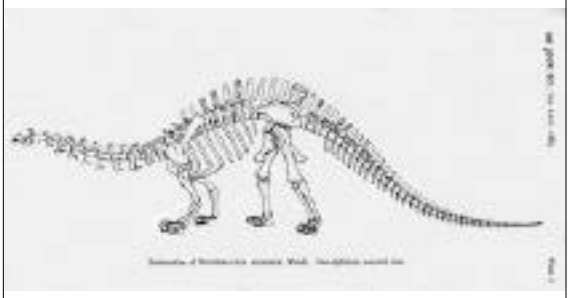
Apatosaurus

- Its more familiar name is Brontosaurus, although that name was given after the name Apatosaurus was applied.
- Apatosaurus was shorter but stockier than Diplodocus. For a long time the wrong head was associated with Apatosaurus. A Camarasaurus-like skull was made up and put on the Apatosaurus skeleton, which otherwise lacked a head. It turns out that a good candidate skull was found in the same quarry as Apatosaurus and fits the skeleton much better. It is a rather typical diplodocid skull, although distinctly different to Diplodocus itself.

Apatosaurus

Apatosaurus

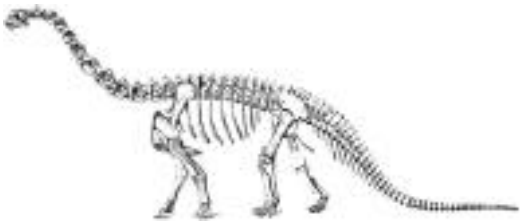
and his two skulls



Apatosaurus

Camarasauridae

- Short heavy skull with a blunt snout
- large, spoon-shaped (spatulate) teeth along the entire length of the mouth
- large nostrils located on the sides of the skull just in front of the eyes
- solidly built body, neither overly long nor overly heavy
- only 12 neck vertebrae

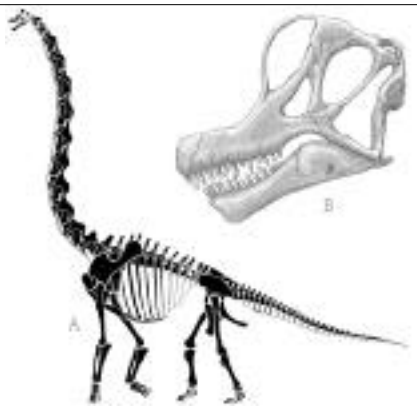


Camarasaurid limbs were stout with humerus to femur ratios of around 0.7 or more - relatively longer than in Diplodocids

The wrist and ankle each had two bones

Brachiosaurids

- one of the heaviest land animals to ever live
- Skull and teeth resembles that of a camarasaurid
- forelimb was long with humerus to femur ratios of greater than 1.0
- Shoulders were higher than hips



Brachiosaurids

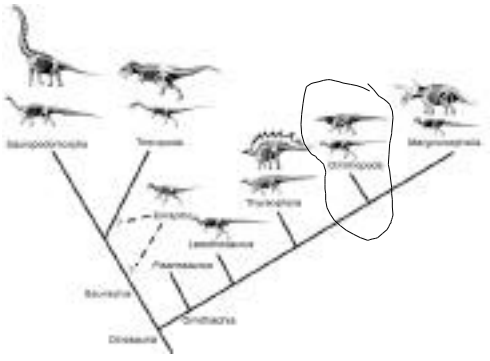
- 13 neck vertebrae - very elongated
- 11 - 12 dorsal vertebrate
- 50 vertebrate in tail - individually short so the tail is not that long

Cetiosaurids

- relatively small sauropods - 12 meters long
- skull similar to camarasaurids with longer muzzle
- numerous, slender teeth - small spoon-shaped crowns
- 12 cervical vertebrae
- 13 dorsal vertebrae
- humerus-to-femur ratio about 0.66

Titanosauridae

- large number of vertebrae in sacrum (6)
- one titanosaurid had body armor



Saurischia

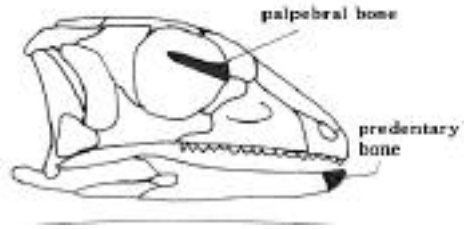
("lizard-hipped" or "reptile-hipped")

Ornithischia
("bird-hipped")

Ornithischia

Ornithischia ("bird hips"):

- Defined as Iguanodon and all taxa closer to Iguanodon than to Megalosaurus
- Also diagnosed by presence of the predentary bone (an extra bone joining the two anterior ends of the dentary, forming a beak) and five or more sacrals
- All known ornithischians were most likely herbivores, with leaf-shaped teeth
- have a pubis that points backwards.

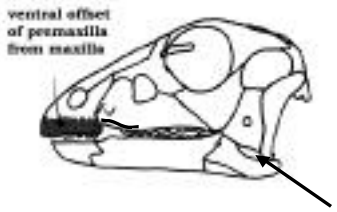


Ornithopods

- Name means "bird foot"; a bit odd, as their feet aren't really bird-like
- Early ornithopods small (1 m long) bipedal animals; later forms increase in size and retain bipedality, but develop more sophisticated chewing jaws

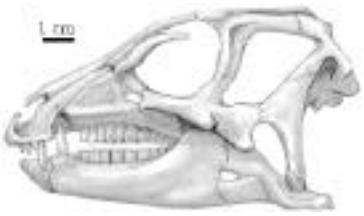
Specialized jaws:

- **Premaxilla lower margin ventral to maxilla lower margin**
- **Jaw articulation ventral to maxilla tooth row**



- bipedal or facilitated quadrupeds
- lacked body armor
- appeared in the Early Jurassic and one of the last dinosaurs to die out

Heterodontosauridae

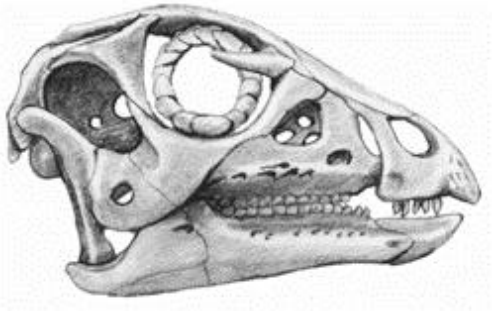


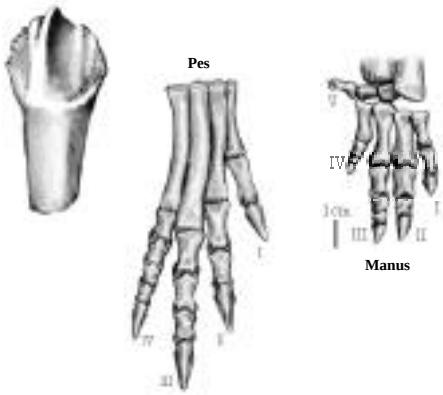
- Best known representative is Early Jurassic *Heterodontosaurus* of southern Africa
- Retained **large grasping hands** (lost in most other ornithischians)
- **Very stout jaws**; lower jaws may have scraped inward to help chew food
- **Back teeth were chisel-like** to shear through tough food
- Some taxa (maybe only males?) had large canine-like fangs
- Some paleontologists think that these may be closer to marginocephalians (we'll talk about them next week) than to true ornithopods

Hypsilophodontidae

- Mostly small 1- 4 m long), obligate bipeds
- Probably fast runners
- Jaws show beginning of a **hinge joint in maxilla** (better developed in iguanodonts)
- Earliest forms in Middle Jurassic, persist until end of Cretaceous
- Most famous representative is ***Hypsilophodon*** of the Early Cretaceous of Europe and North America
- Very likely paraphyletic: some forms were probably more closely related to Iguanodontia than to other hypsilophodonts

- hind limbs much longer than forelimbs
- tail used as counterbalance while running
- no tusks in skull
- narrow, horned beak at tip of jaws



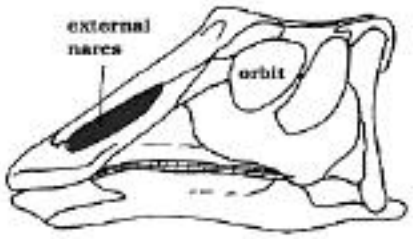


Iguanodontidae

- first dinosaur to be described scientifically
- relatively large - as much as 10 meters long
- herbivores
- Heavily built with heavy shoulders and forelimbs
- Massive hind limbs and broad feet

- Almost all are **larger** than hypsilophodonts or heterodontosaurids
- Most have stout forelimbs, and were probably **facultative bipeds**
  - o Used hindlimbs only when running and feeding on trees
  - o Used all four while walking and when browsing on low vegetation

- Characterized by **loss of premaxillary teeth**
- Earliest are in Middle Jurassic, but become more common in Late Jurassic and Early Cretaceous
- Among the most famous are ***Camptosaurus*** of the Late Jurassic of western North America (and possibly Europe) and ***Tenontosaurus*** of the Early Cretaceous of western North America



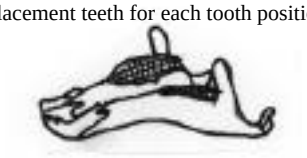
Enlargement of the external nares and no teeth on premaxilla


Iguanodon

Hadrosauridae

- Generally quite large, 7-14 m long
- Spent a lot of time on all fours
- Nares were large
- Manus was highly specialized:
  - Digit I formed a conical spike
  - Digit V was long and opposable
  - Metacarpals II-IV were long
  - Digits II-IV were hoof-like

- Jaws and teeth were also highly specialized
  - Special hinge-like joint between maxilla and rest of face allowed upper jaw to swing outward when lower jaws closed, chewing food (rare in reptiles)
  - Teeth are found only in back half of jaws
  - Complex dental battery with three or more replacement teeth for each tooth position



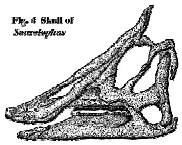
Hadrosaurids, or "duckbills":

- EXTREMELY common in Late Cretaceous of North America, somewhat less common but present in Asia, Europe, South America
- One of the most common plant eaters in Late K: known from eggs through adults
- At least some species lived in herds and had nesting colonies

- Many distinguishing features, including:
  - **End of snout flares outward** to form "duck bill"
  - Huge increase in number of teeth
  - Teeth organized into **dental battery**: a continuous grinding surface
  - Allowed the most complex and sophisticated chewing of any reptile
  - Comparable to the chewing ability in modern herd mammals
  - **Manual digit I lost**
  - **Metacarpals II-IV very long and slender**: probably spent most of the time on all fours

Hadrosaurids are divided into two main clades:

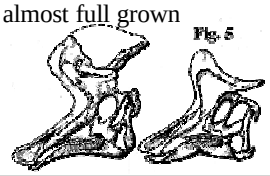
- **Hadrosaurinae**, characterized by **enlarged external nares** and **broader snouts**

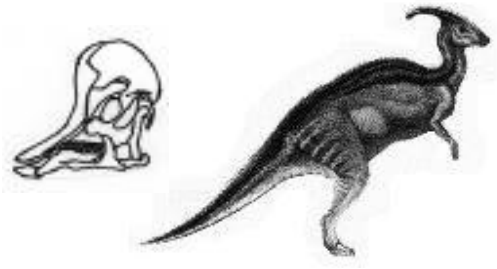


- **Lambeosaurinae**, characterized by **hollow crests on top of head**

- **Lambeosaurinae**, characterized by **hollow crests on top of head**
  - These crests house the nasal passage
  - Debate on possible uses of lambeosaurine crests:
    - Increase surface area for smelling sensors
    - Sound generation (equivalent to woodwind or brass instrument)
    - Visual display
    - Trapping moisture in exhaling breath to keep lungs from drying out
    - Or a combination

- Lambeosaurine crests vary from species to species, and from sex to sex
- Babies, males, and females of a species were often once classified as different species
- Most baby lambeosaurines look alike: their distinctive crests only show up when they were almost full grown





http://www.nmmnh-abq.mus.nm.us/nmmnh/soundsandimages.html