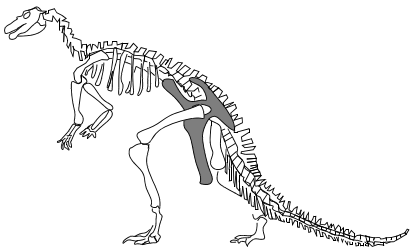
h13 Ornithischia < herbivorous, tetraradiate pelvic girdle, predentary >

Dinosaurs are a group of ruling reptiles that became extinct at the end of the Mesozoic. These include Ornithischia (***Table h13.1***), an order of extinct ruling reptiles. Ornithischians (bird-hipped) dinosaurs are distinguished by a tetraradiate (when viewed from the side) arrangement of their pelvic bones in which the pubis points backward and has a anterior process (forward-pointing outgrowth).

Table ***h13.1*** **Classification of ornithischian dinosaurs**

ORDER		SUBORDER	INFRAORDER	FAMILY
Ornithischia (Two lower jaws joined at the front by a predentary bone. Pubis points backward.)	(Rows of side-by-side teeth in the cheek region, set in from the outer margin of the jaw, occlude when the mouth is closed.)	**Cerapoda** (Uneven covering of enamel on the teeth.)	**Marginocephala** (Frilled head, Horned.)	**Pachycephalosauria** **Ceratopsia**
			Ornithopoda (Bird feet.)	**Hadrosauria** **Iguanodontia** **Hypsilophodontia**
			Thyreophora (Armored.)	**Ankylosauria** **Nodosauria** **Stegosauria**
				Lesothosauria



Primitive ornithischians were relatively small (1 to 2 meters in adult length) and bipedal. Bladelike teeth in the outer margin of the upper and lower jaws, pass between each other when the mouth is closed.

Camptosaurus, except for its large size (species 2 to 5 meters in adult length), was a living fossil for its time (Early Cretaceous, Late Jurassic).

Unique to ornithischians is a predentary bone (***Figure h13.1***) in the front of the lower jaw between the dentaries (the two, lower-front, jawbones).

The ornithischians were all herbivorous. Until the moment of their extinction, they were flourishing. Their greatest diversity was achieved during the Cretaceous when deep oceans had begun to separate the present continents and when these were divided interiorly by flooding epeiric seas. Flowering plants that had appeared were evolving rapidly. Even so, ornithischian diets continued to be (toothsome for them) tough pine and cycad foliage and cones. Ornithischian teeth stayed single-bladed and leaflike. However, to better process rough forage, their teeth changed:

In their most derived condition, in ornithischian suborder Cerapoda, each tooth had an uneven covering of enamel (thicker on the front) (***Figure h13.2***). In the cheek region, teeth were lined up in batteries of ordered rows. For those exposed, there were already formed, underlying, replacement successors. The surface where upper and lower batteries of teeth occluded (came together) and sheared past each other, was kept rough by the differential wear of harder enamel versus softer dentine. Evidently, coarse and fibrous food was ground before swallowing.

In their less derived condition, in infraorder Thyreophora, bladelike teeth side-by-side in a single line are set in from the outer edge of the jaw. This made for a cheek pouch that allowed for

munching. Upper and lower jaw-rows of teeth occluded and sheared past each other in a self-sharpening fashion when the jaw closed. Even so, the arrangement made for only limited chewing. This is where the toothless predentary bones played an essential role. It gave strong support for nipping. This valuable feature enhanced by a corneous covering to them and the premaxillae (two front bones joining the upper jaws), gave orthihischians a beak with a bone core. Ornithischians that persisted just with this condition (*Stegosurus*), or evolved to loose their teeth (*Ankylosaurus*), bolted their food as do most reptiles.

Three ornithischian infraorders (***Figure h13.3***) that flourished in the Cretaceous, characterized as horned, ornithopod, and armored, had evolutionary roots deep in the Jurassic. However, known representatives of these infraorders are relatively few before the Late Jurassic. This lesser diversity could have been because of Pangea's land unity and continentality at the time, or it could be bias in the fossil record because of the latter (erosion works against fossilization).

Fragmentary evidence of Late Triassic ornithischians is that they were all bipedal and relatively small (1 to 2 meters in adult length).

In most ornithichian lines, bipedalism was not continued. However, the persistence of the tetraradiate hipbone and the predentary makes the order Ornithischia a natural group (all the species included evolved from a common ancestor, and similarities in their primitive features are not because of convergence).

HORNED DINOSAURS

Pachycephalosaurs (dome head) and rhinocerous-like **Ceratopsians** (horn face)

The reason the female RHINOCEROSE has the same armament as the male

> As she enters her mating period, her appetite falls off, and she begins to make shrill whistling noises when in the presence of a male. The male responds with deep, heaving sighs. Then they begin to get a bit edgy, tossing their huge heads and trotting about nervously. As the tension continues to build, sooner or later something has to break. It usually happens when the male wheels and charges his lady love. She is far too powerful in her own right to be intimidated by him, though, and she meets his charge head-on. The force of the impact is incredible. Again and again the beasts rush each other, butting and hooking powerfully with their curved horns. The whistles and moans have now given way to great bellows of anger. An hour later, the fight will grow increasingly savage, and it is now, when they are approaching exhaustion, that one of the animals will likely be injured. It is also about this time that the female will decide whether the male is worthy. If she decides to mate, she becomes no gentler, but instead of counterattacking, she begins to parry his lunges, as if to behave as coquettishly as the moment and her ponderous body will allow. Finally she signals her willingness to cooperate. The fighting is finished, but the worst is not yet over.
>
> —Robert A. Wallace, *How they do it*, 1980.[1]

Pachycephalosaurs are known as "dome heads." These were particularly abundant in the Late Cretaceous. In adult length, the smallest *Stegoceras* measured 2.5 meters and the largest *Pachycephalosaurus* 5 meters. Their derivation within the Ceropeda is not certain as their bipedalism could be a persistent feature of a hypsilophodont ancestor. They retained the primitive condition of premaxillary teeth. However, their most distinctive features are a thick forehead skull and small horns. This could be the theme that Ceratopsians evolved, differently, when they became quadrupeds. Facial horns and neck frill was their emphasis. In size they ranged from the moderately large *Monoclonis* to giant *Triceratops* (adult length of 9 meters and weight of 5 tons). Ceratopsians, even the smallest at one meter in length, had a ponderous build that obliged them to be quadrupeds. Their toes ended in "hooves" rather than claws.

Ceratopsians evolved in the Late Cretaceous via hornless, but frilled, Protoceratopsians, from small psittacosaur ancestors. The Early Cretaceous bipedal *Psittacosaurus* had a ceratopsian-like beak and the beginnings of a neck frill at the back of the skull. They differed from ornithopods in having a shorter neck and a shorter tail.

ORNITHOPOD DINOSAURS

Hadrosaurs or trachodonts (duckbill dinosaurs)

Hadrosaurs, the so-called *duckbill dinosaurs*, small to large in size, were many genera during the Late Cretaceous. Some varieties were remarkable for the thin, hollow bone crests formed of the premaxillae and nasals.

The nesting sites with dinosaur eggs of the Late Cretaceous hadrosaur *Maiasaura* have been found in northern Montana in 80 million year old sediments that record a coastal plain environment. The eggs were mummified, possibly by desiccation, before burial by riverine flood deposits. In the eggs with embryos, impressions of the skin show a mosaic of scales, and from some it is known that a web of skin joined between the fingers of the forelegs and that the three toes of the hindlegs had hoofs. Hadrosaurs are judged to have been amphibious. However, their forage was ashore if the massive grinding batteries of their cheek teeth had any function. *Maiasaura* nests are earth-mounds, 2 meters in diameter, with a crestal depression, in which 10 to 20 eggs were laid in a circular pattern. Eight nests described in a single living-layer have a spacing of the adult's length (7 meters). In some, juveniles up to 1 meter long (larger than new hatchlings could have been), and trampled egg shells, suggest that the young stayed, and were raised, in the nest. Hence, to honor a "good mother," the name prefix *Maia* (as was *May* in the Gregorian calendar, after Maia the Roman earth goddess, and not to be confused with Maia the Greek mother of Hermes who, fathered by Zeus, was the first expositor of "Might makes right"). Such a setting is known today only in colonies of ground nesting birds. Nevertheless, the set circular pattern of the *Maiasaura* eggs is reptilian (in the manner of crocodiles, or pythons, and *not* birds which need to turn their incubating eggs—and so they disturb their clutches).[2]

Iguanodonts

The dentition of the iguanodonts is slightly primitive in that the teeth in their vegetable-grinding cheek batteries do not perfectly occlude. Their hindfeet are three toed. Their hands, specialized for defense, or combat, have each a stiff horny spike for a thumb. The genus name *Iguanodon* was coined in 1825 by medical doctor Gideon Mantell for their teeth that somewhat resemble those of iguanas. Mantell's initial reconstruction of bones from a Wealden quarry, positions the single thumb bone he had iguana-like on the nose of a quadruped with hind- and forelegs assumed to be of equal length. In 1834, amid blast-revealed Maidstone quarry *Iguanodon* "Mantle-piece" bones,[3] is a comparatively short humerus. This he assigned to another creature until, in 1848, Isle of Wight quarried bones allowed him to re-envisage *Iguanodon*—its hindlimbs and feet "strong and massive as in the hippopotamus" and with arms "long and slender" that "served as prehensile instruments ... adapted for seizing and pulling down plants and branches of trees." [4] *Iguanodon* were the first dinosaurs to be fully described after an excavation in 1878 had exposed in Bernissart coal mine, Belgium, whole skeletons (26 were collected), and fragments, in several heaped accumulations (evidence of herding). Popular reconstructions show *Iguanodon* as habitually bipedal (hence the appellation "thumbs up" dinosaur) and in a squat while browsing. However, their stiff tail would have precluded squatting and their blunt (hooflike rather than clawed) second and third forearm fingers (unguals) indicated that they strolled on all fours. The fore-digit V was prehensile.

Hypsilophodonts

Hypsilophodon with an adult length of about three meters had typical cerapodian grinding-batteries of cheek teeth but was primitive in the retention of simple incisor-like teeth in the premaxillae.

ARMORED DINOSAURS

Ankylosaurs, **Nodosaurs**, and **Stegosaurs**

The Cretaceous abounded with large armored dinosaurs, all herbivorous: family Ankylosauria with a club tail, and family Nodosauria, less advanced, without. Although commonly called "reptilian tanks," their armament was defensive, for their massive broad, stiff, bony-carapaced body, atop four stumplike legs, made flight from attack no option.

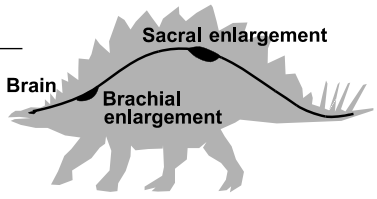
Ankylosaurs and nodosaurs were ecological replacements of stegosaurs that had lived along side them in the Early Cretaceous but went extinct.

Stegosaurs appeared early in the Jurassic and were the first of the dinosaurs, having achieved great size (to 4 m), to adopt a quadrupedal walk to bear more comfortably their weight (to 400 kg). Their bipedal ancestry could account for their hindlegs disproportionately long compared to the length of their forelegs.

Stegosaurs were notable for a series of plates that were down the entire length of their neck, back, and to where four upward pointing spikes adorned the end of their tail. The exact arrangement of the plates is not certain. The tail, when waved about, would have provided a formidable defense. Also for defense were spikes on back, shoulder and hips, and some armor on the flanks. The plates may have been for protection as well, but as each had one side well supplied by circulating blood, they could have been fixed, or flappable, heat-regulating devices. Stegosaurs were slow eating machines, for which task their "smaller than a kitten's" brain was adequate, but when attacked, quick response of legs to maneuver, and tail to flail, required attention closer to the stimulus:

THE DINOSAUR

Behold the mighty dinosaur,
Famous in prehistoric lore,
Not only for his power and strength
But for his intellectual length.
You will observe by these remains
The creature had two sets of brains—
One in his head (the usual place),
The other at his spinal base.
Thus he could reason "A priori"
As well as "A posterior."
No problem bothered him a bit;
He made both head and tail of it.
So wise was he, so wise and solemn,
Each thought filled just a spinal column.



If one brain found the pressure strong,
It passed a few ideas along.
If something slipped his forward mind,
Twas rescued by the one behind,
And if in error he was caught,
He had a saving afterthought.
As he thought twice before he spoke,
He had no judgment to revoke.
Thus he could think without congestion
Upon both sides of every question.
Oh, gaze upon this model beast,
Defunct ten million years at least.

— Bert Leston Taylor (1866-1921).[5] ❑

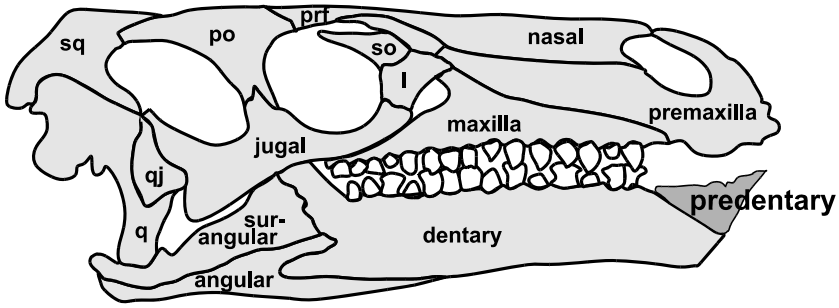


*Figure **h**13.1* [6] The predentary bone, not found in other animals, is present in all ornithischians.

Figure ***h*****13.2** [7] Distinguishing feature of the order Cerapoda

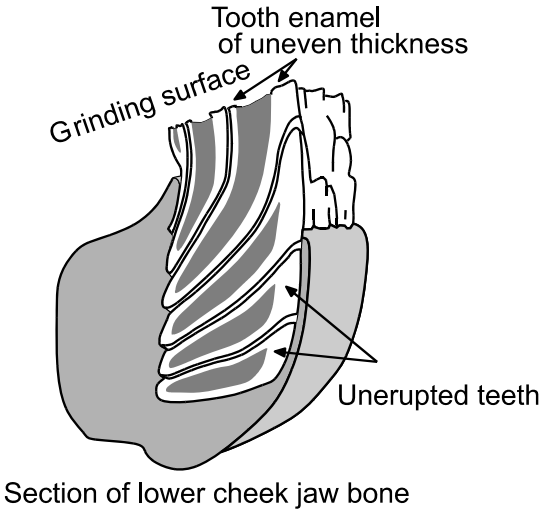


Figure ***h*****13.3** **The phylogenetic tree of the ornithischian dinosaurs**