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Dimetrodon

(di-MEH-tro-don) “Two Measures of Teeth”

Classification

Kingdom	Animalia
Phylum	Chordata
Super Class	Tetrapoda
Order	Pelycosauria
Suborder	Eupelycosauria
Family	Sphenacodontidae
Genus	*Dimetrodon*
Species	*grandis*

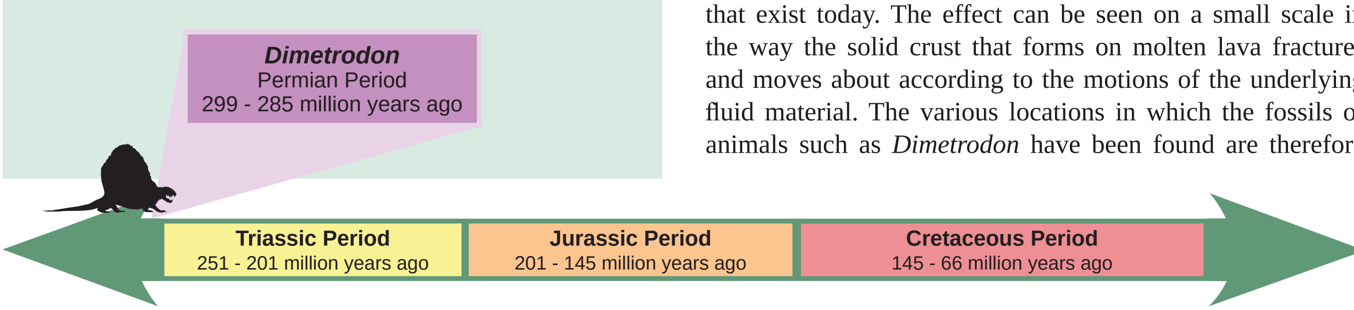
Fossil Location

Eastern Europe (Russia);
North America (Oklahoma, Texas)

Size	Weight
Length 2.5-3 m (8-10 ft) Height 1 m (3.2 ft)	150-250 kg (330-550 lbs)

Diet	Lifespan
Carnivore	Unknown

Time Period



Introduction

Dimetrodon is perhaps the most recognizable member of the **synapsid** reptiles, which is believed to be the hereditary line that eventually gave rise to the mammals. Synapsids are characterized by the presence of temporal openings in the skull below and posterior to each eye socket. These openings both decreased the effective mass of the skull and accommodated the attachment of the jaw muscles to produce stronger jaws. *Dimetrodon* itself is most recognizable by the large sail-like dorsal fin extending like a fan from the back of the neck to a point on the tail behind the lower hips.

Although *Dimetrodon* has been made popularly familiar as a dinosaur, often as the first creature described in children’s books about dinosaurs, it is not a member of the dinosaur family at all. *Dimetrodon* actually lived in the Early **Permian** period, and so, predates the dinosaurs by many millions of years. It shares the feature of a prominent dorsal “sail,” with its contemporary pelycosaur, *Edaphosaurus*. Two Cretaceous dinosaurs, *Spinosaurus* and *Ouranosaurus*, also featured a pronounced dorsal structure reminiscent of *Dimetrodon*’s sail, and for many years, paleontologists believed that they sported a sail structure similar to *Dimetrodon*. More recent research of these Cretaceous dorsal structures indicates that these dorsal structures were slightly different and probably looked more like a hump than a sail.

The widely separated geographic regions in which *Dimetrodon* fossils have been found lend support to the theory that all of the planet’s land masses were once part of the supercontinent known as **Pangaea**. Tectonic activity occurring over millions of years slowly pulled this giant land mass in different directions, fracturing and refracturing it into the various segments that have formed the continental masses that exist today. The effect can be seen on a small scale in the way the solid crust that forms on molten lava fractures and moves about according to the motions of the underlying fluid material. The various locations in which the fossils of animals such as *Dimetrodon* have been found are therefore

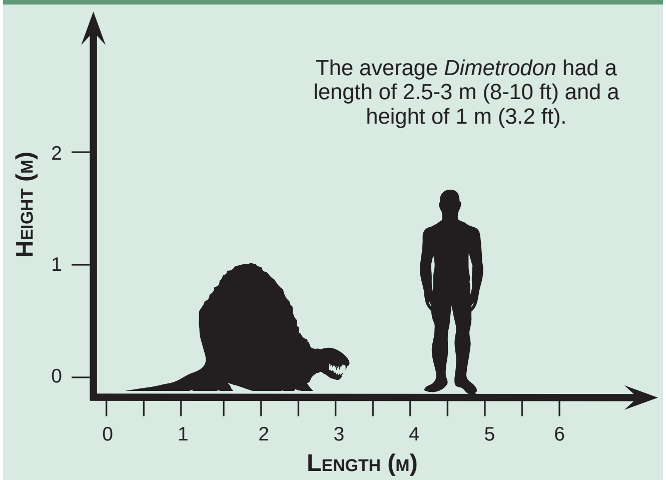
believed to have been part of the same geographical region of Pangaea when those animals were alive some 290 million years ago.

Classification

Dimetrodon is a **pelycosaur**, of the Sphenacodontidae family, which lived in the Permian period of geological time, between 251 and 299 million years ago. The popular association of *Dimetrodon* with the dinosaurs is entirely erroneous, however, because true dinosaurs are not recognized from the fossil record until about 50 million years after the period in which *Dimetrodon* and its relatives flourished. The original classification of *Dimetrodon* as a dinosaur was based on a stereotypical popular image of dinosaurs as oversized primitive reptiles like gigantic lizards and crocodilians.

Classification of plants and animals, including dinosaurs, is generally made according to the system devised by Carl Linnaeus, a Swedish naturalist who lived in the early

Measurement Chart



[Note: Human height is 1.8 m (6 ft)]

eighteenth century. In 1735, Linnaeus published a scientific book called *System of Nature*, in which he classified plants and animals by class, order, genus, and species. Each step in the classification identified a group of decreasing diversity or variation, with the species being the most specific identifier of any living organism. Linnaeus' work marked a revolution in the way in which scientists viewed the living beings of the world.

Biologists since Linnaeus' time have expanded his system of classification by the introduction of cladistics. Cladistic classification is based on the concept of evolution and ties different groups of animals together through common ancestral forms. Thus, the broad classification of the Chordata includes all animals with a spinal structure or spinal chord, and the narrower classification of the Synapsida includes all animals with spinal chords and the synapsid skull structure. This path is typically illustrated with the use of a cladogram, which is essentially just the "family tree" diagram for a creature. Such cladistic analysis is amenable to being adjusted according to new information that becomes available and is also conducive to the development of new theories and the refinement of older ones.

Dimetrodon is classed as a member of the Sphenacodontidae according to the structure of its head and dentition. The Sphenacodontidae are characterized by relatively long and narrow, but massive, jaws armed with large canine teeth and knife-like incisors at the front of the jaw, and smaller shearing teeth along the cheeks.

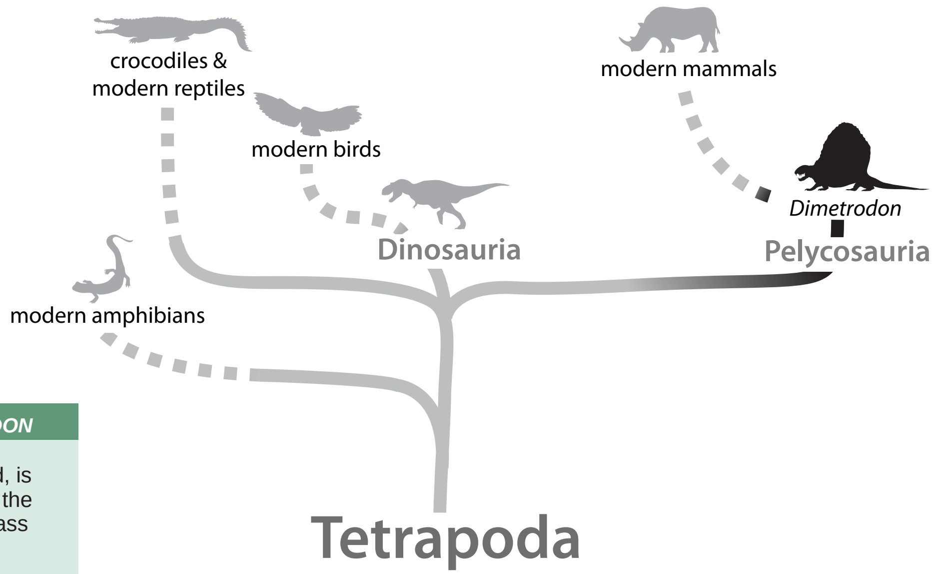
Anatomy

Dimetrodon was a carnivorous quadruped that resembled an oversized lizard. Adult *Dimetrodons* grew to a length of 3 meters (10 ft) and body height of up to 1 meter (3 ft). *Dimetrodon*'s most prominent feature was a large semi-circular, fin-shaped structure that extended from the base of the skull to the base of the tail just behind the rear hips. The fin was formed by the elongated spines of the vertebrae and was believed to have been covered by a more or less fleshy membrane of skin that was richly supplied with blood vessels. This "sail" added another 1 meter (3 ft) to the overall height of the creature. Microscopic examination of the internal structure of fossilized *Dimetrodon* bones reveals a lack of blood vessels consistent with the cold-blooded or **ectothermic** nature of reptiles.

The name *Dimetrodon* is a combination word meaning "two measures (or forms) teeth," due to the nature of its dental equipment. The blunt, square-shaped mouth of *Dimetrodon* was equipped with both large canine teeth at the front of the mouth and well-developed shearing teeth along the sides of the jaws. The large canines enabled *Dimetrodon* to fix its prey with a secure grip and to deliver a killing bite, while the shearing teeth enabled it to bite through and shear off mouth-sized chunks of flesh from its prey. The synapsid structure of *Dimetrodon*'s skull accommodated the extra-large muscles that powered the biting force of the jaws, which is perhaps the main reason it was the top predator of its time.

The actual structure and function of *Dimetrodon*'s sail is the subject of some controversy. Because *Dimetrodon* was a reptile, and not a dinosaur, it is generally accepted among paleontologists that the sail served as a **thermoregulatory structure** that enabled *Dimetrodon* to maintain a fairly constant body temperature. The structure of the spinal vertebrae does not indicate that the sail could be folded down to the body, but that it was held erect at all times. Thus, by turning so that sunlight could impinge directly on the skin of the sail, *Dimetrodon* would have been able to harvest heat from the sun to raise its body temperature when needed. Alternatively, flushing the sail with blood when overheating would have enabled *Dimetrodon* to eliminate excess heat by transferring it to any cooling wind that happened to be blowing.

It is also possible that *Dimetrodon*'s sail was used to communicate with other *Dimetrodons* as part of the mating process or as a threat display to exert dominance over rival *Dimetrodons* and other creatures. This may never be known for certain, as the dorsal sail of the *Dimetrodon* is



Classification of *Dimetrodon*

Dimetrodon, of the Permian Period, is in the Sphenacodontidae family of the Pelycosauria order of the Superclass tetrapoda.

presumably found on fossils of both males and females of the species.

Intelligence

Dimetrodon had a massively built skull that accounted for about 14 percent of its overall length. The skull exhibits a large nasal structure indicative of an acute sense of smell. The brain case itself, however, is very low and sloping, especially over the eyes. This suggests a small brain with a disproportionately large frontal lobe for the sense of smell.

Animal intelligence is estimated using a measurement called the encephalization quotient (EQ). It essentially compares the size of an animal's brain to the average brain size of animals having similar body mass. It is presumed that the level of intelligence corresponds to the EQ, at least in general terms, such that the higher the EQ, the higher the animal's level of intelligence. Conversely, the lower is the EQ, the lower is the intelligence of the animal.

No EQ value for *Dimetrodon* has been estimated. It may, however, have been on a par with that of modern crocodiles and alligators.

Reproduction and Population

It can be argued that *Dimetrodon* was very successful, surviving as a species for as much as 20 million years. As a reptile, the reproductive manner and life span of *Dimetrodon* may very well have been the same as that common to reptiles such as the crocodilians of the present day. That is, *Dimetrodon* was most likely oviparous and may have laid large clutches of eggs in self-heating nests, guarding them until the hatchlings emerged some time later. It may also have nurtured its young until they had grown and developed to the point of having to move on and find their own territorial niches. However, it is not known whether or not *Dimetrodon* was viviparous, giving birth to live young instead of laying eggs.

Diet

Dimetrodon was undoubtedly wholly carnivorous, lacking teeth that would enable it to grind up plant material for digestion, and was also one of the largest predators of its time. The thermoregulatory structure of its sail fin probably provided a practical edge over the animals upon which it preyed, allowing *Dimetrodon* to maintain a relatively constant body temperature. Other reptiles of the time would require longer periods of time to absorb the amount of solar heat necessary to allow them to be fully active. Being capable of full activity while its prey remained somewhat sluggish would have enabled *Dimetrodon* to capture a meal more readily than otherwise.

An adult *Dimetrodon* would have typically weighed between 150–250 kilograms (330–550 lb). Its prey would probably have included such contemporary creatures as *Edaphosaurus*, a sail-backed herbivore approximately the same size as *Dimetrodon*, and *Sphenacodon*, another carnivorous pelycosaur about the same size as *Dimetrodon* but without a dorsal sail fin. *Dimetrodon*'s large, inward-pointing canines and extra-large jaw muscles would have provided a very secure hold on its prey, protecting *Dimetrodon* from injury while procuring its next meal.

It is also possible that *Dimetrodon* was a carrion eater as well as an active hunter. This is suggested by the overly developed nasal and brain structures, typically observed in other carrion scavengers such as *Tyrannosaurus rex* and present-day carrion vultures. An inordinately well-developed sense of smell favors their location of a carrion meal from a distance.

Behavior

Dimetrodon displays the stereotypical lizard-like posture associated with reptiles. Its four legs are approximately equal in length front to back, extending laterally outward from the shoulder and hip joints. This is quite unlike true dinosaurs, in which the legs are positioned directly below the corresponding joints to support the weight of the animal. This also provides superior balance and a higher capacity for speedy movement that is lacking in *Dimetrodon*. It is believed that *Dimetrodon* was not a fast-moving animalbut, rather, moved in much the same manner as present-day crocodilians—spending much of its time resting on its belly with legs splayed out to the side, or walking with its body elevated on all four legs and alternating placements of the front and back feet.

As a carnivore, or possibly a scavenger-carnivore, *Dimetrodon* is thought to have lived a fairly solitary lifestyle.

Habitat and Other Life Forms

The Permian habitat was very different from the environment faced by true dinosaurs millions of years afterward. The Permian climate began continuing the glacial period that began during the preceding **Carboniferous** age. The climate became gradually warmer and drier as ferns and conifers became the dominant terrestrial plants. Some of the plant forms that appeared in the Permian age, such as the ginkgo, still exist in the present time.

The Permian age was replete with life forms other than *Dimetrodon*, although they were relatively primitive in form and structure. Other known creatures of the Permian age include *Cacops*, *Platyhystrix*, *Seymouria*, *Phlegethontia*, *Diplocaulus*, *Pantylus*, *Diadectes*, *Labidosaurus*, *Mesosaurus*, *Araeoscelis*, *Ophiacodon*, *Sphenacodon*, *Edaphosaurus*, and *Casea*.

Research

The fossil remains of *Dimetrodon* were first unearthed by Donald McLeod in 1845 near French River in Nova Scotia, Canada, although they were not identified as *Dimetrodon* until 1963. The animal was first named by Edward Drinker Cope, a nineteenth-century American paleontologist, for fossils found in Texas in the late 1800s. *Dimetrodon* fossil remains have been found in various locations in Canada and the United States. United States.

Richard M. J. Renneboog

Vocabulary

Carboniferous: The geological time period immediately preceding the Permian, corresponding to the time period from 359 million to 299 million years ago. Named for the prodigious amounts of carboniferous material such as coal and crude oil formed from plant matter of that time period.

Ectothermic: A term meaning "outside heat," indicating that the animal's internal body temperature was regulated by absorbing heat from its environment or by radiating away excess heat to raise or lower its body temperature.

Pangaea: A huge landmass that existed more than 250 million years ago, in which all continents were joined together; a supercontinent.

Pelycosaur: Egg-laying synapsid tetrapods that dominated during the Late Carboniferous and Early Permian periods. Characterized by their lizard-like appearance, they vary from other reptiles due to skull structure. They preceded dinosaurs by millions of years and are believed to be closely related to the evolutionary ancestors of mammals.

Permian: A period in the geological timescale that occurred 299–251 million years ago, named for the characteristic rock formations near the Russian city of Perm, which were laid down in that period.

Synapsid: Descriptive classification of creatures having skulls with the synapsid structure typical of mammals and their predecessors, including Dimetrodon.

Thermoregulatory Structure: Any of several possible physical and physiological features that serve to control or regulate an animal's body temperature.

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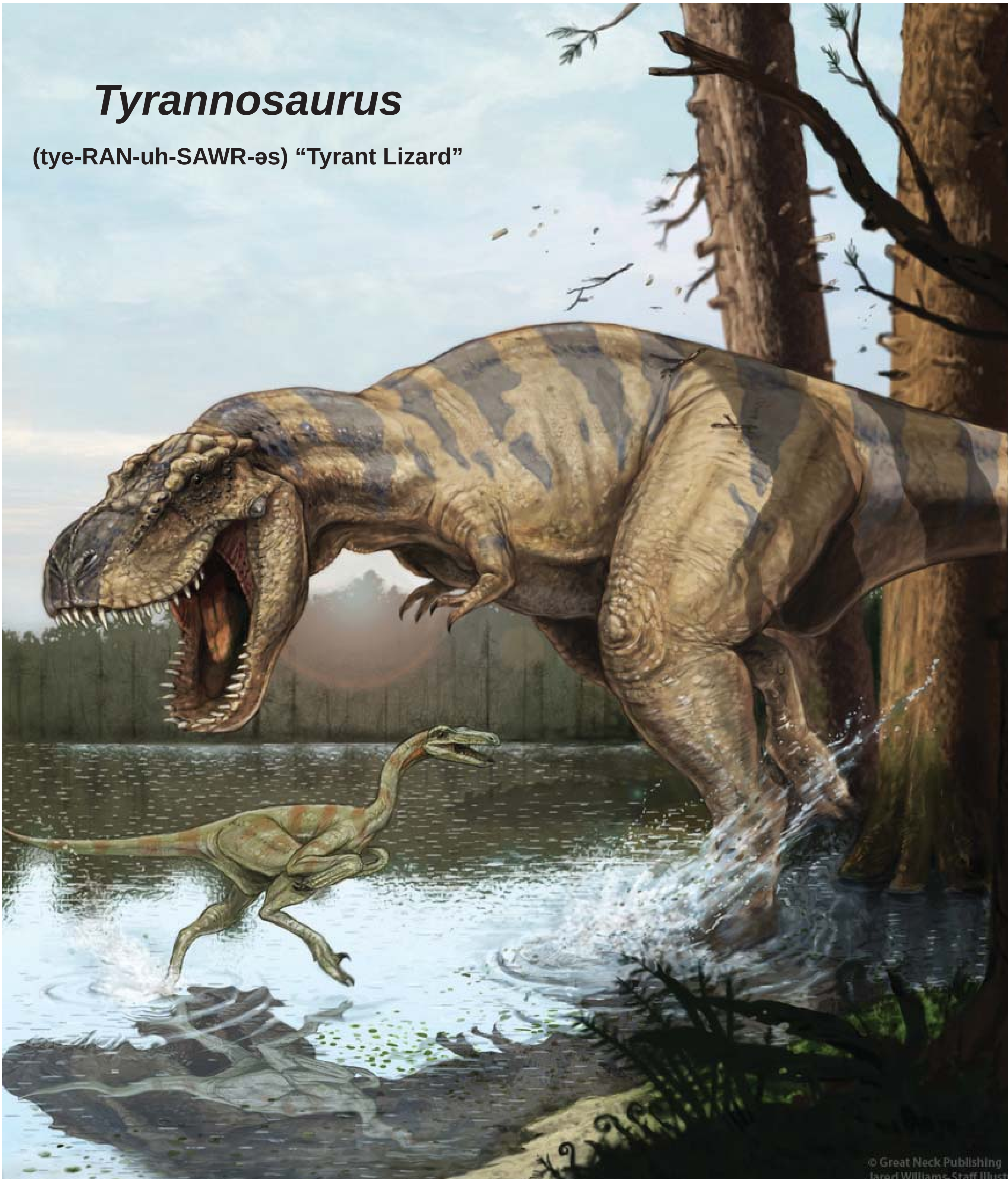
Tyrannosaurus

(tye-RAN-uh-SAWR-əs) “Tyrant Lizard”



Ornithopoda

Introduction

Ornithopoda is defined as all Cerapoda species more closely related to *Edmontosaurus* than to *Triceratops* and is comprised of the small Middle Jurassic heterodontosaurids and the Middle Jurassic to Late Cretaceous euornithopods. The unarmored herbivorous ornithopods were the most prosperous of Ornithischia (bird-hipped) dinosaurs, and were noted for their crests, duck-bills, and beaks.

Ornithopods reached their peak in terms of abundance and diversity in the Cretaceous period. Although the first small bipedal basal forms appeared in the fossil record during the Middle Jurassic, later species evolved into very large forms, which were particularly successful across the North American continent.

Fast Facts

Pronunciation: The term Ornithopoda (or-ni-THOP-o-da) was first introduced by Othniel Charles Marsh in 1881 and means “bird-foot.”

Time Period: Middle Jurassic (176 million years ago) to Late Cretaceous (66 million years ago)

Size: 80 cm to16.5 m (3–55 ft) in length

Weight: 30 kg to 23 ton (66 –50,700 lb)

Diet: Herbivorous

Location: Worldwide

Lifespan: 30 years of age or more

Homologous Traits

All dinosaurs are defined as either bird-hipped ornithischians or lizard-hipped saurischians. Ornithopods are a subgroup of Ornithischia, and therefore share all those traits that define dinosaurs, which include upright posture, modified fourth and fifth digits on the hands, three-toed feet, specialized crests on the humerus and tibia bones, and a femur with a ball-like head at one end, as well as all those traits that define the Ornithischia such as a backwards pointing pubis and ischium, an unpaired predentary bone at the lower jaw, a toothless snout, a narrow palpebral “eyelid” bone, leaf-shaped cheek teeth, at least five sacral vertebrae, and hardened tendons above the pelvis area to stiffen the backbone.

Ornithopods were unarmored bipedal or both bipedal and quadrupedal herbivorous dinosaurs. Homologous traits include a lack of armor, an elongated pubis bone, and no hole in the bone of the outer lower jaw. Many ornithopod skulls also display obvious herbivorous adaptations, such as strong and closely packed teeth with extensive wear and depressed jaw joints.

Ornithopods are classified into the heterodontodaurids, iguanodontids, and hadrosaurids, with the traditional fourth group (the hypsilophodontids) now dissolved. The abundant Iguanodontia species evolved particularly enlarged nostrils but had lost the premaxillary teeth. The hadrosaurs possessed flattened premaxillae and maxillae, which were responsible for their wide duck-like bills. Hadrosaurs also possessed many rows of very closely packed cheek teeth. Such dentition was well adapted to their advanced and effective feeding system in which they ground their food. The apparent adaptation of ornithopod jaws for grinding and ceratopsian jaws for slicing is one of the most notable differences between these two types of ornithischian dinosaurs. Researchers believe that such differences relate to reducing resource competition through different feeding mechanisms and food processing.

Evolutionary Divergences

Early basal forms of ornithopods were likely descended from a common Asian ancestor from before the Jurassic period. The evolutionary split between heterodontosaurids and euornithopods occurred relatively quickly and certainly by the Middle Jurassic, with species dispersing from Asia to Africa, to North America in the Late Jurassic, Europe at the start of the Cretaceous, and finally into South America during the Late Cretaceous. While early ornithopods appeared to have lived in relatively harsh environments, the later euornithopods have been found in a diverse range of habitats, from deltas to broad, river-rich plains.

Perhaps one of the greatest evolutionary adaptations of ornithopods was the development of ever more complex dentition. The densely packed teeth seen in the ceratopsians and hadrosaurs, together with their relatively sophisticated digestive systems, allowed many ornithopod species to benefit from varied plant life. Compared with the saurischian herbivores (the sauropods), the development of a specialized dentition made it possible for ornithischian herbivores to grind and chew their food. This is considered unique among dinosaurs, in fact among all other reptiles, and was traditionally thought to be a specific mammalian trait. Although the method used by ornithopods to chew their food differed from that of mammals, the possession of a rotating lower jaw (as seen in heterodontosaurs) and rotating maxilla (as seen in later ornithopods) made this food processing ability possible. Chewing food may seem commonplace, but it was rare among dinosaurs. The ability of ornithopods to chew their food likely explains their significant success during the Cretaceous period, allowing them to utilize the increasingly diverse vegetation as the previously abundant and highly successful sauropods began to decline.

Creatures in This Group

Ornithopods shared a common ancestor with the other ornithischian subgroups, Thyreophora and Cerapoda (Marginocephalia). The common ancestral link between the thyreophorans, marginocephalians (pachycephalosaurs and ceratopsians), and ornithopods means that species from these divisions are grouped together in the node-based Genasauria clade.

Ornithopoda is a stem-based clade consisting of the small Middle Jurassic Heterodontosauridae and the Middle Jurassic to Late Cretaceous Euornithopoda branches. Traditional classification of Euornithopoda separated it into two monophyletic subgroups, the Hypsilophodontidae and the Iguanodontia; however, recent research has clarified that Hypsilophodontidae is a polyphyletic group and consequently all these species are now placed within other clades.

Heterodontodaurids were the smallest and most basal ornithischians and were noted for a horny beak and a row of tightly-packed teeth. The paraphyletic iguanodontids include a range of species that began to acquire relatively advanced hadrosaursian-like traits. Well known species include *Iguanodon* from Europe and *Ouranosaurus* from North Africa, both of which roamed the landscape during the Early Cretaceous, as well as the Late Jurassic *Camptosaurus* from North America, Middle Jurassic *Callovosaurus* from England, various *Iguanodon* species, and the hadrosaurids. Among the best known and most diverse of ornithopod clades were the duck-billed hadrosaurs from the Late Cretaceous, such as *Hadrosaurus*, *Edmontosaurus*, *Saurolophus*, and *Parasaurolophus*. Hadrosaurs were particularly successful across the North American continent, as well as in Central Asia and China.

Ecology

The hadrosaurian snouts and nasal crests are thought to relate to improved vocal communication, in which the hollow crests were used to amplify and resonate sound over long distances. These crests may also have been related to sexual display and identification or as an indication of age. Certainly, the enlarged nares would have provided these species with a very good sense of smell, a useful tool in avoiding predations and in finding food. Generally speaking, herbivorous dinosaurs were less intelligent than predators. Ornithopods were not as intelligent as the carnivorous theropods, based on body to brain ratio measures (encephalization quotient), but were more intelligent than arkylosaur and stegosaur ornithischians as well as the saurischian sauropods.

As with extant species today, herbivorous dinosaurs evolved ways in which to defend themselves or to avoid predation. Ornithopods were not as fast as the carnivorous theropods, and they did not possess the famous body armor seen in the thyreophoran species. Many paleontologists believe that ornithopodan defense relied on safety in numbers, with many species living in large non-segregated herds, as well as having better running stability and maneuverability than the faster theropods. Ornithopod feeding behavior is relatively well understood compared to other herbivorous species due to intact fossilized stomach contents. In particular, paleontologists have found that hadrosaurs consumed a diet of plant parts that included conifer needles and twigs, which suggests hadrosaurs were active terrestrial browsers that feed on trees, as well as low-lying vegetation. Researchers believe that all ornithopods were active foragers and able to chew their food.

Paleontology News

The term Ornithopoda (bird-foot) was first introduced by Othniel Charles Marsh in 1881 to specifically classify bipedal herbivorous dinosaurs that lacked body armor. Ornithopoda was first introduced by Marsh during the infamous Bone Wars with Edward Drinker Cope. Early literature references referred to ornithopods as bipedal ornithischian dinosaurs. Later research highlighted that all dinosaurs (i.e., ornithischian and saurischian together) likely descended from a basal bipedal reptile and therefore bipedalism is now considered an ancestral trait for all dinosaurs.

Although ornithopods are considered the most important group of ornithischians during the Cretaceous, current understanding of the phylogeny, evolutionary relationships, and cladistic definitions remains unresolved due to a lack of complete descriptions of basal species anatomy. Many paleontologists state that the instability in the position and content of Ornithopoda demonstrates that further ornithischian research is required to explain its current phylogeny and phylogenetic definitions. However, recent discoveries of basal species such as *Changchunsaurus parvus* and *Jeholosaurus shangyuanensis* in China have helped clarify sister-group relationships within early ornithopod forms.

Christine Watts

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CHRONOLOGY OF ANCIENT CREATURES

All time frames measured in millions of years ago.

299-285: Dimetrodon
230-225: Eoraptor

228-222: Azendohsaurus
Pisanosaurus
Staurikosaurus

225-221: Herrerasaurus

225-215: Chindesaurus

220-210: Liliensternus
Plateosaurus
Riojasaurus
Thecodontosaurus

220-205: Coelophysis

216-203: Procompsognathus

215-210: Coloradisaurus

215-205: Euskelosaurus

201-173: Ichthyosaurus
Plesiosaurus

200-195: Lufengosaurus

200-190: Lesothosaurus

199-190: Dilophosaurus
Heterodontosaurus
Massospondylus
Scutellosaurus

183-176: Ammosaurus

170-168: Huayangosaurus
Xuanhanosaurus
Zigongosaurus

170-164: Gasosaurus

168-164: Datosaurus

167-164: Cetiosaurus

166-163: Megalosaurus

165-161: Eustreptospondylus
Piatnitzkysaurus

160-145: Archaeopteryx
Pterodactylus

155-150: Compsognathus
Euhelopus
Kentrosaurus
Lexovisaurus
Tuojiangosaurus
Yangchuanosaurus

155-145: Mamenchisaurus

150.8-145.5: Allosaurus
Apatosaurus

150-145: Barosaurus
Brachiosaurus
Camarasaurus
Ceratosaurus
Diplodocus
Dryosaurus
Stegosaurus

145-140: Camptosaurus

140-115: Kronosaurus

131-125: Amargasaurus