DINO JAWS

INFORMATION SHEETS

for Educators and Students

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Baryonyx

Baryonyx (pronounced bare-e-ON-icks) is a name from Greek origin: 'barys' meaning heavy and 'onyx' meaning claw. This is a genus of carnivorous dinosaur first discovered in clay pits just south of Dorking, England, and later reported from fossils found in northern Spain and Portugal. It is known to contain only one species, *Baryonyx walkeri*. Its fossils have been recovered from formations dating from the early part of the Cretaceous Period, around 130–125 million years ago. *Baryonyx* is one of the few known piscivorous (fish-eating) dinosaurs, with specialized adaptations like a long, low snout with narrow jaws filled with finely serrated teeth and hook-like claws to help it hunt its main prey.

Baryonyx was about 3m (9ft) tall and 10m (31 ft) long. This dinosaur weighed in the region of 1,700–2,700 kg (3,700–6,000 lb) which is about the same as an Asian elephant or adult killer whale. However, analysis of the bones suggests the most complete specimen was not yet fully grown, so *Baryonyx* may have grown even larger.

Baryonyx had a large claw on the thumb of each hand, which measured about 25 cm (10in) in a straight line from tip to base. Its long neck was not as prominently S-curved as in many other theropods. The skull was set at an acute angle, NOT the 90° angle common in similar dinosaurs. The long jaws, a feature seen in present-day crocodiles, had 96 teeth or almost twice as many as *Tyrannosaurus rex*. Sixty-four of the teeth were placed in the lower jaw and 32 larger ones in the upper jaw. The teeth had slight keels on their leading and trailing sides with extremely fine serrations (7 per 1 millimeter!) There was a knob-like protuberance on the nasal bones and research thus far has been inconclusive as to the function or purpose of this 'bump.' The upper jaw had an acute angle near the snout which is distinctly crocodilian and helps to prevent prey from escaping. A similar feature is also seen in shrikes. Shrikes are a species of modern day birds known for their carnivorous habit of catching insects and small vertebrates and impaling their bodies on thorns. This angled snout, of both animals, then helps them to tear the flesh into smaller, more conveniently-sized fragments.

The crocodile-like jaws and large number of finely serrated teeth suggested to scientists *Baryonyx* was a fish-eater. As confirmation, a number of scales and bones from fish were also discovered in the body cavity of the original specimen found in England. It is speculated *Baryonyx* would sit on a riverbank, resting on its front legs, and then sweep fish from the river with its powerful striking claw. This is similar to the modern grizzly bear as it hunts for salmon in a river. Until the discovery of the closely related *Suchomimus*, *Baryonyx* was the only known piscivorous (fish-eating) dinosaur. As we study and learn more, and as new fossilized bones are unearthed, scientists continue to discover new and fascinating aspects of prehistoric life here on Earth.

Fun Fact
The hand claw of *Baryonyx* is proportionate to a human, having a thumbnail almost seven inches long!

Baryonyx

Euoplocephalus

Euoplocephalus (pronounced yu-op-lo-SEF-uh-luhs) is Greek meaning 'well armored head.' The fossils date back to the late Cretaceous Period and are between 76.5 and 67 million years old. This was one of the largest genera of ankylosaurian (an-KY-lo-SOR-e-yan) dinosaurs, at about the size of a small elephant. *Euoplocephalus* was 6 meters (20 ft) long and 2.5 meters (8 ft.) wide. This animal weighed about 2 tons (11,000 lbs). *Euoplocephalus* existed for far longer, and was a member of more distinct faunal groups than any of its contemporaries. Its fossils have been found in Alberta, Canada and Montana in the United States. It is also the ankylosaurian with the best fossil record. Its extensive spiked armor, low-slung body and great club-like tail are well documented and researched. *Euoplocephalus* was a little smaller than *Aletopelta* (which is currently on display here in the *Fossil Mysteries Exhibition*).

The skull of *Euoplocephalus* can be distinguished from other ankylosaurians by several anatomical details, including the pattern of bony sculpturing in front of the eyes. This sculpturing is in the form of small bones over the eyes which may have served as bony eyelids. These may have provided additional protection for the eyes as they were located in the eyelid muscles and were probably mobile enough to be moved over the eyes. *Euoplocephalus* had relatively small eyes but this does not necessarily mean that it had restricted vision. It just appears this animal had a better-developed sense of smell than vision due to its large nasal cavity and broad snout. The complex respiratory passages also suggest *Euoplocephalus* had a good sense of smell. The skull resembles a truncated equilateral triangle when viewed from above, and is slightly wider than it is long.

Euoplocephalus may have had some abilities on par with those of the modern rhinoceros. Like other ankylosaurians, it is thought to have been an herbivore. It had a broad muzzle, which could indicate it was a non-selective feeder, perhaps similar to the hippopotamus. Ankylosaurians have historically been thought to feed using simple up-and-down movements of the jaws, but *Euoplocephalus* appears to have been able to make more complex movements. Tooth wear and jaw articulations suggest the lower jaws were pulled back during feeding, and also pivoted slightly inward. This action would have sheared food into thin strands or slices, possibly providing evidence of a more varied diet. *Euoplocephalus* had a toothless beak probably for cropping small, low level plants. The teeth in the back of the jaws were small and peg-like, resembling leaves, and seemed to be sturdier in the bottom jaw.

The bony armor of *Euoplocephalus* may have had a keratin like covering over it or the boney plates may have floated inside the skin, as is seen in modern crocodiles today. In addition to protection, the presence of blood vessels in the armor may have had a role in thermoregulation (keeping the body warm or cool). *Euoplocephalus* tail clubs are generally interpreted as weapons and could generate sufficient force to break bone during impacts. It remains unknown whether the tail was used for defense, aggression, or both.

Fun Fact

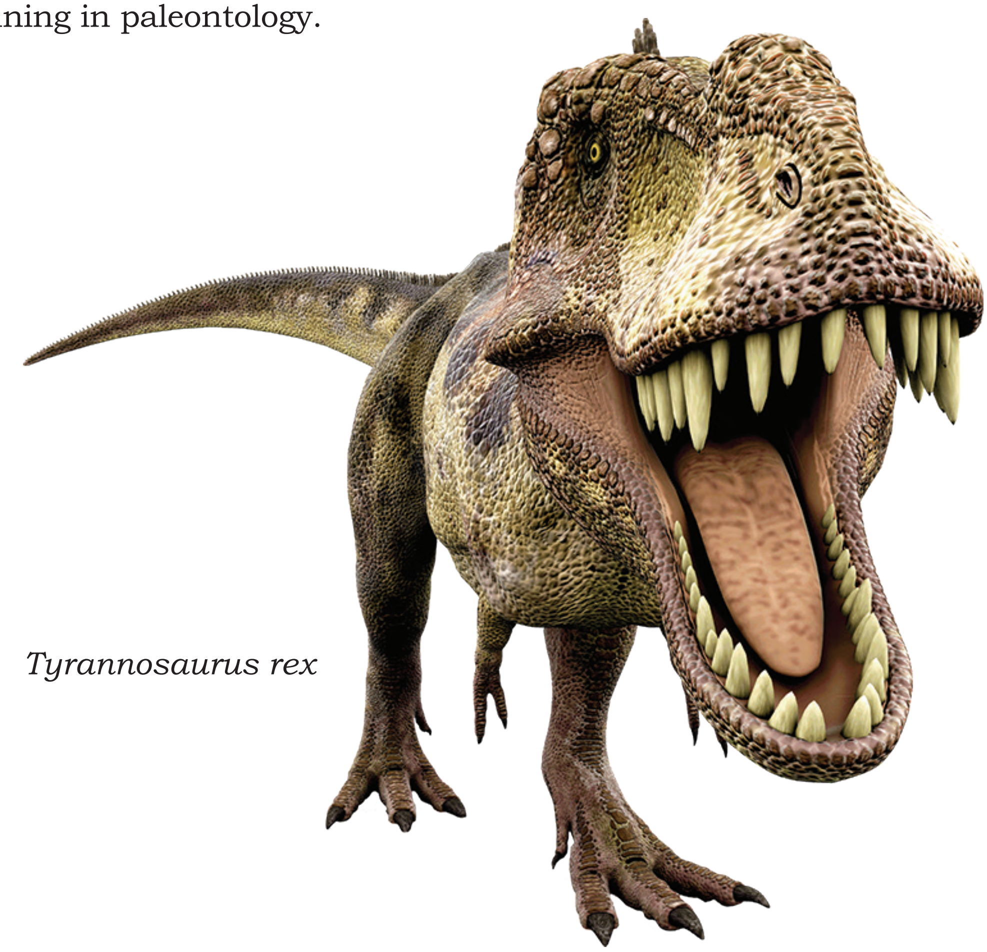
In 1902, a paleontologist discovered and named this species but the name was already *preoccupied* by an insect. It wasn't changed to *Euoplocephalus* until 1910. For eight years, the same name identified both an insect and a two ton reptile!

Euoplocephalus

Tyrannosaurus

Tyrannosaurus rex (pronounced tie-ran-oh-SORE-us rex) is a name from the Greek and Latin roots for 'tyrant lizard king' and lived throughout what is now western North America. Fossils of *Tyrannosaurus* are found in a variety of rock formations dating to the late Cretaceous Period, 67 to 65.5 million years ago. It was among the last of the non-avian type dinosaurs to exist before their extinction. More than 30 specimens of *Tyrannosaurus rex* have been identified, some of which are almost complete skeletons. Soft tissue and proteins have been reported in at least one specimen and the abundance of this material has allowed significant research into many aspects of its biology, including life history and the way it may have moved. The feeding habits, physiology and potential speed of *Tyrannosaurus rex* are still subjects of heated debate.

Tyrannosaurus was a bipedal carnivore with a massive skull balanced by a long, heavy tail. Relative to the large and powerful hind limbs, *Tyrannosaurus* forelimbs were small, though unusually powerful for their size, and had two clawed digits. Although other theropods rivaled or exceeded *Tyrannosaurus* in size, it was one of the largest known land predators with the most complete specimen measuring up to 12.3 m (40 ft) in length, up to 4 meters (13 ft) tall at the hips, and up to 6.8 metric tons (14,000 lbs). This is roughly the same weight as a full grown bull African elephant. By far the largest carnivore in its environment, *Tyrannosaurus rex* may have been an apex predator or a simple scavenger. The debate over *Tyrannosaurus'* eating habits and dietary requirements is among the longest running in paleontology.



Tyrannosaurus rex

The largest known *Tyrannosaurus rex* skull measures 1.5 m (5 ft) in length. *Tyrannosaurus'* skull was significantly different from those of other large theropods. It was extremely wide at the rear but had a narrow snout, allowing for good binocular vision. The skull bones were massive; and the nasal and some other bones were fused, preventing movement between them. Many were pneumatized (contained a "honeycomb" of tiny air spaces) which may have made the bones more flexible as well as lighter. These and other skull-strengthening features are part of the *Tyrannosaurus'* trend towards an increasingly powerful bite, which easily surpassed all other theropods. The tip of the upper jaw was U-shaped while most theropod carnivores had V-shaped upper jaws. This increased the amount of tissue and bone a *Tyrannosaurus* could rip out with one bite, making it a very efficient eater.

A recent study showed the bite force of *Tyrannosaurus* could have been the strongest bite force of *any* terrestrial animal that has *ever* lived. By comparison, humans have a bite force of about 150 PSI (pounds per square inch), gorillas have 1,300 PSI, hippopotamuses have 1,800 PSI and salt-water crocodiles have a 5,000 PSI bite. *Tyrannosaurus rex* had an estimated 21,000 PSI bite force!

The teeth of *Tyrannosaurus rex* displayed marked differences in shape. The teeth at the front of the upper jaw were closely packed, D-shaped in cross-section, had reinforcing ridges on the rear surface, with tips that were chisel-like blades and curved backwards. This type of formation reduced the risk of teeth snapping when *Tyrannosaurus* bit and pulled flesh from its prey. The remaining teeth in the upper jaw were robust, slightly curved, more widely spaced and reinforced with ridges. The majority of the teeth in the lower jaw were smaller than the upper teeth. The largest tooth found so far is 30 centimeters (12 in) long including the root, making it the largest tooth of any carnivorous dinosaur yet found.

The debate about whether *Tyrannosaurus* was a predator or a pure scavenger is complicated and evidence exists to support both ideas. A scientist in 1917 described a good skeleton of *Tyrannosaurus*' close relative *Gorgosaurus* and concluded that it (and therefore also *Tyrannosaurus)* was a pure scavenger, because the teeth showed hardly any wear. This argument is no longer taken seriously, because we know now theropods replaced their teeth quite rapidly.

Three feeding theories have been proposed for *Tyrannosaurus rex.*

1. It was exclusively a scavenger and did not engage in active hunting at all.
2. It may have been a predator exclusively.
3. It may have been an opportunistic feeder and engaged in both practices.

In fact, the debate is so divisive, many paleontologists may teach and believe one hypothesis, but never publish anything official about it for fear of being professionally shunned or ultimately 'wrong' in their conclusions. Nevertheless, there are arguments to support both ideas.

- *Tyrannosaur* arms are short when compared to other known predators. Perhaps the arms were too short to make the necessary gripping force to hold on to prey. However, opponents to this idea point out the head and jaws have more than adequate strength for gripping their prey (subsequently crushing, suffocating and breaking neck vertebrae). This is also a behavior found in many predators today.

- *Tyrannosaurs* had large olfactory bulbs and olfactory nerves (relative to their brain size). These suggest a highly developed sense of smell which could sniff out carcasses over great distances, just as modern vultures do. Opponents have used the example of vultures in the opposite way, arguing the scavenger hypothesis is implausible because the only modern pure scavengers are large gliding birds, which use their keen senses and energy-efficient gliding to cover vast areas more efficiently.

- In a similar line of thought, researchers concluded an ecosystem as productive as the current Serengeti would provide sufficient carrion for a large theropod scavenger, although the theropod might have had to be cold-blooded in order to get more calories from carrion than it spent on foraging. In response, some scientists say modern ecosystems like the Serengeti have no large terrestrial scavengers *because* gliding birds now do the job much more efficiently as opposed to back in the Cretaceous Period. Back in the Cretaceous Period large theropods did not face scavenger competition from gliding birds, because they did not even exist.

- *Tyrannosaur* teeth could crush bone, and therefore could extract as much food as possible from carcass remnants, including bone marrow, often regarded as the least nutritious parts. Paleontologists have found bone fragments in fossilized feces that they do attribute to *Tyrannosaurs*, but point out a *Tyrannosaur*'s teeth were not well adapted to systematically chewing bone (like hyenas do) to extract marrow.

- Biometric evidence suggests Tyrannosaurus was unable to run. Thus, the inability to chase prey could indicate it was a scavenger. Conversely, recent analyses suggest *Tyrannosaurus*, while slower than large modern terrestrial predators, may well have been just fast enough (or had a sizeable advantage and/or gait) to prey on large, slow, plant eating dinosaurs. Social behavior studies and analyses of juvenile specimens have further suggested the hunting was done in family groups, where the young juveniles, being faster, would do the hunting, and the adults feed on the kills after the fact.

- The eye-sockets of *Tyrannosaurs* are positioned so that the eyes would point forward, giving them binocular vision slightly better than that of modern hawks, thus providing evidence for the hunter hypothesis. The *Tyrannosaur* lineage had a history of steadily improving binocular vision. It is not obvious why natural selection would have favored this long-term trend if *Tyrannosaurs* had been pure scavengers. They would not have needed the advanced depth perception stereoscopic vision provides if *Tyrannosaur* was just a scavenger. In modern animals, binocular vision is usually found only in predators.

A skeleton of the hadrosaur *Edmontosaurus* has been described from Montana with healed *Tyrannosaur*-inflicted damage on its tail vertebrae. The fact that the damage seems to have healed suggests the *Edmontosaurus* survived a *Tyrannosaur* attack on a living target; this is evidence perhaps the *Tyrannosaur* had attempted active predation.

When examining “Sue” (the world famous *Tyrannosaur rex* skeleton now on display at the Field Museum, Chicago), paleontologists found a broken and healed fibula and tail vertebrae, scarred facial bones and a tooth from another *Tyrannosaurus* embedded in a neck vertebra. These might be strong evidence for aggressive behavior between *Tyrannosaurs* but whether it would have been competition for food and mates or active cannibalism is unclear. Some researchers argue if *Tyrannosaurus* were a scavenger, another dinosaur had to be the top predator in it’s time period. Therefore, scavenger hypothesis adherents have suggested the size and power of *Tyrannosaurus* allowed them to steal kills from smaller predators, although they may have had a hard time finding enough meat to scavenge being outnumbered by these smaller theropods. Most paleontologists accept *Tyrannosaurus* was both an active predator and a scavenger like the large carnivores of today.

Some possible evidence of cannibalism for *Tyrannosaurus* exists after scientists studied some specimens with tooth marks in the bones attributable to the same genus! The tooth marks were identified in the arm and foot bones and this was seen as evidence for opportunistic scavenging, rather than wounds caused from combat. In a fight, it would be difficult to reach down to bite the feet of a rival, making it more likely the bite marks were made in a carcass. Since the bite marks were made in body parts with relatively small amounts of flesh, it is suggested the *Tyrannosaurus* was feeding on a dead carcass in which the more fleshy parts were already consumed.

Fun Fact

This species is so popular in our culture it is the only dinosaur that is commonly known to the general public by its full scientific or binomial name: *Tyrannosaurus rex*!

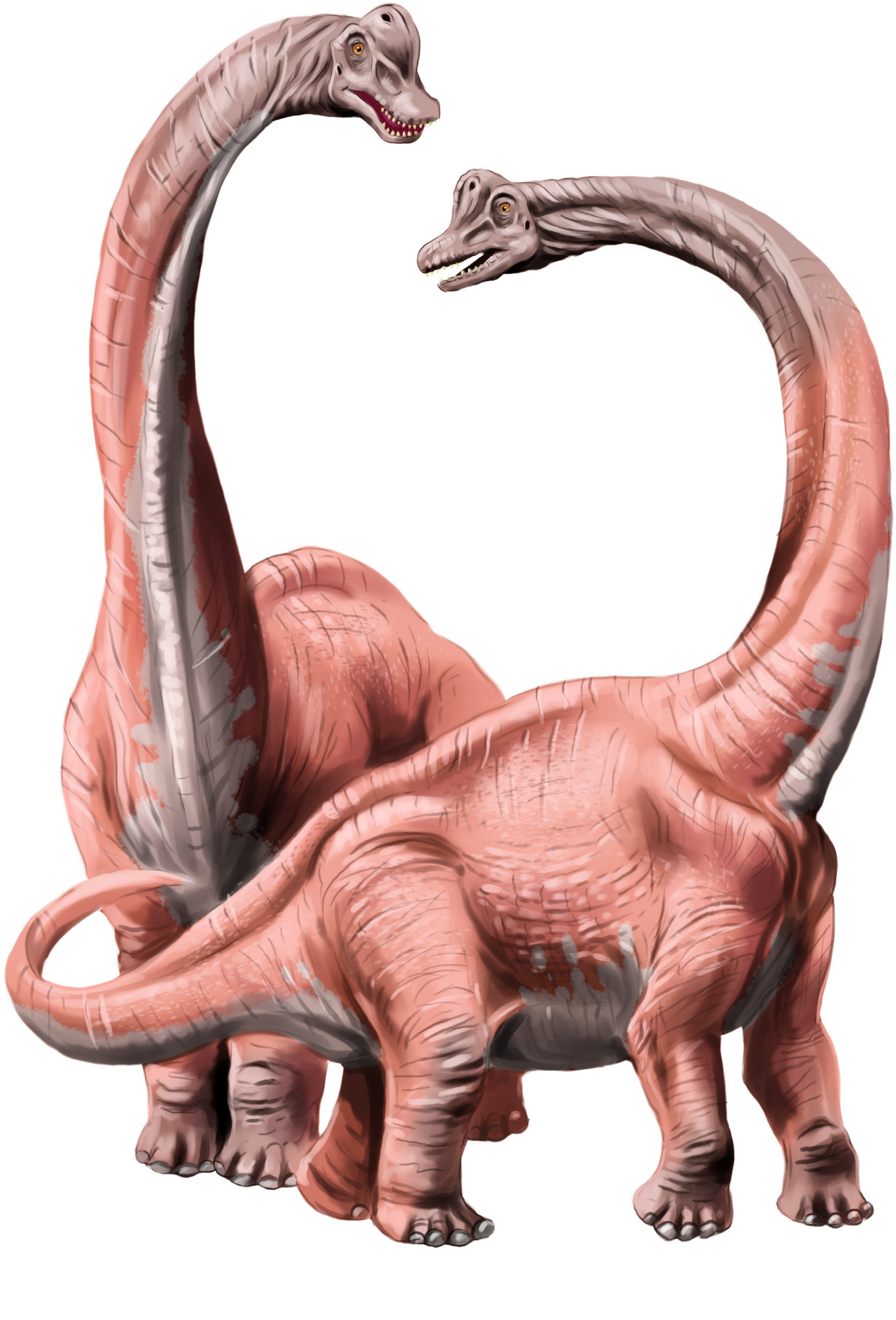
Brachiosaurus

Brachiosaurus (pronounced BRACK-e-oh-SORE-us) is a genus of sauropod dinosaur and lived in what is now present day western Colorado in North America. It was first described in 1903 from fossils found in the Colorado River and was named *Brachiosaurus altithorax*, and declared to be "the largest known dinosaur." The discoverer derived the genus name from the Greek word 'brachion' meaning 'arm' and 'sauros' meaning 'lizard,' because he realized the length of the arms were unusual for a sauropod. The species name *altithorax* was chosen because of the unusually deep and wide chest cavity, from the Latin words 'altus' meaning 'deep,' and thorax meaning 'breastplate.' *Brachiosaurus* was typical for most sauropods with a long neck, small skull, and very large body size. However, the forelimbs were longer than the hind limbs, which result in a steeply inclined body, making the overall body trapezoidal in shape, reminiscent of a modern giraffe.

Brachiosaurus is known only from the Morrison Formation during the Jurassic Time Period (145 to 210 million years ago) in western North America. This period is interpreted as a semiarid environment with distinct wet and dry seasons and flat floodplains. Vegetation varied from gallery forests (river–lining forests in otherwise treeless settings) to tree ferns, savannas with star pine trees sparsely populating the environment. This is important to note as this animal was an herbivore and was also probably warm-blooded, meaning its need to consume the requisite vegetation for survival may have ultimately outweighed the availability of resources. *Brachiosaurus* (13 species) was one of the least abundant Morrison Formation sauropods, numbering only about 1/10th the number of similar species like *Apatosaurus* (112) and *Diplodocus* (98). *Brachiosaurus* fossils are found only in the lower-middle part of the expansive Mesozoic time period, dated to about 154-153 million years ago, and long before the Cretaceous Period (The Age of Dinosaurs). This makes their time on earth actually very brief, geologically speaking.

Brachiosaurus is actually one of the more rare sauropod fossils to be found. It is regarded as a high browser, probably cropping or nipping vegetation as high as 9 meters (30 ft) off of the ground. Unlike other sauropods, it was not suited for rearing on its hind limbs, thus depicted incorrectly in the film *Jurassic Park*. It has been used as an example of a dinosaur that was most likely cold-blooded due to its large size and the corresponding need for forage. However, more recent research indicated it may have been warm-blooded like mammals.

Like all sauropod dinosaurs, *Brachiosaurus* was a quadrupedal animal with a long, muscular tail and slender, columnar limbs. The skull had a robust, wide muzzle and thick jaw bones, with spoon–shaped teeth. Large air sacs connected to the lung system were present in the neck and body, invading the vertebrae and ribs, greatly reducing the overall density. Unusual for a sauropod, the forelimbs



Brachiosaurus

were longer than the hind limbs. Also, unlike other sauropods, *Brachiosaurus* appears to have been slightly sprawled at the shoulder joint and the ribcage was unusually deep. This led to the body being inclined, with the front much higher than the hips, and the neck exiting the body at a steep angle. This shape resembles a giraffe more than any other living animal.

Size estimates for *Brachiosaurus* are highly subjective. There is an additional element of uncertainty for North American *Brachiosaurus* because the most complete skeleton appears to have come from a sub-adult or juvenile. Taking that in to account, over the years the estimates have varied between 31 and 48 tons, depending on what species of *Brachiosaurus* was found, where it was found, who found it and who estimated the mass. Suffice to say, its mass seems to be on average about 40 tons or equivalent to that of a modern California Grey Whale. The length of *Brachiosaurus*, however, has been estimated at 26 meters (85 ft), which is nearly twice as long as the whale.

Brachiosaurus is thought to have been a high browser, feeding on foliage well above the ground. Even if it did not hold its head near vertical, and instead had a straighter neck, its head height may still have been over 9 meters (30 ft) off the ground. At this height, *Brachiosaurus* would have access to high vegetation regardless of the neck position. In fact, from the roof of the San Diego Natural History Museum, *Brachiosaurus* could have been hand fed leaves and vegetation! *Brachiosaurus* probably fed mostly on foliage above 5 meters (16 ft). Its diet likely consisted of ginkgo trees (with deciduous, fan-like leaves), conifers, tree ferns, and large cycads (similar to a Sago Palm) with individual intake estimated at 200 to 400 kilograms (440 to 880 lb) of plant matter daily. *Brachiosaur* feeding involved simple up–and–down jaw motion. The teeth were arranged to shear material as they closed, and were arranged to probably crop and/or nip vegetation from high branches.

It has repeatedly been suggested (like in the film *Jurassic Park*) that *Brachiosaurus* could rear into a bipedal or tripodal pose to feed. However, a detailed physical analysis with models completed by scientists working with the BBC in London found sauropod rearing capabilities existed, but the unusual *Brachiosaurus* body shape and limb length ratio made them exceptionally unsuited for rearing up. The forward position of the center of mass would have led to problems with stability, and required unreasonably large forces and bone strength in the hips to obtain an upright posture. Furthermore, the height gain in feeding for this action would be very little, possibly negligible. Therefore, it seems unlikely *Brachiosaurus* would have developed this 'rearing up' trait and almost impossible for them to physically do it anyway.

Fun Fact:

With a certain irony, a very large main belt asteroid in our solar system has been named ***"9954 Brachiosaurus"*** in honor of this dinosaur genu

Iguanodon

Iguanodon (pronounced e-GWAN-oh-don) is of Spanish-Taino and Latin origin meaning 'iguana (or Iwana) tooth.' This reptile is in a genus of ornithopod dinosaur that existed roughly during the mid-Jurassic Time Period and was a basal member or first ancestor of the highly successful hadrosaurs. While many species have been classified in the genus *Iguanodon*, research suggests there is only one well-substantiated species, *Iguanodon bernissartensis*. This animal lived during the early Cretaceous Period in what is present day Belgium about 126 million years ago.

Named in 1825, *Iguanodon* was the second type of dinosaur formally named, after *Megalosaurus*. Together with *Hylaeosaurus*, it was one of the three genera originally used to define Dinosauria. The genus *Iguanodon* belongs to the larger group of the duck-billed hadrosaurs, which is currently on display in the *Fossil Mysteries Exhibition* at the San Diego Natural History Museum. Scientific understanding of *Iguanodon* has changed over time as new information has been obtained from fossils. The numerous specimens of this genus have allowed researchers to make informed hypotheses regarding many aspects of the animal, including feeding, movement, and social behavior. As one of the first well-known dinosaurs, *Iguanodon* has occupied a small but notable place in the public's perception of dinosaurs with its artistic representation changing significantly in response to new interpretations of its remains.

Iguanodons were large, bulky herbivores that could shift-on-the-fly from bipedalism to quadrupedalism; that is running on two legs then able to run on four legs. This is an amazing and significant adaptation when you compare and think of modern animals like canines. (Imagine your dog running on just two hind legs then dropping to all four to go faster!) *Iguanodon* is estimated to have weighed about 3.5 tons (7,000 lbs) on average, and measured about 10 meters long (33 ft) as an adult. These animals had large, tall but narrow skulls, with toothless beaks probably covered with keratin (like a modern duck's bill) and teeth like those of modern iguanas, just arranged more closely together due to their diet.

The arms of *Iguanodons* were long (up to 75% the length of the legs) and robust with rather stiff, inflexible hands built so the three central fingers could bear the weight of the animal. The thumbs were conical spikes that stuck out away from the three main digits. They could have been used for defense, or for foraging for food. The little fifth finger was elongated and dexterous, and could have even been used to grasp objects or assist in foraging for food. The legs were powerful, but not built for running, and each foot had three toes. The backbone and tail were supported and stiffened by tendons that turned to bone during the animal's life.

One of the first details noted about *Iguanodon* was it had the teeth of an herbivorous reptile, although there has not always been agreement on how it ate.

The front portions of the upper and lower jaw were unlike any modern reptile in that they were scoop-shaped and lacked teeth. The best comparison found was to that of the two-toed sloth and the extinct ground sloth *Mylodon*. Poorly preserved specimens originally suggested a lacking of musculature in the mouth and therefore suggesting a prehensile tongue like modern giraffes. However, numerous well preserved specimens now propose the modern understanding of a muscular, **non-prehensile** tongue was probably used for moving food around in the mouth.

Iguanodon teeth are, as the name suggests, like those of an iguana, only larger. Unlike later relatives (the Hadrosaurs) which had columns of replacement teeth, *Iguanodon* only had one replacement tooth at a time for each position. The upper jaw held up to 29 teeth per side with none at the front of the jaw, and the lower jaw with 25 teeth. The numbers differ because teeth in the lower jaw are broader than those in the upper. Because the tooth rows are deeply inset from the outside of the jaw, it is believed that *Iguanodon* had some sort of cheek-like structure to retain food in the mouth before swallowing.

The skull was structured in such a way that as the jaw closed shut, the bones holding the teeth in the upper jaw would curve out. This would cause the inner surfaces of the upper jaw teeth to rub against the outer surface of the lower jaw teeth, thus shearing anything caught in between like scissors. Because the teeth were always replaced, the animal could have used this mechanism throughout its life, and could eat very tough plant material, perhaps even wood! Additionally, the front ends of the animal's jaws were toothless and tipped with bony nodes, both upper and lower, providing a rough margin that was likely covered and lengthened by a keratinous material to form a cropping beak for biting off twigs and shoots. Its food gathering would have been aided by its flexible little finger, which could have been used to manipulate and grasp objects, unlike the other fingers that were stationary and weight bearing.

Exactly what *Iguanodon* ate with its well-developed jaws is not known and open to wide interpretation. The size of the larger species would have allowed them access to food from ground level to tree foliage at 4–5 meters (13–16 ft) off the ground. A diet of Equisetum (horsetail, snake grass, puzzle grass), cycads (Sago Palm), and conifers has been suggested although *Iguanodons* in general have been tied to the advance of angiosperms (flowering plants) in the Cretaceous due to the dinosaurs' inferred low browsing habits. Angiosperm growth, according to this hypothesis, would have been encouraged by *Iguanodon* feeding because the more nutritious gymnosperms (seed producing plants) would be removed, allowing more space for the weed-like angiosperms to grow. The evidence is inconclusive and somewhat conjecture. Whatever its exact diet, due to its size and abundance, *Iguanodon* is regarded as a dominant, medium to large herbivore for its ecological community. This community also included large predators like *Baryonyx* (found in this exhibit) and the armored herbivore *Polacanthus* (similar to *Euoplocephalus*, also found in this exhibit).

Fun Fact

In 1852, two lifesize reconstructions of *Iguanodon* were built in London. Their thumb spikes were mistaken for horns and scientists placed the spikes on the animal's nose! Although in error, this reconstructing greatly advanced the general public's interest in 'dinosaurs.' It was the first time an attempt was made at constructing full-size dinosaur models from fossils. Later research revealed the true location of the thumb spikes, although their exact function is still debated today.

Iguanodon

Velociraptor

Velociraptor (pronounced VAH-loss-uh-RAP-tor) is derived from Latin words (*velox* meaning 'swift' and *raptor* meaning 'robber') and is in a genus of dromaeosaurid (bird-like) theropods that lived approximately 75 to 71 million years ago during the later part of the Cretaceous Period. Two species are currently recognized, although others have been assigned in the past and then reassigned later. The most notable type is *Velociraptor mongoliensis* whose fossils were found in Mongolia.

Smaller than other dromaeosaurids, *Velociraptors* nevertheless shared many of the same anatomical features. It was a bipedal, feathered carnivore with a long tail and an enlarged sickle-shaped claw on each hind foot, which is thought to have been used to kill its prey. *Velociraptor* can be distinguished from other dromaeosaurids by its long and low skull, with an upturned snout. *Velociraptor* (commonly shortened to 'raptor') is one of the dinosaur genera most familiar to

Velociraptor

the general public due to its prominent role in the *Jurassic Park* films. In the films, however, it was **shown with several anatomical inaccuracies** including being much larger than it was in real life and without any of the feathers we now know it had. It's more helpful to think of *Velociraptor* like an oversized road-runner rather than the cunningly fast and quick witted bipedal lizards portrayed in the movies.

Velociraptor was a mid-sized dromaeosaurid, with adults measuring up to 2m (7 ft) long nose to tail, but only about ½ a meter (18–20 inches) high at the hip, and weighing only about 15 kg (33 lb). The skull, which grew up to 25 cm (10 in) long, was uniquely up-curved, concave on the upper surface and convex on the lower. The jaws were lined with 26–28 widely spaced teeth on each side, each more strongly serrated on the back edge than the front.

Since the skull was relatively small, and the jaw oddly if not uniquely formed, *Velociraptor* had a large 'hand' with three strongly curved claws, which were similar in construction and flexibility to the wing bones of modern birds. Studying the 'hands' greatly advanced our knowledge of what *Velociraptor* ate and how it defended itself in its environment. For example:

- The second digit was the longest of the three digits present, while the first was the shortest. The structure of the wrist bones prevented turning of the wrist and forced the 'hands' to be held with the 'palm' surface facing inwards, not downwards.
- The first digit of the foot, as in other theropods, was a small dewclaw. However, whereas most theropods had feet with three digits contacting the ground, *Velociraptor* walked on only their third and fourth digits.
- The second digit, for which *Velociraptor* is most famous, was highly modified and held retracted off of the ground. It had a relatively large, sickle-shaped claw. This enlarged claw, which could be over 6.5 cm (nearly 3 in) long around its outer edge, was most likely a predatory device used to tear into prey, possibly even delivering a fatal blow.

In modern Queensland Australia, the very rare and elusive bird known as the cassowary has a similar claw and still engages in the same kind of hunting and prey capture today that perhaps *Velociraptor* did 70 million years ago.

The second digit (with the distinctive claw) has traditionally been depicted as a slashing weapon; it's assumed use being to cut and disembowel prey. In one famous specimen, *Velociraptor* was found lying underneath its prey, with one of its sickle claws apparently embedded in the throat of its prey, while the mouth of the prey is clamped down upon the right forelimb of the *Velociraptor*. This suggests *Velociraptor* may have used its sickle claw to pierce vital parts of the throat (such as the jugular vein, carotid artery, or windpipe) rather than slashing the abdomen. The inside edge of the claw was rounded and **not** unusually sharp, which may have precluded any sort of cutting or slashing action. The thick abdominal wall of skin and muscle of large prey species would have been difficult to slash without a specialized cutting surface. The slashing hypothesis was tested by scientists and documentary producers where an artificial *Velociraptor* leg with the sickle claw was used on a modern pig carcass to simulate the dinosaur's prey. Though the sickle claw did penetrate the abdominal wall, it was unable to tear it open, indicating the claw was perhaps not used to disembowel prey after all. Although many isolated fossils of *Velociraptor* have been found in Mongolia, none were closely associated with any other individuals of the same species. Therefore, while *Velociraptor* is commonly depicted as a pack hunter, (again, incorrectly in *Jurassic Park* films) there is only limited fossil evidence to support this theory and none specific to *Velociraptor* itself. The animal depicted in the film more closely resembled the distant relative *Deinonychus* which was found around the remains of its known prey.

Scientists have also suggested a new method by which dromaeosaurs like *Velociraptor* may have taken and eaten smaller prey. This model, known as the RPR model of predation (or "raptor prey restraint"), proposes *Velociraptors* killed their prey in a manner very similar to modern birds of prey: by leaping onto the prey, pinning it under their body weight, and gripping it tightly with the large, sickle-shaped claws. Similar to the birds of prey, the *Velociraptor* would then begin to feed on the animal while still alive, until it eventually died from blood loss and organ failure. Scientists also found the feet and legs of *Velociraptors* most closely resemble those of eagles and hawks, especially in terms of having an enlarged second claw and a similar range of grasping motion. The RPR method of predation would be consistent with other aspects of *Velociraptor'*s anatomy, such as their unusual jaw and arm morphology. The arms, which could exert a lot of force but were likely covered in long feathers, may have been used as flapping stabilizers for balance while atop a struggling prey animal, along with the stiff counterbalancing tail, also remarkably similar to present day birds of prey. The jaws, thought to be comparatively weak, would have been useful for eating prey alive but not as useful for the quick, forceful killing of the prey.

Then scientists discovered teeth of a *Velociraptor* skeleton near a tooth-marked jaw bone of a *Protoceratops*. They concluded the find represented late-stage carcass consumption by *Velociraptor*. This conclusion was made as the predator would have eaten other parts of a freshly killed *Protoceratops* before biting the jaw area, which had very little (if any) meat, thus also supporting a scavenger hypothesis.

Fun Fact

Not until 2007, fourteen years after the *Jurassic Park* movie opened, did paleontologists report the discovery of quill knobs (feathers) on a well-preserved *Velociraptor mongoliensis*.

Coelophysis

Coelophysis (pronounced see-low-FY-sus), is from Greek origin meaning 'hollow form' in reference to its hollow bones. It was a small, carnivorous biped that lived about 250 million years ago during the late Triassic Period in the southwestern United States. The best known species, *Coelophysis bauri*, was discovered and described in 1889.

Coelophysis bauri is known from numerous complete fossil skeletons and was a lightly built dinosaur measuring up to 3 meters (10 ft) in length and was more than a meter (3 ft) tall at the hips. *Coelophysis* was very slim and it probably would have been a fast runner. Despite being an early dinosaur, the development of the theropod body form had already advanced greatly. The torso of *Coelophysis* conforms to the basic theropod body shape, but the chest bones display some interesting special characteristics like having a furcula or 'wishbone,' the earliest known example in a dinosaur. *Coelophysis* also preserves the ancestral condition of possessing four digits on the 'hand.' It had only three functional digits, as the fourth was completely embedded in the flesh of the hand becoming a vestigial (no longer used) digit.

Coelophysis had large eyes and good eyesight with a long neck and head. The tail was also long and had an unusual structure within its interlocking vertebrae. This formed a semi-rigid lattice, possibly to stop the tail from moving up and down. This may have let the tail act as a rudder or counterweight when the animal was maneuvering at high speeds.

Coelophysis had a long narrow head, and its sharp, curved, jagged teeth show that it ate meat - probably the small, lizard-like animals that were found with its body cavity fossils. It may also have hunted in packs to tackle larger prey. *Coelophysis* had an elongated snout with large natural openings which helped to reduce skull weight, while narrow struts of bones preserved the structural integrity of the skull. The neck also had a pronounced curve, like that of a modern bird.

The teeth were typical of predatory dinosaurs, blade-like and curved with fine serrations on both leading and trailing edges. Since knowledge of *Coelophysis* comes mainly from the specimens excavated at Ghost Ranch in New Mexico, there is a tendency to see this massive congregation of animals as evidence for huge packs of *Coelophysis* roaming the land. However, no direct evidence for flocking exists; the deposits only indicate large numbers of *Coelophysis*, along with other Triassic animals, were buried together. Some of the evidence from the study of how these fossils came to exist on the site indicates these animals may have been gathered together to feed at (or drink from) a depleted water hole or to feed perhaps on a spawning run of fish. They then became buried, it seems, in a catastrophic flash flood. These catastrophic floods were very common during this time period and in this geographical range.

It has also been suggested that *Coelophysis* was a cannibal, based on supposed juvenile specimens found “within” the abdominal cavities of some fossils. However, several specimens were actually small reptiles of another species and in some cases bigger individuals were crushed on top of smaller ones. There is no longer any evidence to support cannibalistic behavior in *Coelophysis*. Two forms of *Coelophysis* have been found, a more graceful form and a slightly more robust form. Opinion common among paleontologists is these different forms are just examples of sexual dimorphism, or male and female variants.

Fun Fact

Coelophysis is the state fossil of New Mexico, and its skull has traveled into outer space aboard the space shuttle *Endeavour*!

Coelophysis

Oviraptor

Oviraptor (pronounced OH-va-rap-tor) is a genus of small Mongolian theropod dinosaur first discovered in 1924. Its name is Latin for 'egg robber', referring to the fact the first fossil specimen was discovered on a pile of what were thought to be *Protoceratops* eggs. The species name of *Oviraptor* is *philoceratops*, which means 'lover of horned face', also given as a result of this find. The name was given due to the close proximity of the skull as it was separated from the eggs by only four inches of sand. However, caution was given at the time as the name *Oviraptor* may be false in its nature and belie its meaning. In the 1990s, the discovery of nesting *Oviraptor* proved this was in fact a misnomer. These finds showed the eggs in question probably belonged to *Oviraptor* itself, and the original specimen was actually brooding its eggs, not stealing them.

Oviraptor lived in the late Cretaceous period about 75 million years ago; only one definitive specimen is known and it was discovered with an associated nest of about fifteen eggs from Mongolia. A possible *second* specimen (found amazingly also with eggs) comes from the northeast region of Inner Mongolia, China.

When it was living, *Oviraptor* was one of the most bird-like of the non-avian dinosaurs. Its bone structure, in particular, displayed several features typical of birds including a rigid rib cage. A relative of *Oviraptor* called *Nomingia* (no-MIN-jee-uh) was found with a set of fused vertebrae that would later help support the tail feathers of birds. Skin impressions from more primitive *Oviraptors* show an extensive covering of feathers on the body, feathered wings and feathered tail fans. A tail fan is also indicated by the presence of the same fused vertebrae suggesting this feature was widespread among *Oviraptors*. Additionally, the nesting position of the brooding specimens implies they used feathered wings to cover their eggs. Given the close anatomical similarity between these species and *Oviraptor*, it is highly likely that *Oviraptor* itself had feathers.

Oviraptor is traditionally depicted with a distinctive crest, similar to that of the 'horn' found in modern cassowaries from Queensland, Australia. It is likely *Oviraptor* did have a crest, but its exact size and shape are unknown due to the fact that the only recognized specimen has a crushed skull. While this original specimen of *Oviraptor* was poorly preserved, new and more complete *Oviraptor* specimens were assigned to the genus in the 1970s and 1980s. This re-examining and renaming is incredibly common in scientific communities; as new discoveries and contrasting analyses shed light onto existing evidence, theories and ideas that were before accepted as fact can now be disputed or even negated completely.

As its name suggests, *Oviraptor* was originally presumed to have eaten eggs, based on its association with a fossilized nest. The idea of a crushing jaw was first proposed because of the toothless beak found on the original skull. Together with an extension of several bones below the jaw from the palate, this would have made an ‘egg-piercing’ tool. Later it was argued the strength of the beak would indicate it was strong enough to break the shells of mollusks, such as clams, which are found in the same geological formation as *Oviraptor*. These bones converge in the middle to form a pair of prongs. A beak then covered the edges of the upper and lower jaws and probably the palate, giving *Oviraptor* a very ‘bird-like’ appearance and useful shell cracking tool.

The discovery of nesting specimens of relative species with the same types of egg in the original *Oviraptor* specimen proved the eggs actually belonged to *Oviraptor* itself. This would indicate the accepted specimen was likely brooding the eggs, not feeding on them. While this discovery did not rule out the possibility *Oviraptor* included eggs in its diet, its exact feeding strategies remain unknown. The only *Oviraptor philoceratops* skeleton preserved also contains the remains of a lizard, implying the species was at least occasionally a carnivore.

Fun Fact Scientists have estimated *Oviraptor* could run as fast as an Ostrich, up to 43 mph!

Oviraptor

Edmontosaurus

Edmontosaurus (pronounced ed-MON-tuh-SAWR-us) is a genus of crestless hadrosaur (or duck-billed) dinosaur. It contains two known species: *Edmontosaurus regalis* and *Edmontosaurus annectens*. Their fossils have been found in rocks of western North America dating from the Late to Early Cretaceous Period 73 million to 65.5 million years ago. *Edmontosaurus* was one of the last non-avian dinosaurs, and lived alongside *Triceratops* and *Tyrannosaurus rex* shortly before most of the dinosaurs became extinct.

Edmontosaurus included some of the largest hadrosaur species, measuring up to 12 meters (39 ft) long and weighing around 4 metric tons (9,000 lbs). Several well-preserved specimens are known that include not only bones, but in some cases extensive skin impressions and possible gut contents.

Scientists recorded data from all known "Edmontosaurus" skulls and used it to plot a morphometric graph, comparing variable features of the skull with the skull size. Their results showed within both recognized *Edmontosaurus* species, many features previously used to classify additional species or genera were directly correlated with skull size. The interpretation, therefore, of these results strongly suggested the shape of *Edmontosaurus* skulls **changed dramatically as they grew**. To put it another way, the way an *Edmontosaurus'* skull looked was so different as a hatchling, compared to that of an adolescent, compared to that of a young adult, compared to that of a mature adult, scientists previously thought they were **all different species!** This has led to several mistakes in classification in the past. The skulls had all become longer and flatter as the animals grew and matured.

Edmontosaurus has a lengthy and complicated taxonomic history dating to the late 19th century. The first fossils named *Edmontosaurus* were discovered in southern Alberta, Canada, in the Horseshoe Canyon Formation. *Edmontosaurus* was widely distributed across western North America suggesting it preferred the coastal plains. It was an herbivore that could move on both two legs and four. Because it is known from several bone beds with other numerous skeletons, it is thought *Edmontosaurus* lived in groups and may even have been migratory. The wealth of fossils has allowed researchers to study its paleobiology in detail, including its brain, how it may have fed, its injuries and pathologies. There is even evidence of a *Tyrannosaur* attack on one *Edmontosaurus* specimen. Like other *Hadrosaur* specimens, it was a bulky animal with a long, laterally flattened tail and a head with an expanded, duck-like beak. Unlike many other *Hadrosaur* specimens, the skull had no hollow or solid crest. The front legs were not as heavily built as the hind legs, but were long enough to be used in standing or moving.

The skull of a fully grown *Edmontosaurus* could be over a meter (3 ft) long. The skull was roughly triangular in profile with no bony cranial crest. Viewed from

Edmontosaurus

above, the front and rear of the skull were expanded, with the broad front forming a duck-bill or spoon-bill shape. The beak was toothless, and both the upper and lower beaks were extended by keratinous material. Substantial remains of the upper beak are known from the famous 'mummy' *Edmontosaurus*. In this specimen, the preserved non-bony part of the beak extended for at least 8 centimeters (3 in) beyond the bone, projecting vertically down. The nasal openings of *Edmontosaurus* were elongate and housed in deep depressions surrounded by distinct bony rims above, behind, and below. In at least one case (the 'mummy' specimen), rarely preserved series of eye-socket bones, called sclerotic rings, were found intact. Another rarely seen bone, the reptilian ear bone called the stapes, has also been seen in a specimen of *Edmontosaurus.*

Edmontosaurus was a large terrestrial herbivore. Its teeth were continually replaced and packed into dental batteries containing hundreds of teeth, only a relative handful of which were in use at any time. The type and shape of *Edmontosaurus* teeth are very significant. The battery of teeth was present only in the upper cheeks and main bone of the lower jaw. The teeth were continually replaced, taking about half a year to form. They grew in columns, or batteries, with an observed maximum of six in each, and the number of columns varied based on the animal's size. Known column counts for the two species are 53 to 49, with the teeth of the upper jaw being slightly narrower than those in the lower jaw. This is remarkable because the teeth continually replaced themselves, but were NOT separated like the teeth in sharks. If any comparison could be made, it would be more like the teeth were on a slow moving conveyor belt sitting side by side. *Edmontosaurus* used its broad beak to cut loose food, perhaps by cropping, or by closing the jaws in a clamshell-like manner over twigs and branches and then stripping off the more nutritious leaves and shoots. Because the tooth rows are deeply indented from the outside of the jaws, it is inferred *Edmontosaurus* had cheek-like structures. The function of the cheeks was to retain food in the mouth. This is quite a significant difference from current reptile and bird feeding habits as most are 'bite and swallow' type feeders, holding little if any food in the mouth. The *Edmontosaurus'* feeding range would have been from ground level to around 4 meters (13 ft) high.

Before the 1960s and 1970s, the prevailing interpretation of hadrosaurs like *Edmontosaurus* was they were aquatic and fed on aquatic plants. It was proposed the animal had a diet much like that of some modern ducks, filtering plants and aquatic invertebrates like mollusks and crustaceans from the water and discharging water via V-shaped furrows along the inner face of the upper beak. This interpretation of the beak has now been rejected, as the furrows and ridges are more like those of herbivorous turtle beaks than the flexible structures seen in filter-feeding birds.

The prevailing model of how *Hadrosaur* fed was proposed by scientists who found the structure of the skull itself permitted motion between bones. This led to backward and forward motion of the lower jaw and outward bowing of the tooth-bearing bones of the upper jaw when the mouth was closed. The teeth of the upper jaw would grind against the teeth of the lower jaw like rasps, processing plant material trapped between them. This could be interpreted as 'chewing' in modern mammals, highly **unlike** modern reptiles and birds. An important piece of evidence for this model is the orientation of scratches on the teeth showing the direction of jaw action.

Further work found *Edmontosaurus* lacked the types of skull joints seen in modern animals known to have kinetic skulls (skulls that permit motion between their bones). Research has been interpreted to propose joints which were thought to permit movement in dinosaur skulls were actually cartilage-filled growth zones ultimately reshaping the skull many times over the animal's lifetime.

Both of the 'mummy' specimens of *Edmontosaurus* collected were reported to have had possible gut contents. The plant remains have been described, but have proven difficult to interpret. The plants found in the carcass included needles of conifer tree, twigs from conifer and broadleaf trees, and numerous small seeds or fruits. Upon their description in 1922, it was interpreted as the *possible* gut contents of the animal, but scientists could not rule out that the plants may have been washed into the carcass after death. After this interpretation, radically conflicting hypotheses developed on where these animals lived and what they ate. Scientific analyses show strong support for both a water-bound and terrestrial existence.

Fun Fact

The nostrils of Edmontosaurus were large and hollow. They may have been covered with loose skin that the animal could have filled with air. When inflated, these bags may have been used to make loud bellowing sounds. Communication was probably important to this animal; it lived in large groups with both adults and offspring. These bags may also have been brightly colored for display to attract a mate or to help other animals from the same species recognize each other.

Protoceratops

Protoceratops, (pronounced pro-toe-SARE-uh-tops), is Greek meaning 'first horned face.' It belongs to a genus of sheep-sized herbivorous ceratopsian dinosaur from the Early Cretaceous Period about 125 million years ago in an area of what is now Mongolia. It was a member of a group of early horned dinosaurs. *Protoceratops* was a much smaller creature lacking well-developed horns and retained some primitive traits not seen in later specimens. *Protoceratops* was known for its large neck frill which was likely used as a display to impress other members of the species. Other hypotheses about its function include protection of the neck and anchoring of jaw muscles, but the fragility of the frill and the poor leverage offered by possible muscle attachment here (not to mention the fact that no known reptiles have facial muscles) makes these ideas rather implausible.

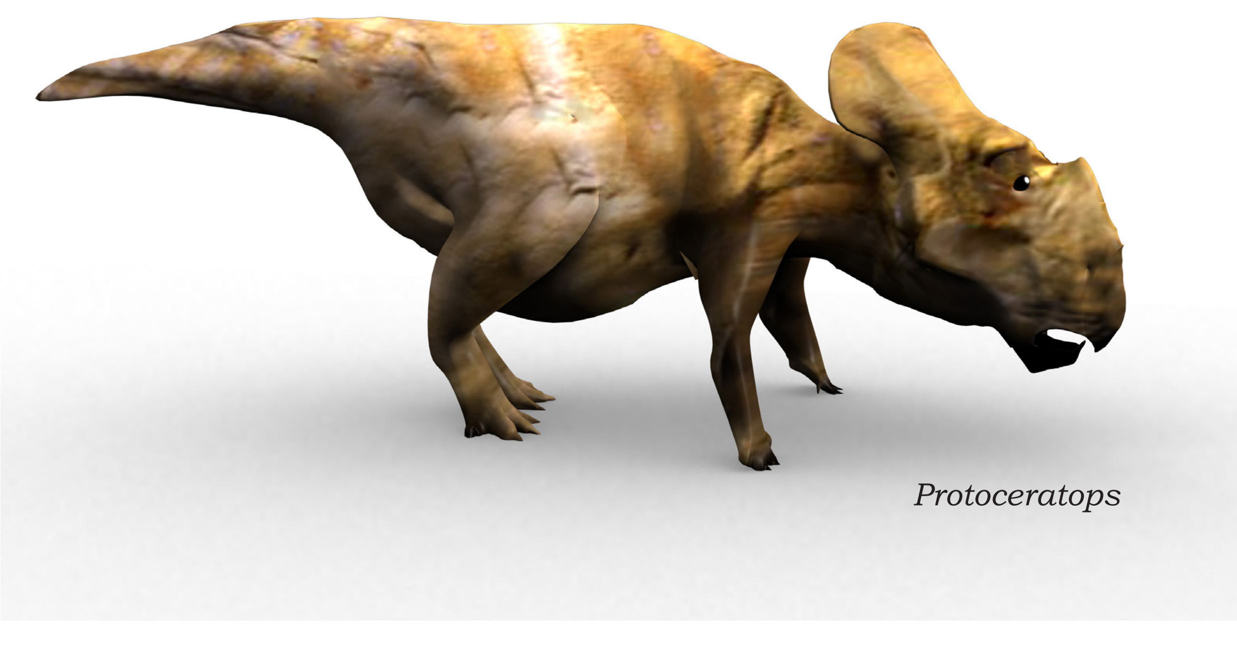
Protoceratops was approximately 1.8 meters (6 ft) in length and ½ a meter (2 ft) high at the shoulder. A fully grown adult would have weighed about 180 kg (400 lbs). The large numbers of fossil specimens found in high concentration suggest that *Protoceratops* lived in herds. *Protoceratops* was a relatively small dinosaur with a proportionately large skull. It was a quadrupedal herbivore with a parrot-like beak and teeth in the cheeks. These teeth were distinctly different and defined the diet of the *Protoceratops.* This animal appears to have had muscular jaws capable of a powerful bite. Imagine a reptile the size of a sheep with a beak like a parrot and perhaps a bite force like a modern alligator. This animal's beak could probably crop or cut any plant material it came across. These jaws were packed with dozens of teeth, well suited for chewing tough vegetation maybe even branches or trunks of small trees.

Protoceratops' frill itself contained two large holes, while its cheeks had large or high cheekbones. The exact size and shape of the neck frill varied by individual; some specimens had short, compact frills, while others had frills nearly half the length of the skull. Some researchers attribute the different sizes and shapes of these bones to male and female variants, as well as the age of the specimen at the time of death. The skull consisted of a massive frontal beak, and four pairs of fenestrae or skull openings. The foremost hole, the naris, was considerably smaller than the nostrils seen in later genera. *Protoceratops* also had large orbits (the holes for its eyes), which measured around 50 millimeters (3.5 in) in diameter. These large eyes were probably necessary to look out for predators.

Fun Fact

Folklorists and historians of early humankind have suggested the exquisitely preserved fossil skeletons of *Protoceratops* found by ancient nomads, who mined gold in Central Asia, may have given us the root image of the mythical creature known as the Griffin. Griffins were described as lion-sized quadrupeds with large claws, a bird-like beak and they laid their eggs in nests on the ground.

Greek writers began describing the Griffin around 675 B.C.E., the same time the Greeks first made contact with the ancient nomads. Griffins were described as guarding the gold deposits in the sandstone formations. Amazingly, the region of China where many *Protoceratops* fossils are found is rich in gold runoff from the neighboring mountains, lending some chilling credit to the theory that these fossils were the basis of Griffin myths.



Protoceratops

Glossary

Abdominal – of, in, on or pertaining to the part of the body of an animal between the thorax and the pelvis; the belly; the cavity of this part of the body containing the stomach, intestines, etc.

Apex predator – a hunter at the top of the food web

Binocular vision – vision that involves using both eyes at the same time

Bipedal – any animal having or using only two feet

Biometrics - Biometric identifiers are the distinctive, measurable characteristics used to label and describe individuals in a species

Carrion- dead and decaying flesh

Dewclaw - a functionless claw of some animals not reaching the ground in walking

Disembowel - to remove the bowels or entrails from; eviscerate the abdomen of 'the guts'

Dromaeosaurid(s) - are a family of bird-like theropod dinosaurs. They were small- to medium-sized feathered carnivores that flourished in the Cretaceous Period. The name means 'running lizards.'

Ecology (ical) - branch of biology dealing with the relations and interactions between organisms and their environment, including other organisms, and the area at large in which they dwell

Fibula - a corresponding bone, often rudimentary with the tibia, of the leg or hind limb of an animal

Genus - the usual major subdivision of a family or subfamily in the classification of organisms, usually consisting of more than one species

Hypothesis (es) - a proposition, or set of propositions, set forth as an explanation for the occurrence of some specified group of phenomena, either asserted merely as a provisional conjecture to guide investigation or accepted as highly probable in the light of established facts

Keels - a longitudinal ridge, as on a leaf or bone

Keratinous – of or containing a scleroprotein or albuminoid substance, found in the dead outer skin layer, and in horn, hair, feathers, hoofs, nails, claws, bills, etc.

Lattice - a structure of crossed strips usually arranged to form a diagonal pattern of open spaces between the strips; a slanted diagonal checker-board

Morphometric – a technique of taxonomic analysis using measurements and formations of an organism; the evolutionary development of those organism's formations

Nodes - a knot-like mass of tissue

Non-avian type dinosaurs - Dinosaurs are a diverse and varied group of animals. Paleontologists have identified over 500 distinct genera and more than 1,000 different species of **non-avian dinosaurs.** Some dinosaurs are or were herbivorous, others carnivorous. Some have been bipedal, others quadrupedal, and others have been able to shift between these body postures. **Many non-avian species** developed elaborate skeletal modifications such as bony armor, horns or crests. Avian dinosaurs have been the planet's dominant flying vertebrate since the extinction of the pterosaurs. Although generally known for the large size of some species, most dinosaurs were human-sized or even smaller. Most groups of dinosaurs are known to have built nests and laid eggs.

Olfactory bulbs and olfactory nerves – of or pertaining to the sense of smell

Ornithopod - any herbivorous dinosaur of the suborder Ornithopoda whose members usually walked erect on their hind legs

Prongs - one of the pointed tines of a fork, any pointed, projecting part, as of an antler or tooth

Protuberance - bulging out beyond the surrounding surface; protruding; projecting

Quadrupedal - an animal having four feet; being four-footed

Rasp(s) - to scrape or abrade with a rough instrument, to grate upon or irritate, to file down by scraping with a rough edge

Sauropod - any herbivorous dinosaur of the suborder Sauropoda, from the Jurassic and Cretaceous periods, having a small head, long neck and tail, and five-toed limbs: the largest known land animal

Serengeti - a plain in NW Tanzania, including a major wildlife reserve

Serrations (ed) - notched on the edge like a saw

Stereoscopic – of or pertaining to three dimensional vision

Terrestrial - living on or in the ground; not aquatic, arboreal, or aerial

Theropod(s) – any member of the sub-order comprising carnivorous dinosaurs that had short forelimbs and walked or ran on their hind legs

Trapezoidal - a quadrilateral figure having two parallel sides with different lengths and two nonparallel sides with the same length

Tripodal - having three feet or legs, or with animals using the tail as support acting as a 'third leg'

Truncated equilateral triangle – a three-sided polygon that has been shortened by or having a part cut off

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