Shedding Light on the Dinosaur-Bird Connection

This text is provided courtesy of the American Museum of Natural History.

When people think of dinosaurs, two types generally come to mind: the huge herbivores with their small heads and long tails and those fearsome carnivores that walked on two legs and had a mouthful of teeth like kitchen knives.

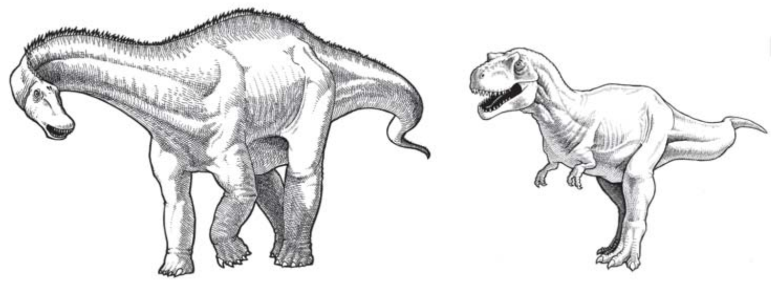
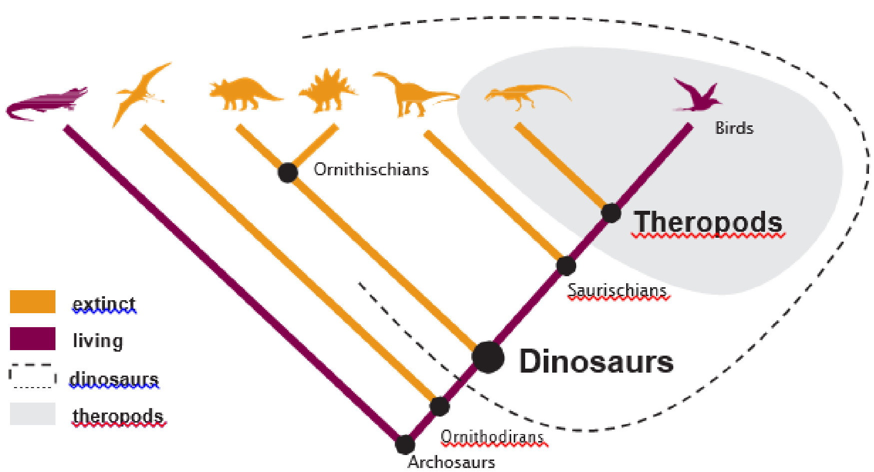


Image Credit: © AMNH

Living Dinosaurs

These large dinosaurs are no longer around, but dinosaurs still live among us today. They are the birds. It's difficult to imagine that a bird on your window sill and a *T. rex* have anything in common. One weighs less than a pound; the other was the size of a school bus, tipping the scales at eight tons. But for all their differences, the two are more closely related than you might think. Birds are living dinosaurs, and they are remarkably similar to their closest extinct relatives, the non-bird theropod dinosaurs.



You are looking at just one branch of a cladogram, a "tree" showing the relationships among organisms. The group called dinosaurs includes the extinct dinosaurs and all their living descendants. All its members, including living birds, descended from the very first dinosaur—their common ancestor. That's why birds are a kind of dinosaur (just as humans are a kind of primate).
Image Credit: © AMNH

Finding the Evidence

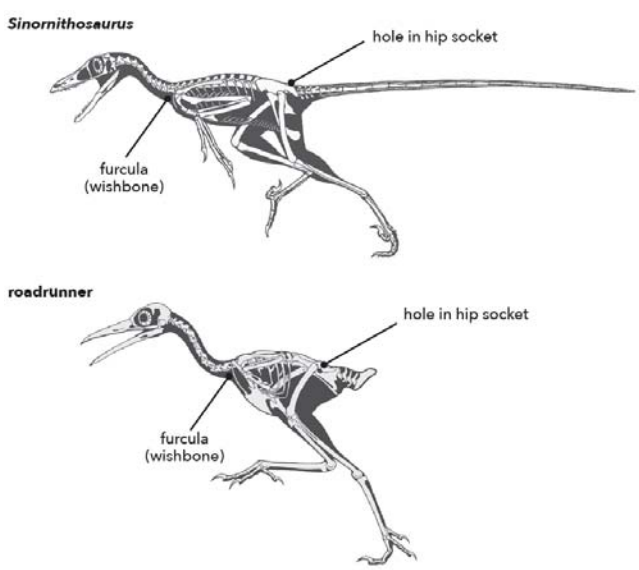

Photo Credit: © Pamala Wilson

When scientists study living animals, they can look at behavior, morphology, embryology, and DNA. It's a different story altogether when it comes to long-extinct animals. Behavior cannot be observed and their DNA has long since been destroyed. So understanding extinct animals and how they are related to living ones takes a special kind of detective work. Paleontologists use the clues found in ancient rocks: fossilized bones, teeth, eggs, footprints, teeth marks, and even dung.

To better understand the link between non-bird theropod dinosaurs and birds, scientists look for the answers to questions such as: What features do they share? What behavioral similarities are there? Scientists use the process of comparative biology to answer these questions. It's a powerful approach to understanding how birds and non-bird dinosaurs are alike and how they evolved.

Skeletal Evidence

Many similarities can be found when comparing a skeleton of a living bird to the fossilized skeleton of a non-bird theropod, like *Sinornithosaurus*. They both have a hole in the hipbone, a feature that distinguishes most dinosaurs from all other animals. This feature allows an animal to stand erect, with its legs directly beneath its body. All theropod dinosaurs, including birds, have a fused clavicle bone called a furcula, also known as a wishbone. Another shared characteristic is the presence of hollow bones. Hollow bones reduce the weight carried by an animal, resulting in the ability to run faster. This feature probably also played a role in the evolution of flight.



Sinornithosaurus and the roadrunner are both theropod dinosaurs.
Image Credit: © AMNH / Sean Murtha

Behavioral Evidence

When scientists look at non-bird theropod fossils they see evidence of behaviors that are common to living birds, such as nest-building, egg-laying, and brooding. These behaviors were first observed when, in 1993, an expedition to the Gobi Desert in Mongolia made an amazing discovery. Scientists unearthed a *Citipati* fossil brooding a cluster of eggs. Its limbs were folded back against its body. It is one of the few fossils ever found that demonstrates behavior—in this case, parental care. It shows that the behavior of brooding the nests that we see all around us today in living birds was already present in the non-bird ancestors of birds.

***Citipati* fossil nest**

Photo Credit: © AMNH / Mick Ellison

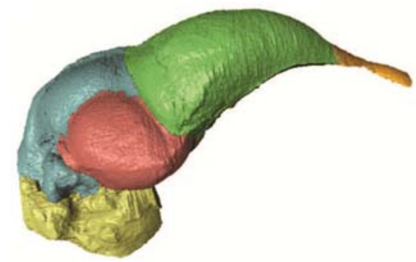
Citipati, like many other non-bird dinosaurs, had feathers. Yet it could not fly. Feathers were once thought to have evolved for flight. The discovery of more and more non-flying dinosaurs with feathers disproved that explanation. For these dinosaurs, feathers may have served other functions, including gliding, insulation, protection, and display. Feathers play that same role in many bird species today.

Sinornithosaurus had feathers similar to those of modern birds—even though it could not fly.
Photo Credit: © AMNH / Mick Ellison

Based on the evidence of shared characteristics, scientists have concluded that birds are a type of theropod dinosaur.

Brain Evidence

Birds are the only dinosaurs capable of flight. This is particularly interesting to scientists who want to know when the capability of flight emerged. One promising new area of research is focused on the brains of bird and non-bird dinosaurs. Soft tissue, such as brains, is almost never preserved in the fossil record. What is preserved is the imprint the brain left on the inside of the skull. Now scientists are using computed tomography (CT) scanners to create digital endocranial casts—detailed, three-dimensional reconstructions of the interiors of fossilized skulls. In a recent study researchers were able to peer inside the braincases of more than two dozen specimens, including birds and closely related non-bird dinosaurs. "Technology allows us to look inside these specimens without destroying them," says Dr. Amy Balanoff, a Museum research associate. "It's a non-destructive way to basically slice up a dinosaur brain and look inside and see what it can tell us about the evolution of the brain within dinosaurs. Most of us grew up thinking that dinosaurs had tiny brains, but actually some had really big brains."



Scientists use computed tomography (CT) scans of dinosaur skulls to create detailed, 3-D reconstructions of their interiors, like this one of *Archaeopteryx*. *Image Credit: © AMNH / Amy Balanoff*

The endocranial casts allow Balanoff and other researchers to explore the outer shape of the brain in more detail. In addition, the casts also provide new information about the total volume of each digital brain cast, as well as the volume and shape of different brain regions, including the olfactory bulbs, cerebrum, optic lobes, cerebellum, and brainstem. For example, the casts have provided scientists with a detailed view of the dinosaur cerebrum, a center for cognition and coordination in the brain. They found that this region was very large in non-bird dinosaurs closely related to birds. Dr. Balanoff's research suggests that these dinosaurs developed big brains long before flight, laying the cerebral foundation that made the eventual development of powered flight possible. Just as bigger brains in primates prepared the way for them to walk on two legs, bigger brains in dinosaurs prepared the way for flight.

One of the brains sampled by Dr. Balanoff was that of *Archaeopteryx* a non-bird dinosaur that was thought to mark the transition from non-bird dinosaur to bird. "If *Archaeopteryx* had a flight-ready brain, which is almost certainly the case given its morphology, then so did at least some other non-bird dinosaurs," says Dr. Balanoff. She points out though, that there is no longer a clear boundary showing where the non-bird dinosaurs end and where birds begin. "That's how evolution works. It can be a slow and messy process, and eventually we end up with the amazing diversity of things flying around us today."

Name: ______________________________ **Date:** ________________

1. What is a dinosaur that still lives among us today?

A) a *Sinornithosaurus*

B) an *Archaeopteryx*

C) a bird

D) a reptile

2. What does the author compare to living birds in this text?

A) non-bird theropods

B) living reptiles

C) huge herbivores with small heads

D) extinct birds

3. Read this sentence from the text.

“Based on the evidence of shared characteristics, scientists have concluded that birds are a type of theropod dinosaur.”

What is a piece of skeletal evidence that supports the conclusion that birds are a type of theropod dinosaur?

A) Birds brood their nests, just as non-bird theropod dinosaurs did.

B) Feathers may have been used by non-bird dinosaurs in some of the ways that birds use their feathers today.

C) The cerebrum in non-bird dinosaurs closely related to birds was very large.

D) Birds and non-bird theropod dinosaurs have a hole in their hipbone.

4. Read this sentence from the text.

“Based on the evidence of shared characteristics, scientists have concluded that birds are a type of theropod dinosaur.”

What is a piece of behavioral evidence that supports the conclusion that birds are a type of theropod dinosaur?

A) Birds brood their nests, just as non-bird theropod dinosaurs did.

B) The cerebrum in non-bird dinosaurs closely related to birds was very large.

C) Birds and non-bird theropod dinosaurs have a hole in their hipbone.

D) Birds and non-bird theropod dinosaurs have hollow bones.

5. What is the main idea of this text?

A) The behavior of animals that have been extinct for a long time cannot be observed, and their DNA has been destroyed.
B) Feathers were once thought to have evolved for flight, but now scientists think feathers may have originally served other purposes.
C) Skeletal and behavioral evidence show that birds are dinosaurs, and brain evidence supports this conclusion.
D) Scientists are using technology to reconstruct the inside of fossilized skulls and learn more about dinosaur brains.

6. Read these sentences from the text.
"One of the brains sampled by Dr. Balanoff was that of *Archaeopteryx*, a non-bird dinosaur that was thought to mark the transition from non-bird dinosaur to bird. 'If *Archaeopteryx* had a flight-ready brain, which is almost certainly the case given its morphology, then so did at least some other non-bird dinosaurs,' says Dr. Balanoff. She points out though, that there is no longer a clear boundary showing where the non-bird dinosaurs end and where birds begin. 'That's how evolution works. It can be a slow and messy process, and eventually we end up with the amazing diversity of things flying around us today.'"

What does the word "evolution" mean here?

A) a sudden and unexpected increase in size or amount
B) a sudden and unexpected decrease in size or amount
C) change that takes a day or two to happen
D) change that happens over many generations

7. Choose the answer that best completes the sentence.
"Bigger brains in primates prepared the way for them to walk on two legs. ___________, bigger brains in dinosaurs prepared the way for flight."

A) Otherwise
B) Similarly
C) For instance
D) In particular

8. What did Dr. Balanoff and other researchers discover about the size of the dinosaur cerebrum in non-bird dinosaurs closely related to birds?

9. What might big brains in certain dinosaurs have made possible, according to Dr. Balanoff's research?

10. Explain whether Dr. Balanoff's research supports the conclusion that birds are a type of dinosaur. Support your answer with information from the text.