

**JINNAH UNIVERSITY FOR WOMEN**

2nd assignment of zoology

Topic: dinosaur discoveries

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Dinosaur discoveries

**Introduction:**

**Scientific classification**

Kingdom: Animalia

Phylum: Chordata

Class: Reptilia

Clade: Dinosauriformes

Clade: Dinosauria

Owen, 1842

**Major groups**

*Ornithischia*

†Ornithopoda

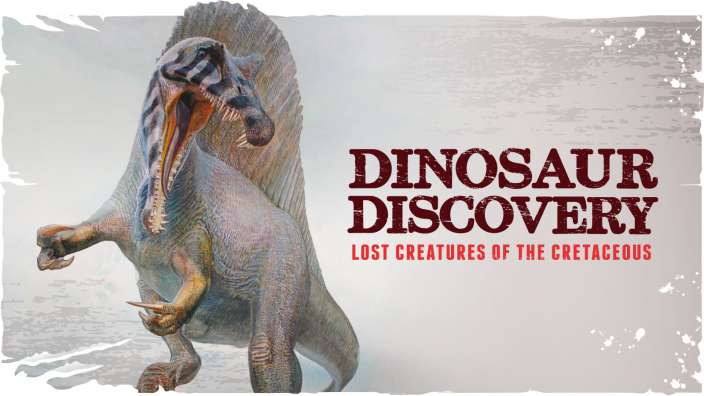
†Thyreophora

†Marginocephalia

*Saurischia*

†Sauropodomorpha

Theropoda



Dinosaurs are a diverse group of animals of the clade Dinosauria that first appeared during the Triassic period. Although the exact origin and timing of the evolution of dinosaurs is the subject of active research, the current scientific consensus places their origin between 231 and 243 million years ago. They became the dominant terrestrial vertebrates after the Triassic–Jurassic extinction event 201 million years ago. Their dominance continued through the Jurassic and Cretaceous periods and ended when the Cretaceous-Paleogene extinction event led to the extinction of most dinosaur groups 66 million years ago.

Until the late 20th century, all groups of dinosaurs were believed to be extinct; however, the fossil record indicates that birds are the modern descendants of feathered dinosaurs, having evolved from theropod ancestors during the Jurassic Period, and are now termed "avian dinosaurs". As such, birds were the only dinosaur lineage to survive the mass extinction event. Throughout the remainder of this article, the term "dinosaur" is sometimes used generically to refer to both the avian and non-avian dinosaurs combined, while at other times it is used to refer to the non-avian dinosaurs specifically, and the avian dinosaurs are sometimes simply referred to as "birds". This article deals primarily with non-avian dinosaurs.

Dinosaurs are a varied group of animals from taxonomic, morphological and ecological standpoints. Birds, at over 10000 living species, are the most diverse group of vertebrates besides perciform fish. Using fossil evidence, paleontologists have identified over 500 distinct genera and more than 1000 different species of non-avian dinosaurs.

Dinosaurs are represented on every continent by both extant species and fossil remains. Some are herbivorous, others carnivorous. While dinosaurs were ancestrally bipedal, many extinct groups included quadrupedal species, and some were able to shift between these stances. Elaborate display structures such as horns or crests are common to all dinosaur groups, and some extinct groups developed skeletal modifications such as bony armor and spines. Evidence suggests that egg laying and nest building are additional traits shared by all dinosaurs. While the modern-day surviving lineage of dinosaurs (birds) are generally small due to the constraints of flight, many prehistoric dinosaurs were large-bodied—the largest sauropod dinosaurs are estimated to have reached lengths of 39.7 meters (130 feet) and heights of 18 meters (59 feet) and were the largest land animals of all time. Still, the idea that non-avian dinosaurs were uniformly gigantic is a misconception based in part on preservation bias, as large, sturdy bones are more likely to last until they are fossilized. Many dinosaurs were quite small: Xixianykus, for example, was only about 50 cm (20 in) long.

Although the word dinosaur literally means "terrible lizard", the name is something of an etymological misnomer; even though dinosaurs are reptiles, they are not lizards, nor are they descended from them. Instead, dinosaurs, like many extinct forms of reptile sub-groups, did not exhibit characteristics which were traditionally regarded as reptilian, such as a sprawling limb posture or ectothermy (colloquially referred to as "cold-bloodedness"). Additionally, many other prehistoric animals, including mosasaurs, ichthyosaurs, pterosaurs, plesiosaurs, and Dimetrodon, while often popularly conceived of as dinosaurs, are not taxonomically classified as dinosaurs.

Through the first half of the 20th century, before birds were recognized to be dinosaurs, most of the scientific community believed dinosaurs to have been sluggish and cold-blooded. Most research conducted since the 1970s, however, has indicated that all dinosaurs were active animals with elevated metabolisms and numerous adaptations for social interaction.

Since the first dinosaur fossils were recognized in the early 19th century, mounted fossil dinosaur skeletons have been major attractions at museums around the world, and dinosaurs have become an enduring part of world culture. The large sizes of some dinosaur groups, as well as their seemingly monstrous and fantastic nature, have ensured dinosaurs' regular appearance in best-selling books and films, such as Jurassic Park. Persistent public enthusiasm for the animals has resulted in

significant funding for dinosaur science, and new discoveries are regularly covered by the media.

**Etymology:**

The taxon Dinosauria was formally named in 1842 by paleontologist Sir Richard Owen, who used it to refer to the "distinct tribe or sub-order of Saurian Reptiles" that were then being recognized in England and around the world. The term is derived from the Greek words δεινός (deinos, meaning "terrible", "potent", or "fearfully great") and σαῦρος (sauros, meaning "lizard" or "reptile"). Though the taxonomic name has often been interpreted as a reference to dinosaurs' teeth, claws, and other fearsome characteristics, Owen intended it merely to evoke their size and majesty.

[](https://en.wikipedia.org/wiki/File:LA-Triceratops_mount-2.jpg)

[*Triceratops horridus*](https://en.wikipedia.org/wiki/Triceratops_horridus)skeleton, [Natural History Museum of Los Angeles County](https://en.wikipedia.org/wiki/Natural_History_Museum_of_Los_Angeles_County)

**General description**

Using one of the above definitions, dinosaurs can be generally described as archosaurs with hind limbs held erect beneath the body.[19] Many prehistoric animal groups are popularly conceived of as dinosaurs, such as ichthyosaurs, mosasaurs, plesiosaurs, pterosaurs, and pelycosaurs (especially Dimetrodon), but are not classified scientifically as dinosaurs, and none had the erect hind limb posture characteristic of true dinosaurs. Dinosaurs were the dominant terrestrial vertebrates of the Mesozoic, especially the Jurassic and Cretaceous periods. Other groups of animals were restricted in size and niches; mammals, for example, rarely exceeded the size of a domestic cat, and were generally rodent-sized carnivores of small prey.

Dinosaurs have always been an extremely varied group of animals; according to a 2006 study, over 500 non-avian dinosaur genera have been identified with certainty so far, and the total number of genera preserved in the fossil record has been estimated at around 1850, nearly 75% of which remain to be discovered. An earlier study predicted that about 3400 dinosaur genera existed, including many that would not have been preserved in the fossil record. By September 17, 2008, 1047 different species of dinosaurs had been named. In 2016 the estimated number of dinosaur species that existed in the Mesozoic era was estimated to be 1,543–2,468. Some are herbivorous, others carnivorous, including seed-eaters, fish-eaters, insectivores, and omnivores. While dinosaurs were ancestrally bipedal (as are all modern birds), some prehistoric species were quadrupeds, and others, such as Ammosaurus and Iguanodon, could walk just as easily on two or four legs. Cranial modifications like horns and crests are common dinosaurian traits, and some extinct species had bony armor. Although known for large size, many Mesozoic dinosaurs were human-sized or smaller, and modern birds are generally small in size. Dinosaurs today inhabit every continent, and fossils show that they had achieved global distribution by at least the early Jurassic period. Modern birds inhabit most available habitats, from terrestrial to marine, and there is evidence that some non-avian dinosaurs (such as Microraptor) could fly or at least glide, and others, such as spinosaurids, had semi-aquatic habits.

[[](https://en.wikipedia.org/wiki/File:Neognathae.jpg)](https://en.wikipedia.org/wiki/File:Neognathae.jpg)

In phylogenetic taxonomy, birds are included in the group Dinosauria.

**Origins and early evolution:**

Dinosaurs diverged from their archosaur ancestors during the middle to late Triassic period, roughly 20 million years after the Permian–Triassic extinction event wiped out an estimated 95% of all life on Earth. Radiometric dating of the rock formation that contained fossils from the early dinosaur genus Eoraptor at 231.4 million years old establishes its presence in the fossil record at this time. Paleontologists think that Eoraptor resembles the common ancestor of all dinosaurs; if this is true, its traits suggest that the first dinosaurs were small, bipedal predators. The discovery of primitive, dinosaur-like ornithodirans such as Marasuchus and Lagerpeton in Argentinian Middle Triassic strata supports this view; analysis of recovered fossils suggests that these animals were indeed small, bipedal predators. Dinosaurs may have appeared as early as 243 million years ago, as evidenced by remains of the genus Nyasasaurus from that period, though known fossils of these animals are too fragmentary to tell if they are dinosaurs or very close dinosaurian relatives.

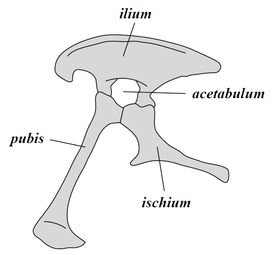
When dinosaurs appeared, they were not the dominant terrestrial animals. The terrestrial habitats were occupied by various types of archosauromorphs and therapsids, like cynodonts and rhynchosaurs. Their main competitors were the pseudosuchia, such as aetosaurs, ornithosuchids and rauisuchians, which were more successful than the dinosaurs. Most of these other animals became extinct in the Triassic, in one of two events. First, at about 215 million years ago, a variety of basal archosauromorphs, including the protorosaurs, became extinct. This was followed by the Triassic–Jurassic extinction event (about 200 million years ago), that saw the end of most of the other groups of early archosaurs, like aetosaurs, ornithosuchids, phytosaurs, and rauisuchians. Rhynchosaurs and dicynodonts survived (at least in some areas) at least as late as early-mid Norian and early Rhaetian, respectively, and the exact date of their extinction is uncertain. These losses left behind a land fauna of crocodylomorphs, dinosaurs, mammals, pterosaurians, and turtles. The first few lines of early dinosaurs diversified through the Carnian and Norian stages of the Triassic, possibly by occupying the niches of the groups that became extinct.

**Classification:**

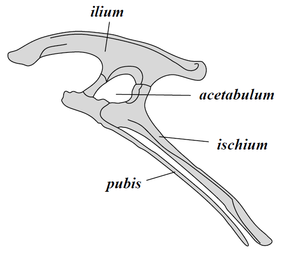
Dinosaurs belong to a group known as archosaurs, which also includes modern crocodilians. Within the archosaur group, dinosaurs are differentiated most noticeably by their gait. Dinosaur legs extend directly beneath the body, whereas the legs of lizards and crocodilians sprawl out to either side.

Collectively, dinosaurs as a clade are divided into two primary branches, Saurischia and Ornithischia. Saurischia includes those taxa sharing a more recent common ancestor with birds than with Ornithischia, while Ornithischia includes all taxa sharing a more recent common ancestor with Triceratops than with Saurischia. Anatomically, these two groups can be distinguished most noticeably by their pelvic structure. Early saurischians—"lizard-hipped", from the Greek sauros (σαῦρος) meaning "lizard" and ischion (ἰσχίον) meaning "hip joint"—retained the hip structure of their ancestors, with a pubis bone directed cranially, or forward. This basic form was modified by rotating the pubis backward to varying degrees in several groups (Herrerasaurus, therizinosauroids, dromaeosaurids, and birds). Saurischia includes the theropods (exclusively bipedal and with a wide variety of diets) and sauropodomorphs (long-necked herbivores which include advanced, quadrupedal groups).

By contrast, ornithischians—"bird-hipped", from the Greek ornitheios (ὀρνίθειος) meaning "of a bird" and ischion (ἰσχίον) meaning "hip joint"—had a pelvis that superficially resembled a bird's pelvis: the pubis bone was oriented caudally (rear-pointing). Unlike birds, the ornithischian pubis also usually had an additional forward-pointing process. Ornithischia includes a variety of species which were primarily herbivores. (NB: the terms "lizard hip" and "bird hip" are misnomers – birds evolved from dinosaurs with "lizard hips".)

* [](https://en.wikipedia.org/wiki/File:Saurischia_pelvis.png)[](https://en.wikipedia.org/wiki/File:Tyrannosaurus_pelvis_left.jpg)

[*Saurischian*](https://en.wikipedia.org/wiki/Saurischia)*pelvis structure (left side)* [*Tyrannosaurus*](https://en.wikipedia.org/wiki/Tyrannosaurus)*pelvis (showing saurischian structure – left side)*

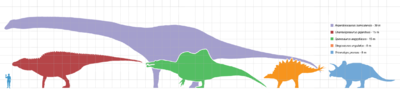
* [](https://en.wikipedia.org/wiki/File:Ornithischia_pelvis.png)[](https://en.wikipedia.org/wiki/File:Edmontosaurus_pelvis_left.jpg)

[*Ornithischian*](https://en.wikipedia.org/wiki/Ornithischia)*pelvis structure (left side)* [*Edmontosaurus*](https://en.wikipedia.org/wiki/Edmontosaurus) pelvis (showing ornithischian structure – left side)

**Biology:**

Knowledge about dinosaurs is derived from a variety of fossil and non-fossil records, including fossilized bones, feces, trackways, gastroliths, feathers, impressions of skin, internal organs and soft tissues. Many fields of study contribute to our understanding of dinosaurs, including physics (especially biomechanics), chemistry, biology, and the earth sciences (of which paleontology is a sub-discipline). Two topics of particular interest and study have been dinosaur size and behavior.

* **Size**

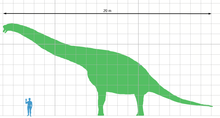
Current evidence suggests that dinosaur average size varied through the Triassic, early Jurassic, late Jurassic and Cretaceous periods.[39] Predatory theropod dinosaurs, which occupied most terrestrial carnivore niches during the Mesozoic, most often fall into the 100 to 1000 kg (220 to 2200 lb) category when sorted by estimated weight into categories based on order of magnitude, whereas recent predatory carnivoran mammals peak in the 10 to 100 kg (22 to 220 lb) category. The mode of Mesozoic dinosaur body masses is between one and ten metric tonnes. This contrasts sharply with the size of Cenozoic mammals, estimated by the National Museum of Natural History as about 2 to 5 kg (4.4 to 11.0 lb). [](https://en.wikipedia.org/wiki/File:Largestdinosaursbysuborder_scale.png)

Scale diagram comparing the average human to the largest known dinosaurs in five major [clades](https://en.wikipedia.org/wiki/Clade): [Sauropoda](https://en.wikipedia.org/wiki/Sauropoda" \o "Sauropoda) (*[Argentinosaurus huinculensis](https://en.wikipedia.org/wiki/Argentinosaurus" \o "Argentinosaurus)*), [Ornithopoda](https://en.wikipedia.org/wiki/Ornithopod" \o "Ornithopod) (*[Shantungosaurus giganteus](https://en.wikipedia.org/wiki/Shantungosaurus" \o "Shantungosaurus)*), [Theropoda](https://en.wikipedia.org/wiki/Theropoda)(*[Spinosaurus aegyptiacus](https://en.wikipedia.org/wiki/Spinosaurus" \o "Spinosaurus)*), [Thyreophora](https://en.wikipedia.org/wiki/Thyreophora" \o "Thyreophora) ([*Stegosaurus armatus*](https://en.wikipedia.org/wiki/Stegosaurus)) and[Marginocephalia](https://en.wikipedia.org/wiki/Marginocephalia) ([*Triceratops prorsus*](https://en.wikipedia.org/wiki/Triceratops))

The sauropods were the largest and heaviest dinosaurs. For much of the dinosaur era, the smallest sauropods were larger than anything else in their habitat, and the largest were an order of magnitude more massive than anything else that has since walked the Earth. Giant prehistoric mammals such as Paraceratherium (the largest land mammal ever) were dwarfed by the giant sauropods, and only modern whales approach or surpass them in size. There are several proposed advantages for the large size of sauropods, including protection from predation, reduction of energy use, and longevity, but it may be that the most important advantage was dietary. Large animals are more efficient at digestion than small animals, because food spends more time in their digestive systems. This also permits them to subsist on food with lower nutritive value than smaller animals. Sauropod remains are mostly found in rock formations interpreted as dry or seasonally dry, and the ability to eat large quantities of low-nutrient browse would have been advantageous in such environments.

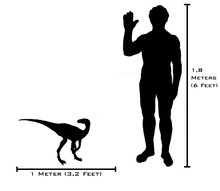
**Largest and smallest:**

Scientists will probably never be certain of the largest and smallest dinosaurs to have ever existed. This is because only a tiny percentage of animals ever fossilize, and most of these remain buried in the earth. Few of the specimens that are recovered are complete skeletons, and impressions of skin and other soft tissues are rare. Rebuilding a complete skeleton by comparing the size and morphology of bones to those of similar, better-known species is an inexact art, and reconstructing the muscles and other organs of the living animal is, at best, a process of educated guesswork.

[](https://en.wikipedia.org/wiki/File:Giraffatitan_scale.png)

Comparative size of Giraffatitan to the average human

The tallest and heaviest dinosaur known from good skeletons is Giraffatitan brancai (previously classified as a species of Brachiosaurus). Its remains were discovered in Tanzania between 1907 and 1912. Bones from several similar-sized individuals were incorporated into the skeleton now mounted and on display at the Museum für Naturkunde Berlin; this mount is 12 meters (39 ft) tall and 21.8–22.5 meters (72–74 ft) long, and would have belonged to an animal that weighed between 30000 and 60000 kilograms (70000 and 130000 lb). The longest complete dinosaur is the 27 meters (89 feet) long Diplodocus, which was discovered in Wyoming in the United States and displayed in Pittsburgh's Carnegie Natural History Museum in 1907.

[[](https://en.wikipedia.org/wiki/File:Human-eoraptor_size_comparison(v2).png)](https://en.wikipedia.org/wiki/File:Human-eoraptor_size_comparison(v2).png)

Comparative size of *[Eoraptor](https://en.wikipedia.org/wiki/Eoraptor" \o "Eoraptor)* to the average human

There were larger dinosaurs, but knowledge of them is based entirely on a small number of fragmentary fossils. Most of the largest herbivorous specimens on record were discovered in the 1970s or later, and include the massive Argentinosaurus, which may have weighed 80000 to 100000 kilograms (90 to 110 short tons); some of the longest were the 33.5 meters (110 ft) long Diplodocus hallorum (formerly Seismosaurus) and the 33–34 meters (108–112 ft) long Supersaurus; and the tallest, the 18 meters (59 ft) tall Sauroposeidon, which could have reached a sixth-floor window. The heaviest and longest dinosaur may have been Amphicoelias fragillimus, known only from a now lost partial vertebral neural arch described in 1878. Extrapolating from the illustration of this bone, the animal may have been 58 meters (190 ft) long and weighed 122400 kg (270000 lb). However, as no further evidence of sauropods of this size has been found, and the discoverer, Edward Cope, had made typographic errors before, it is likely to have been an extreme overestimation. The largest known carnivorous dinosaur was Spinosaurus, reaching a length of 12.6 to 18 meters (41 to 59 ft), and weighing 7–20.9 tonnes (7.7–23 short tons). Other large carnivorous theropods included Giganotosaurus, Carcharodontosaurus and Tyrannosaurus. Therizinosaurus and Deinocheirus were among the tallest of the theropods.

The smallest dinosaur known is the bee hummingbird, with a length of only 5 cm (2.0 in) and mass of around 1.8 g (0.063 oz). The smallest known non-avialan dinosaurs were about the size of pigeons and were those theropods most closely related to birds. For example, Anchiornis huxleyi is currently the smallest non-avialan dinosaur described from an adult specimen, with an estimated weight of 110 grams and a total skeletal length of 34 cm (1.12 ft). The smallest herbivorous non-avialan dinosaurs included Microceratus and Wannanosaurus, at about 60 cm (2.0 ft) long each.

* **Behavior:**

Many modern birds are highly social, often found living in flocks. There is general agreement that some behaviors that are common in birds, as well as in crocodiles (birds' closest living relatives), were also common among extinct dinosaur groups. Interpretations of behavior in fossil species are generally based on the pose of skeletons and their habitat, computer simulations of their biomechanics, and comparisons with modern animals in similar ecological niches.

The first potential evidence for herding or flocking as a widespread behavior common to many dinosaur groups in addition to birds was the 1878 discovery of 31 Iguanodon bernissartensis, ornithischians that were then thought to have perished together in Bernissart, Belgium, after they fell into a deep, flooded sinkhole and drowned. Other mass-death sites have been discovered subsequently. Those, along with multiple trackways, suggest that gregarious behavior was common in many early dinosaur species. Trackways of hundreds or even thousands of herbivores indicate that duck-bills (hadrosaurids) may have moved in great herds, like the American bison or the African springbok. Sauropod tracks document that these animals traveled in groups composed of several different species, at least in Oxfordshire, England, although there is no evidence for specific herd structures. Congregating into herds may have evolved for defense, for migratory purposes, or to provide protection for young. There is evidence that many types of slow-growing dinosaurs, including various theropods, sauropods, ankylosaurians, ornithopods, and ceratopsians, formed aggregations of immature individuals. One example is a site in Inner Mongolia that has yielded the remains of over 20 Sinornithomimus, from one to seven years old. This assemblage is interpreted as a social group that was trapped in mud. The interpretation of dinosaurs as gregarious has also extended to depicting carnivorous theropods as pack hunters working together to bring down large prey. However, this lifestyle is uncommon among modern birds, crocodiles, and other reptiles, and the taphonomic evidence suggesting mammal-like pack hunting in such theropods as Deinonychus and Allosaurus can also be interpreted as the results of fatal disputes between feeding animals, as is seen in many modern diapsid predators.

[](https://en.wikipedia.org/wiki/File:Centrosaurus_dinosaur.png)

Artist's rendering of two[*Centrosaurus apertus*](https://en.wikipedia.org/wiki/Centrosaurus) engaged in intra-specific combat

The crests and frills of some dinosaurs, like the marginocephalians, theropods and lambeosaurines, may have been too fragile to be used for active defense, and so they were likely used for sexual or aggressive displays, though little is known about dinosaur mating and territorialism. Head wounds from bites suggest that theropods, at least, engaged in active aggressive confrontations.

[[](https://en.wikipedia.org/wiki/File:Maiasaurusnest.jpg)](https://en.wikipedia.org/wiki/File:Maiasaurusnest.jpg)

A nesting ground of hadrosaur[*Maiasaura peeblesorum*](https://en.wikipedia.org/wiki/Maiasaura) was discovered in 1978.

From a behavioral standpoint, one of the most valuable dinosaur fossils was discovered in the Gobi Desert in 1971. It included a Velociraptor attacking a Protoceratops, providing evidence that dinosaurs did indeed attack each other. Additional evidence for attacking live prey is the partially healed tail of an Edmontosaurus, a hadrosaurid dinosaur; the tail is damaged in such a way that shows the animal was bitten by a tyrannosaur but survived. Cannibalism amongst some species of dinosaurs was confirmed by tooth marks found in Madagascar in 2003, involving the theropod Majungasaurus.

Comparisons between the scleral rings of dinosaurs and modern birds and reptiles have been used to infer daily activity patterns of dinosaurs. Although it has been suggested that most dinosaurs were active during the day, these comparisons have shown that small predatory dinosaurs such as dromaeosaurids, Juravenator, and Megapnosaurus were likely nocturnal. Large and medium-sized herbivorous and omnivorous dinosaurs such as ceratopsians, sauropodomorphs, hadrosaurids, ornithomimosaurs may have been cathemeral, active during short intervals throughout the day, although the small ornithischian Agilisaurus was inferred to be diurnal.

Based on current fossil evidence from dinosaurs such as Oryctodromeus, some ornithischian species seem to have led a partially fossorial (burrowing) lifestyle. Many modern birds are arboreal (tree climbing), and this was also true of many Mesozoic birds, especially the enantiornithines. While some early bird-like species may have already been arboreal as well (including dromaeosaurids such as Microraptor) most non-avialan dinosaurs seem to have relied on land-based locomotion. A good understanding of how dinosaurs moved on the ground is key to models of dinosaur behavior; the science of biomechanics, pioneered by Robert McNeill Alexander, has provided significant insight in this area. For example, studies of the forces exerted by muscles and gravity on dinosaurs' skeletal structure have investigated how fast dinosaurs could run, whether diplodocids could create sonic booms via whip-like tail snapping, and whether sauropods could float.

**Communication:**

Modern birds are known to communicate using visual and auditory signals, and the wide diversity of visual display structures among fossil dinosaur groups suggests that visual communication has always been important in dinosaur biology. However, the evolution of dinosaur vocalization is less certain. In 2008, paleontologist Phil Senter examined the evidence for vocalization in Mesozoic animal life, including dinosaurs. Senter found that, contrary to popular depictions of roaring dinosaurs in motion pictures, it is likely that most Mesozoic dinosaurs were not capable of creating any vocalizations To draw this conclusion, Senter studied the distribution of vocal organs in modern reptiles and birds. He found that vocal cords in the larynx probably evolved multiple times among reptiles, including crocodilians, which are able to produce guttural roars. Birds, on the other hand, lack a larynx. Instead, bird calls are produced by the syrinx, a vocal organ found only in birds, and which is not related to the larynx, meaning it evolved independently from the vocal organs in reptiles.

The syrinx depends on the air sac system in birds to function; specifically, it requires the presence of a clavicular air sac near the wishbone or collar bone. This air sac leaves distinctive marks or opening on the bones, including a distinct opening in the upper arm bone (humerus). While extensive air sac systems are a unique characteristic of saurischian dinosaurs, the clavicular air sac necessary to vocalize does not appear in the fossil record until the enantiornithines (one exception, Aerosteon, probably evolved its clavicular air sac independently of birds for reasons other than vocalization). Senter suggests that non-avian dinosaurs used primarily visual communication, in the form of distinctive-looking (and possibly brightly colored) horns, frills, crests, sails and feathers. This is similar to some modern reptile groups such as lizards, in which many forms are largely silent (though like dinosaurs they possess well-developed senses of hearing) but use complex coloration and display behaviors to communicate. In addition, other, non-vocal, methods of producing sound for communication include hissing, jaw grinding or clapping, use of environment (such as splashing), and wing beating (possible in winged maniraptoran dinosaurs). Senter states that the presence of resonance chambers in some dinosaurs is not necessarily evidence of vocalization as modern snake such chambers which intensify their hisses.

[[](https://en.wikipedia.org/wiki/File:Lambeosaurus_magnicristatus_DB.jpg)](https://en.wikipedia.org/wiki/File:Lambeosaurus_magnicristatus_DB.jpg)

Artist's impression of a striking and unusual visual display in a[*Lambeosaurus magnicristatus*](https://en.wikipedia.org/wiki/Lambeosaurus)

**Reproductive biology:**

Three bluish eggs with black speckling sit atop a layer of white mollusk shell pieces, surrounded by sandy ground and small bits of bluish stone

[](https://en.wikipedia.org/wiki/File:Gniazdo_sieweczki_RB.JPG)

Nest of a [plover](https://en.wikipedia.org/wiki/Plover) (*[Charadrius](https://en.wikipedia.org/wiki/Charadrius" \o "Charadrius)*)

All dinosaurs lay amniotic eggs with hard shells made mostly of calcium carbonate. Eggs are usually laid in a nest. Most species create somewhat elaborate nests, which can be cups, domes, plates, beds scrapes, mounds, or burrows. Some species of modern bird have no nests; the cliff-nesting common guillemot lays its eggs on bare rock, and male emperor penguins keep eggs between their body and feet. Primitive birds and many non-avialan dinosaurs often lay eggs in communal nests, with males primarily incubating the eggs. While modern birds have only one functional oviduct and lay one egg at a time, more primitive birds and dinosaurs had two oviducts, like crocodiles. Some non-avialan dinosaurs, such as Troodon, exhibited iterative laying, where the adult might lay a pair of eggs every one or two days, and then ensured simultaneous hatching by delaying brooding until all eggs were laid.

When laying eggs, females grow a special type of bone between the hard outer bone and the marrow of their limbs. This medullary bone, which is rich in calcium, is used to make eggshells. A discovery of features in a Tyrannosaurus rex skeleton provided evidence of medullary bone in extinct dinosaurs and, for the first time, allowed paleontologists to establish the sex of a fossil dinosaur specimen. Further research has found medullary bone in the carnosaur Allosaurus and the ornithopod Tenontosaurus. Because the line of dinosaurs that includes Allosaurus and Tyrannosaurus diverged from the line that led to Tenontosaurus very early in the evolution of dinosaurs, this suggests that the production of medullary tissue is a general characteristic of all dinosaurs.

[[](https://en.wikipedia.org/wiki/File:Citipati_IGM_100_979.jpg)](https://en.wikipedia.org/wiki/File:Citipati_IGM_100_979.jpg)

Fossil interpreted as a nesting[oviraptorid](https://en.wikipedia.org/wiki/Oviraptoridae) *[Citipati](https://en.wikipedia.org/wiki/Citipati" \o "Citipati)* at the [American Museum of Natural History](https://en.wikipedia.org/wiki/American_Museum_of_Natural_History). Smaller fossil far right showing inside one of the eggs.

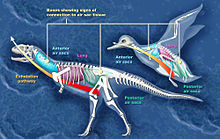
Another widespread trait among modern birds is parental care for young after hatching. Jack Horner's 1978 discovery of a Maiasaura ("good mother lizard") nesting ground in Montana demonstrated that parental care continued long after birth among ornithopods, suggesting this behavior might also have been common to all dinosaurs. There is evidence that other non-theropod dinosaurs, like Patagonian titanosaurian sauropods, also nested in large groups. A specimen of the Mongolian oviraptorid Citipati osmolskae was discovered in a chicken-like brooding position in 1993, which may indicate that they had begun using an insulating layer of feathers to keep the eggs warm. Parental care being a trait common to all dinosaurs is supported by other finds. For example, a dinosaur embryo (pertaining to the prosauropod Massospondylus) was found without teeth, indicating that some parental care was required to feed the young dinosaurs. Trackways have also confirmed parental behavior among ornithopods from the Isle of Skye in northwestern Scotland. Nests and eggs have been found for most major groups of dinosaurs, and it appears likely that all dinosaurs cared for their young to some extent either before or shortly after hatching.

**Physiology:**

Because both modern crocodilians and birds have four-chambered hearts (albeit modified in crocodilians), it is likely that this is a trait shared by all archosaurs, including all dinosaurs. While all modern birds have high metabolisms and are "warm blooded" (endothermic), a vigorous debate has been ongoing since the 1960s regarding how far back in the dinosaur lineage this trait extends. Scientists disagree as to whether non-avian dinosaurs were endothermic, ectothermic, or some combination of both.

After non-avian dinosaurs were discovered, paleontologists first posited that they were ectothermic. This supposed "cold-bloodedness" was used to imply that the ancient dinosaurs were relatively slow, sluggish organisms, even though many modern reptiles are fast and light-footed despite relying on external sources of heat to regulate their body temperature. The idea of dinosaurs as ectothermic and sluggish remained a prevalent view until Robert T. "Bob" Bakker, an early proponent of dinosaur endothermy, published an influential paper on the topic in 1968.

Modern evidence indicates that even non-avian dinosaurs and birds thrived in cooler temperate climates, and that at least some early species must have regulated their body temperature by internal biological means (aided by the animals' bulk in large species and feathers or other body coverings in smaller species). Evidence of endothermy in Mesozoic dinosaurs includes the discovery of polar dinosaurs in Australia and Antarctica as well as analysis of blood-vessel structures within fossil bones that are typical of endotherms. Scientific debate continues regarding the specific ways in which dinosaur temperature regulation evolved.

[](https://en.wikipedia.org/wiki/File:Dino_bird_h.jpg)

Comparison between the [air sacs](https://en.wikipedia.org/wiki/Air_sacs) of an [abelisaur](https://en.wikipedia.org/wiki/Abelisaur) and a bird

In saurischian dinosaurs, higher metabolisms were supported by the evolution of the avian respiratory system, characterized by an extensive system of air sacs that extended the lungs and invaded many of the bones in the skeleton, making them hollow. Early avian-style respiratory systems with air sacs may have been capable of sustaining higher activity levels than mammals of similar size and build could sustain. In addition to providing a very efficient supply of oxygen, the rapid airflow would have been an effective cooling mechanism, which is essential for animals that are active but too large to get rid of all the excess heat through their skin.

Like other reptiles, dinosaurs are primarily uricotelic, that is, their kidneys extract nitrogenous wastes from their bloodstream and excrete it as uric acid instead of urea or ammonia via the ureters into the intestine. In most living species, uric acid is excreted along with feces as a semisolid waste. However, at least some modern birds (such as hummingbirds) can be facultatively ammonotelic, excreting most of the nitrogenous wastes as ammonia. They also excrete creatine, rather than creatinine like mammals. This material, as well as the output of the intestines, emerges from the cloaca. In addition, many species regurgitate pellets, and fossil pellets that may have come from dinosaurs are known from as long ago as the Cretaceous period.

**Soft tissue and DNA:**

One of the best examples of soft-tissue impressions in a fossil dinosaur was discovered in Pietraroia, Italy. The discovery was reported in 1998, and described the specimen of a small, very young coelurosaur, Scipionyx samniticus. The fossil includes portions of the intestines, colon, liver, muscles, and windpipe of this immature dinosaur.

In the March 2005 issue of Science, the paleontologist Mary Higby Schweitzer and her team announced the discovery of flexible material resembling actual soft tissue inside a 68-million-year-old Tyrannosaurus rex leg bone from the Hell Creek Formation in Montana. After recovery, the tissue was rehydrated by the science team. When the fossilized bone was treated over several weeks to remove mineral content from the fossilized bone-marrow cavity (a process called demineralization), Schweitzer found evidence of intact structures such as blood vessels, bone matrix, and connective tissue (bone fibers). Scrutiny under the microscope further revealed that the putative dinosaur soft tissue had retained fine structures (microstructures) even at the cellular level. The exact nature and composition of this material, and the implications of Schweitzer's discovery, are not yet clear.

In 2009, a team including Schweitzer announced that, using even more careful methodology, they had duplicated their results by finding similar soft tissue in a duck-billed dinosaur, Brachylophosaurus canadensis, found in the Judith River Formation of Montana. This included even more detailed tissue, down to preserved bone cells that seem even to have visible remnants of nuclei and what seem to be red blood cells. Among other materials found in the bone was collagen, as in the Tyrannosaurus bone. The type of collagen an animal has in its bones varies according to its DNA and, in both cases, this collagen was of the same type found in modern chickens and ostriches.

The extraction of ancient DNA from dinosaur fossils has been reported on two separate occasions; upon further inspection and peer review, however, neither of these reports could be confirmed. However, a functional peptide involved in the vision of a theoretical dinosaur has been inferred using analytical phylogenetic reconstruction methods on gene sequences of related modern species such as reptiles and birds. In addition, several proteins, including hemoglobin, have putatively been detected in dinosaur fossils.

In 2015, researchers reported finding structures similar to blood cells and collagen fibers, preserved in the bone fossils of six Cretaceous dinosaur specimens, which are approximately 75 million years old.