

Scientists are starting to crack the once imponderable  
mystery of how the big reptiles had sex

*By Brian Switek*

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PALEONTOLOGY

# LOVE AMONG THE DINOSAURS

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**W**AS SHUFFLING THROUGH CHICAGO'S O'HARE INTERNATIONAL AIRPORT WHEN I SAW IT: A MAGNIFICENT, towering skeleton of a dinosaur. At first I thought it was a mirage created by my travel-addled brain. But the scene did not evaporate as I approached. Pillarlike forelimbs and brawny shoulders supported a long swerve of neck bones leading up to the dinosaur's small, boxy skull, which peered over the top of a banner touting the airport's Wi-Fi, as if looking to the tarmac beyond to check the latest departures and arrivals. I stopped and stared at the behemoth—a replica of *Brachiosaurus* inherited from the Field Museum in Chicago—mentally filling in the internal organs, muscles and skin of a creature that at 85 feet long is one of the largest dinosaurs ever found. And then a strange thought bubbled up in my mind: How did such a gargantuan animal have sex?

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Giddy and tired, I envisioned a pair of amorous *Brachiosaurus* standing in a clearing in a conifer forest some 150 million years ago during the Jurassic period, each one waiting for the other to make the first move. But try as I might, I couldn't quite figure out the mechanics of what should come next. Could the male rear up to mount the female? Could the female support his weight? Wouldn't her massive tail get in the way? Alas, my flight started boarding, so I had to part ways with the skeleton, but I continued to ponder the



mating mystery on the plane. It has captivated me ever since.

Dinosaurs must have had sex to reproduce. As in nearly all modern-day reptiles, males would have deposited sperm inside females, which would later lay fertilized eggs containing developing dinosaur embryos. Yet although scientists have managed to deduce quite a bit about dinosaur biology, the nuts and bolts of dinosaur sex remained largely unknown—in part because studying the sexual behavior of animals was taboo historically and the topic seemed so beyond the reach of science that very little could be said about dinosaur mating with confidence. Not all hope is lost, however. Dinosaur fossils have furnished clues to such intimate details as when during development these reptiles reached sexual maturity and how they attracted mates. Meanwhile studies of birds and crocodylians—the closest living relatives of dinosaurs—hint at what the external reproductive anatomy of dinosaurs looked like. And computer modeling offers the possibility of testing theories about how these giants managed to do the deed itself. Much remains to be discovered, but scientists are slowly drawing back the curtain on dinosaur amour.

### LOCK AND KEY

SIGNS OF SEX are hard to find in the fossil record of any creature. Among the rare examples are 47-million-year-old turtles that died while copulating and a pair of 320-million-year-old sharks that might have been courting when they were rapidly buried. Sadly no dinosaur skeletons have been found locked in romantic embrace. And not even the most beautifully preserved of these beasts retain remains of their reproductive organs.

For insights into the private parts of these extinct animals, scientists have had to turn to their closest extant relatives: birds and crocodylians. Birds are living dinosaurs, a specialized lineage that evolved around 150 million years ago and continues to thrive today. Crocodylians—a group that includes the alligators, gharials and crocodiles—are the closest living relatives of the group formed by extinct dinosaurs and modern birds. A trait present in both birds and crocodylians is likely to have been present in nonavian dinosaurs as well. One such trait is a cloaca—the single end point for the reproductive, urinary and intestinal tracts in both sexes of birds and crocodylians and probably, by extension, dinosaurs. Thus, an *Apatosaurus's* genitals would not be visible as it plodded by. Instead they would have been concealed in the cloaca, which would have appeared only as a slit underneath the dinosaur's tail.

Most male birds do not have a penis inside their cloaca and instead pass semen to females by pressing their orifice to the female's in a "cloacal kiss." But some male birds are well endowed, and, intriguingly, their lineages are all near the base of the bird family tree. According to Patricia Brennan of the University of Massachusetts Amherst and her colleagues, this pattern means that ancient birds had penises and that other lineages of birds lost this trait later in their evolution. Like waterfowl and

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other archaic bird lineages, male crocodylians have penises, too, which they use to inseminate females in the same fashion. Thus, male dinosaurs almost certainly had them. And if the genitals of crocs and endowed birds are any indication, the dinosaur phallus took the form of a single, unpaired organ with at least one long runnel down which semen flowed during sex. That being said, with more than 1,850 genera of dinosaurs estimated to have lived between 245 million and 66 million years ago, there were probably numerous variations on this theme.

### BOY OR GIRL?

RECONSTRUCTING the mating habits of dinosaurs requires more than just an understanding of their reproductive organs, however. Scientists need to be able to tell males apart from females, which in the absence of genitalia is easier said than done. Investigators have long sought skeletal characteristics that might distinguish one sex from the other in lieu of soft tissue. But most of the traits proposed to fit this bill—such as a large crest atop the head marking *Lambeosaurus* individuals as male—have turned out to be unreliable indicators of gender.

Because skeletal differences between male and female dinosaurs are so elusive, if there are any at all, the only way that we can identify dinosaur sexes is through more direct evidence. Finding developing eggs inside a dinosaur's body cavity—as with a rare oviraptorosaur specimen from China—is one way to pinpoint a female dinosaur. But there is another option. In 2000 a special specimen of *Tyrannosaurus rex* finally yielded a way to identify hidden female dinosaurs. When some species of female birds are growing eggs, they develop a thin layer of tissue called medullary bone inside the shafts of the long bones in their hind limbs. This tissue is calcium-rich and acts as a store of raw material for creating eggshells. When Mary H. Schweitzer of North Carolina State University examined the broken thighbone of the *T. rex*, she spotted medullary bone. The specimen must have been a female who was pregnant when she died. Not only did the discovery mean that this physiological response to pregnancy evolved in the dinosaur ancestors of birds, but it also revealed a means of identifying female dinosaurs—at least pregnant ones.

Building on Schweitzer's discovery, Andrew Lee, now at Midwestern University, and Sarah Werning of the University of California, Berkeley, investigated when in their development dinosaurs became sexually active. Previous work had shown that dinosaurs have rings in their bones that can be used to estimate their age at death. These so-called lines of arrested growth (or

### IN BRIEF

**Scientists historically skirted** the subject of how dinosaurs had sex, out of

modesty and an absence of evidence. **But studies** of the closest living relatives

of dinosaurs are providing insights into their probable reproductive anatomy.

**And computer models** can test the plausibility of putative mating positions.

LAGs), most likely represent a yearly slowdown in growth during tough times, such as a dry season when water and food are scarce. The LAGs, along with reconstructions of dinosaur growth curves, indicate that many dinosaurs grew rapidly during their early lives and slowed as they approached skeletal maturity.

Looking at the LAGs in the pregnant *T. rex*, as well as two other dinosaurs containing traces of medullary bone—a beaked herbivore called *Tenontosaurus* and the carnivore *Allosaurus*—Lee and Werning concluded that all three dinosaurs were young moms when they died. *Tenontosaurus* perished at around eight years of age, *Allosaurus* at 10 and *Tyrannosaurus* at 18. All these dinosaurs were still growing—their skeletons had not yet developed to full maturity. And the medullary bone only indicated the latest date at which each female started having sex.

Dinosaurs lived fast and died young. Rapid growth and early reproduction, Lee and Werning suggested, might attest to difficult, dangerous lives in which mating early was required for a dinosaur to pass along its genes to the next generation. Early breeding would have been particularly important for the biggest dinosaurs. If an 80-foot dinosaur such as *Apatosaurus* took decades to grow to sexual maturity, there would be very few of them left to mate by the time they matured. Instead, Lee and Werning estimated, these dinosaurs probably started copulating long before they reached maximum size, probably by 19 years of age. Teenagers will be teenagers, after all.

### BIG BANG THEORIES

BEFORE GETTING DOWN and dirty, however, dinosaurs had to attract mates. Paleontologists have wondered whether many of the extravagant adornments of dinosaurs—including crests, spikes, plates, horns and feathers—could have served to seduce. The long necks of sauropods might have functioned similarly. Although the extravagant necks most likely evolved to allow these dinosaurs to reach a wide range of food, they could have been co-opted during the mating season, possibly developing striking color patterns to advertise their good health to potential partners. (Many immense sauropods were too big to be threatened by predators and so could afford to ditch the camouflage in favor of flashy hues.) Other dinosaurs probably showed off, too. Maybe the spiky dinosaur *Kentrosaurus* found the plates and spikes of the opposite sex arousing, and perhaps females of the sauropod *Amargasaurus* looked for males with the longest neck spines. Yet for all their appeal, these extravagant traits surely complicated the act itself. Which brings us back to the question that I found myself pondering when I came across *Brachiosaurus* at O'Hare. After all the posturing and showing off, how did dinosaurs actually mate? Hypotheses for exactly how this occurred depend on what feats of strength scientists think dinosaurs were physically capable of.

Biomechanics expert R. McNeill Alexander of the University of Leeds in England imagined that dinosaurs mated just like today's elephants and rhinoceroses—females had to bear the extra weight of the mounting male. The main difference would be that dinosaurs had those big, relatively stiff tails. Working from the idea that male dinosaurs threw one of their legs over the back of the female, Alexander pointed out that the weight of the male would have rested on the female's hindquarters. This would have been a massive load, but, as Alexander noted, the

resulting stresses involved would not have been any worse than those that arise from walking because, during the step cycle, the dinosaur's weight would be supported by just one hind leg as the other swung in the air during a step. "If dinosaurs were strong enough to walk, they were strong enough to copulate," Alexander wrote in 1991. "They were presumably strong enough to do both."

British paleontologist Beverly Halstead also argued that male dinosaurs had to mount the females to inseminate them. But rather than likening them to elephants and rhinos, he believed that dinosaurs did as lizards and alligators do today. Males threw one hind leg over the back of their partners, he surmised, and this move would push their hips underneath the tails of the females to bring their cloacae together. Longer-tailed species may have even intertwined their tails for more tactile stimulation, just as some snakes twist their bodies around one another.

Personally, I have never been satisfied by this standard explanation of dinosaur sex. Scientists do

not really know if the legs and tails of sauropods could have bent and flexed enough to achieve the traditional position. Bipedal carnivores such as *Allosaurus* also looked like they would have required a good deal of balance and cooperation to make this kind of mating work. It is easy enough to draw a two-dimensional image of flexible dinosaurs,

but no one had tested these ideas against the bones or evaluated the plausibility of other positions. Did female dinosaurs lie down on their sides during the act? Or might the lovers have backed up into each other? Researchers had no shortage of ideas but exhibited seemingly little interest in going beyond line drawings.

The plated, spiked stegosaurs are perhaps the most perplexing paramours of all. Consider *Kentrosaurus*, a cousin of the more famous *Stegosaurus*. This armored dinosaur sported huge spikes on its lower back and hips that must have looked dangerous to males in the mood. I asked my paleontologist friend Heinrich Mallison of the Museum of Natural History in Berlin to evaluate the possibility that *Kentrosaurus* mated in the leg-over-back position using computer models he had previously developed to study how flexible the animal was. Mallison tested dinosaur sex positions in three dimensions and concluded that the traditional dinosaur sex position did not work for *Kentrosaurus*. If a male tried to throw his leg over the back of a crouching female, he would castrate himself on her sharp spikes. One hip spike in particular seemed to be placed to strike fear in the hearts of stegosaur suitors. These prickly dinosaurs must have had sex another way—maybe the female lay down on her side, and the male reared up to rest his torso over her hindquarters. Other dinosaur species no doubt assumed different positions, which future studies may reveal. By subjecting old bones to new technologies, scientists will start to understand how the dinosaurs proliferated over their astonishing reign. ■

Extravagant traits surely complicated the act itself.

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