United States Geological Survey

By Ronald J. Litwin, Robert E. Weems, and Thomas R. Holtz, Jr.

Few subjects in the Earth sciences are as fascinating to the public as dinosaurs. The study of dinosaurs stretches our imaginations, gives us new perspectives on time and space, and invites us to discover worlds very different from our modern Earth.

From a scientific viewpoint, however, the study of dinosaurs is important both for understanding the causes of past major extinctions of land animals and for understanding the changes in biological diversity caused by previous geological and climatic changes of the Earth. These changes are still occurring today. A wealth of new information about dinosaurs has been learned over the past 30 years, and science's old ideas of dinosaurs as slow, clumsy beasts have been totally turned around. This pamphlet contains answers to some frequently asked questions about dinosaurs, with current ideas and evidence to correct some long-lived popular misconceptions. Although much has been discovered recently about dinosaurs, there is still a great deal more to learn about our planet and its ancient inhabitants.

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When did the dinosaurs first appear on earth?

The oldest dinosaur types are known from rocks in Argentina and Brazil and are about 230 million years old. The most primitive of these types, *Eoraptor*, was a small meat-eating dinosaur. Because *Eoraptor*'s skeleton shows some advanced skeletal features, older dinosaurs may yet be found.

Are all fossil animals dinosaurs?

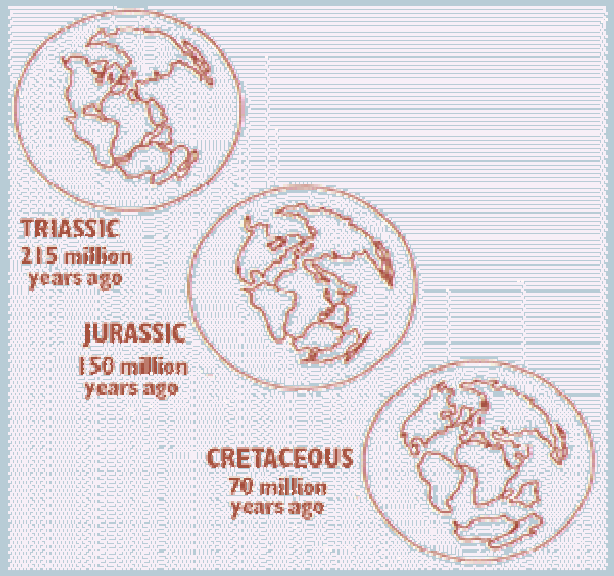
No. Dinosaurs are a group of ancient reptiles that had a set of particular skeletal features. The hips, hind legs, and ankles were specialized and allowed the legs to move directly under the body, rather than extending out from the side of the body as in modern lizards. This arrangement enabled dinosaurs to bring their knees and ankles directly below their hips and provided the necessary attachments for very strong leg muscles. Dinosaur skeletons were well designed for supporting a large body, for standing erect (upright), and for running. The front legs were adapted for grasping prey, for supporting weight, or for walking and running. The skulls of dinosaurs were designed for maximum strength, for minimum weight, and (in some cases) for grasping, holding, or tearing at prey. These skeletal features separated dinosaurs from other ancient reptiles such as *Dimetrodon*, the plesiosaurs, and pterosaurs. Fossil mammals, like mammoths and "saber-toothed tigers" (e.g., *Smilodon*), are also often incorrectly called dinosaurs.

Did people and dinosaurs live at the same time?

No! After the dinosaurs died out, nearly 65 million years passed before people appeared on Earth. However, small mammals (including shrew-sized primates) *were* alive at the time of the dinosaurs. Many scientists who study dinosaurs (vertebrate paleontologists) now think that birds are direct descendants of one line of carnivorous dinosaurs, and some consider that they in fact represent modern living dinosaurs. This theory remains under discussion and shows that there is still much we don't know about dinosaurs.

Where did dinosaurs live?

Paleontologists now have evidence that dinosaurs lived on all of the continents. At the beginning of the age of dinosaurs (during the Triassic Period, about 230 million years ago) the continents we now know were arranged together as a single supercontinent called Pangea. During the 165 million years of dinosaur existence this supercontinent slowly broke apart. Its pieces then spread across the globe into a nearly modern arrangement by a process called plate tectonics. Volcanoes, earthquakes, mountain building, and sea-floor spreading are all part of plate tectonics, and this process is still changing our modern Earth.



Did all the dinosaurs live together, and at the same time?

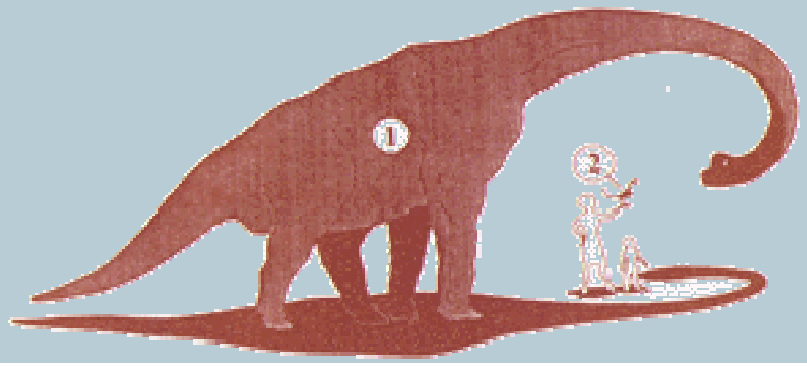
Dinosaur communities were separated by both time and geography. The "age of dinosaurs" (the Mesozoic Era) included three consecutive geologic time periods (the Triassic, Jurassic, and Cretaceous Periods). Different dinosaur species lived during each of these three periods. For example, the Jurassic dinosaur *Stegosaurus* already had been extinct for approximately 80 million years before the appearance of the Cretaceous dinosaur *Tyrannosaurus*. In fact, the time separating *Stegosaurus* and *Tyrannosaurus* is greater than the time separating *Tyrannosaurus* and you. At the beginning of dinosaur history (the Triassic Period), there was one supercontinent on Earth (Pangea). Many dinosaur types were widespread across it. However, as Pangea broke apart, dinosaurs became scattered across the globe on separate continents, and new types of dinosaurs evolved separately in each geographic area

How are dinosaurs named?

Dinosaurs generally are named after a characteristic body feature, after the place where they were found, or after a person involved in the discovery. Usually the name consists of two Greek or Latin words (or combinations); in order, these are the genus (plural, genera) and the species name. For example, the Greek and Latin combination (binomen) *Tyrannosaurus rex* means "king of the tyrant lizards." Biologists name modern animals exactly the same way. Some examples include humans (*Homo sapiens*), domestic dogs (*Canis familiaris*), golden eagles (*Aquila chrysaetos*), box turtles (*Terrapene carolina*), and rattlesnakes (*Crotalus horridus*).

What was the biggest dinosaur? What was the smallest?

The largest complete dinosaur we know of was *Brachiosaurus* ("arm lizard"); it reached 23 m in length and 12 m in height (about the length of two large school buses and the height of a four-story building). Fragmentary leg bones and vertebrae of even larger dinosaur species are known, but these skeletal remains are too incomplete to determine their exact size. Several of these (*Argentinasaurus* and *Amphicoelias*) might have been one and a half to two times larger than *Brachiosaurus*. The smallest dinosaurs were just slightly larger than a chicken; *Compsognathus* ("pretty jaw") was 1 m (3 ft) long and probably weighed about 2.5 kg (about 6.5 lb). These three dinosaur types all lived during the Jurassic Period. *Mussaurus* ("mouse lizard") was claimed as the smallest dinosaur, but it is now known to be the hatchling of a dinosaur type that was much larger than *Compsognathus* when fully grown. If birds **are** advanced dinosaurs, then the smallest dinosaur would be the hummingbird!



How many types of dinosaurs are known?

Approximately 700 species have been named. However, a recent scientific review suggests that only about half of these are based on fairly complete specimens that can be shown to be unique and separate species. These species are placed in about 300 valid dinosaur genera (*Stegosaurus*, *Diplodocus*, etc.), although about 540 have been named. Recent estimates suggest that about 700 to 900 *more* dinosaur genera may remain to be discovered.

Most dinosaur genera presently contain only one species (for example, *Deinonychus*) but some have more (for example, *Iguanodon*). Even if all of the roughly 700 published species are valid, their number is still less than one-tenth the number of currently known living bird species, less than one-fifth the number of currently known mammal species, and less than one-third the number of currently known spider species.

Were dinosaurs warm-blooded?

Scientists have conflicting opinions on this subject. Some paleontologists think that all dinosaurs were "warm-blooded" in the same sense that modern birds and mammals are: that is, they had rapid metabolic rates. Other scientists think it unlikely that any dinosaur could have had a rapid metabolic rate. Some scientists think that very big dinosaurs could have had warm bodies because of their large body size, just as some sea turtles do today. It may be that some dinosaurs were warm-blooded. The problem is that it is hard to find evidence that unquestionably shows what dinosaur metabolisms were like.

How long could a dinosaur live?

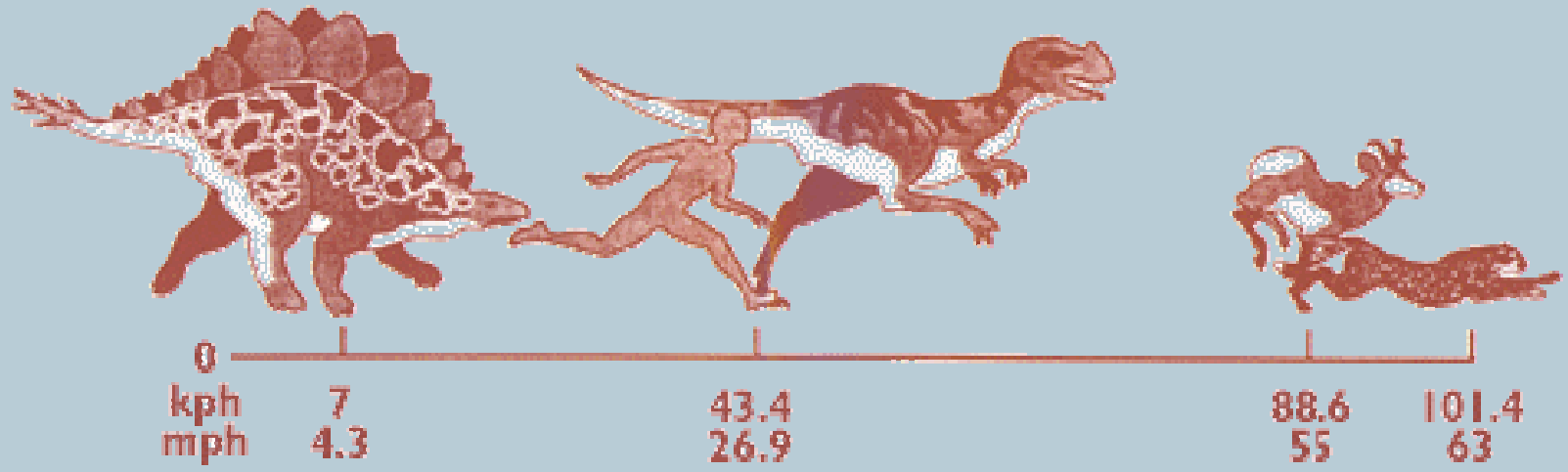
Animal lifespans relate in part to their body size and in part to their type of metabolism. Dinosaur lifespans probably varied in length from tens of years to hundreds of years. Their possible maximum age can be estimated from the maximum lifespans of modern reptiles, such as the 66-year lifespan of the common alligator (*Alligator mississippiensis*) and the impressive lifespan of a Black Seychelles Tortoise (*Geochelone (Aldabrachelys) sumeirei*). One specimen of this now-extinct species, which was an adult when captured, lived a record 152 years in captivity (1766-1918) and had an accidental death. These estimates, based on lifespans of cold-blooded animals, would be too long if dinosaurs had metabolisms more similar to modern birds and mammals.

What did dinosaurs eat?

Some dinosaurs ate lizards, turtles, eggs, or early mammals. Some hunted other dinosaurs or scavenged dead animals. Most, however, ate plants (but not grass, which hadn't evolved yet). Rocks that contains dinosaur bones also contain fossil pollen and spores that indicate hundreds to thousands of types of plants existed during the Mesozoic Era. Many of these plants had edible leaves, including evergreen conifers (pine trees, redwoods, and their relatives), ferns, mosses, horsetail rushes, cycads, ginkos, and in the latter part of the dinosaur age flowering (fruiting) plants. Although the exact time of origin for flowering plants is still uncertain, the last of the dinosaurs certainly had fruit available to eat.

How fast could dinosaurs walk or run?

Estimates of dinosaur speeds vary because several different methods are used to calculate them. One recent estimate suggests that an average person might have been able to to outrun an adult *Tyrannosaurus* (although you probably would not volunteer to try). The two basic approaches for estimating dinosaur speed are comparing to recorded speeds of modern animals of similar body size and build, and measuring distances between fossil footprints in a trackway and using these distances to calculate estimated speed. Walking-speed estimates for medium-sized bipedal (two-legged) dinosaurs vary from 4 kph to 6 kph, and peak running-speed estimates vary from 37 kph to 88 kph. The highest figure (88.6 kph) is the same as the peak speed of the currently fastest land animals, such as the North American pronghorn "antelope" (*Antilocapra americana*), and very probably is too high.



Did dinosaurs communicate?

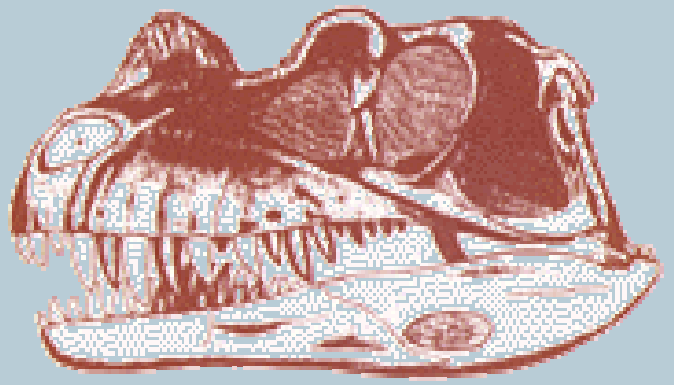
Dinosaurs probably communicated both vocally and visually. The chambered headcrests on some dinosaurs such as *Corythosaurus* and *Parasaurolophus* might haved been used to amplify grunts or bellows. Defensive posturing, courtship behavior, and territory fights probably involved both vocal and visual displays. An angry *Triceratops* bull shaking his head at you, even silently, would have made himself very clearly understood!

Why did some dinosaurs grow so big?

Paleontologists don't know for certain, but perhaps a large body size protected them from most predators, helped to regulate internal body temperature, or let them reach new sources of food (some probably browsed treetops, as giraffes do today). No modern animals except whales are even close in size to the largest dinosaurs; therefore, paleontologists think that the dinosaurs' world was much different from the world today and that climate and food supplies must have been favorable for reaching great size.

Which was the smartest dinosaur?

Although there is no direct way to measure a dinosaur's intelligence, one of the few possible measures of intelligence might be a large brain in a small body. The genus that perhaps fits this description best was the Cretaceous bird-like dinosaur *Troodon*, which also may have had binocular vision (depth perception) and excellent eyesight and was built for speed. Even so, this dinosaur was probably not as "intelligent" as most modern birds and mammals.

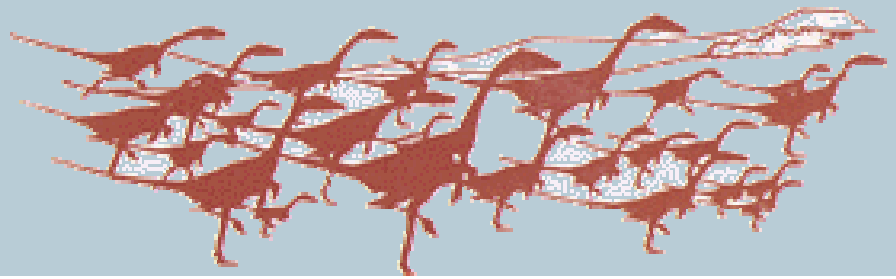


What colors were dinosaurs?

Direct fossil evidence for dinosaur skin color is unknown. Paleontologists think that some dinosaurs likely had protective coloration, such as pale undersides to reduce shadows, irregular color patterns ("camouflage") to make them less visible in vegetation, and so on. Those dinosaurs that had enough armor, such as the stegosaurs and ceratopsians, may not have needed protective coloration but may have been brightly colored as a warning to predators or as a display for finding a mate. Most dinosaurs probably were as brightly colored as modern lizards, snakes, or birds.

Were dinosaurs social animals?

Some dinosaurs were social creatures. Recently discovered evidence indicates that they travelled together and that some may even have migrated (because dinosaur fossils have been found above the Arctic Circle, where food supply would have been seasonal). Grouped hadrosaur nest sites have been found with badly crushed eggshells and skeletons of baby dinosaurs (with slightly worn teeth) still in the nests, suggesting that some babies stayed in their nests after hatching and probably were fed by parents.



When did dinosaurs become extinct?

Dinosaurs went extinct about 65 million years ago (at the end of the Cretaceous Period), after living on Earth for about 165 million years. If all of Earth time from the very beginning of the dinosaurs to today were compressed into 365 days (1 calendar year), the dinosaurs appeared January 1 and became extinct the third week of September. (Using this same time scale, the Earth would have formed approximately 18.5 years earlier.) By comparison, people (*Homo sapiens*) have been on earth only since December 31 (New Year's eve). The dinosaurs' long period of dominance certainly makes them unqualified successes in the history of life on Earth.

Why did the dinosaurs die out?

There are dozens of theories to explain a probable cause or causes. Throughout the Mesozoic Era, individual dinosaur species were evolving and becoming extinct for various reasons. The unusually massive extinction at the end of the Cretaceous exterminated the last of the dinosaurs, the flying reptiles, and the large swimming reptiles, as well as many other marine animals. There is now widespread evidence that a meteorite impact was at least the partial cause for this extinction. Impact craters are visible on most planets in our solar system. A spectacular example of this was witnessed in 1994, when Jupiter was struck by a series of cometary fragments. Some of these impact blasts were larger than the Earth's diameter. Other factors such as extensive release of volcanic gases, climatic cooling (with related changes in ocean currents and weather patterns), sea-level change, low reproduction rates, poison gases from a comet, or changes in the Earth's orbit or magnetic field may have contributed to this extinction event