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# How to Bring a Dinosaur to Life?

**Visitors to natural history museums can admire replicas of animals that died out ages ago. What tricks can be used to "bring them to life"? How have such animals been reconstructed in the past, and how is it done today?**

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Extinct plants and animals have fascinated people around the world for centuries. As long as 30,000 years ago, human beings were already treating fossils as something unique, using them to make ornaments and including them among burial goods. Since ancient times, people have attributed them with magical and healing powers. The fossilized bones that can be found in rocks in various places around the globe posed a puzzling mystery, and the largest ones gave rise to incredible legends. They are the source of stories about giants and dragons – in China, to this very day, dinosaurs are referred to as *konglong*, or "terrible dragons."

Of all extinct animals, dinosaurs are the most intriguing, mainly due to the enormous size of some species. These extinct Mesozoic reptiles can be admired in natural history museums and are also present in literature; they "act" in movies, entertain us at amusement parks and even decorate objects of everyday use. But how do we really know what they looked like when they were alive, since they are usually preserved as incomplete remains?

## Back to life

Striving to bring dinosaurs back to life is a joint task for paleontologists and artists. The initial work must, of course, be done by scientists – excavating, securing and classifying the finds, which are usually fossilized bones. The remains of other organisms, such as invertebrates or plants, found in the same layers as the skeletons, help us to reconstruct the environment in which the dinosaurs lived. Then, working in close collaboration with researchers, artists try to produce images of these extinct reptiles, depicting them as faithfully as possible.

At first, the skeletal structure must be reconstructed. In cases when paleontologists have complete remains at their disposal, and the animal moreover belongs to one of the well-known genera of dinosaurs, piecing them back together in the anatomically correct configuration poses no great problem. Unfortunately, it is incomplete skeletons that are most often found, sometimes just single bones or fragments thereof, which poses a big problem both for identifying them and for later reconstruction. Newly discovered bones are compared against the finds gathered in ever-growing scientific collections. Even fragments that are small, yet diagnostic, can successfully be assigned to the correct species or at least to closely-affiliated groups. Missing bones can then be reconstructed by artists,

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*Polonosuchus*. Reconstruction by Marta Szubert, Museum of Evolution, PAS Institute of Paleobiology


*Nemegtosaurus*.
Skull reconstruction,
Museum of Evolution,
PAS Institute of Paleobiology

in the form of sketches, sculptures, or 3D graphics, based on their similarity to analogous bones found in the skeletons of closely related dinosaurs.

In order to exhibit a skeleton of an entire dinosaur that was found incomplete, it is sometimes necessary to borrow the missing part from another, albeit similar species. Such a reconstruction can be seen at the Museum of Evolution of the PAS Institute of Paleobiology in Warsaw: a replica of a skeleton of a certain large sauropod *Opisthocoelicaudia skarzynskii*, whose skull unfortunately still remains unknown, topped with a replica of a skull of *Nemegtosaurus mongoliensis*.

Reconstruction of soft tissues is aided by a thorough knowledge of the anatomy of animals living today, which should also be possessed by artists dealing with reconstructions. All tetrapods have homologous elements of body structure – ones that are composed of the same tissues and are of the same origin, but which may differ in shape, like a dog's paw and a bird's wing. This makes it possible, for instance, to reconstruct the arrangement of muscles in dinosaurs by modelling them after the musculature of crocodiles. Very rarely paleontologists recover finds that are very useful in this respect: fossilized fragments of skin or even dinosaur "mummies" (mineralized bodies), making it possible to almost perfectly recreate the appearance of the species to which they belonged. An example of this perfect state of preservation can be found in *Borealopelta markmitchelli*, a herbivorous armored dinosaur, unearthed in Canada and first described in 2017.

In most cases, the appearance of skin and body coverings are borrowed from present-day vertebrates known to inhabit similar environments – scales from reptiles, feathers from birds – and in reproducing coloration, the patterns of spots or stripes that are found in mammals are often used as models.

Nowadays, computer techniques even make it possible to reconstruct the way dinosaurs moved. Again, knowledge of the kinetic mechanics of today's animals is utilized here. Assistance may also come from ancient tracks preserved in fossil form, making it possible to interpret the relative position of their limbs and measure the step-length of a given species. Artists

*Tarbosaurus*.
Original skeleton assembled in "kangaroo position," Museum of Evolution, PAS Institute of Paleobiology


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specializing in computer animation can create realistic films showing dinosaurs as if they were alive in their natural (and of course also reconstructed) environment.

## Shifting appearances

In 19th-century Europe, thanks to the ongoing advancement of the natural sciences, bones found in rocks began to be studied in a scientific way. In 1842, the naturalist Richard Owen gave the name *Dinosauria*, or "terrible lizards," to a previously unknown group of huge animals discovered in this way.

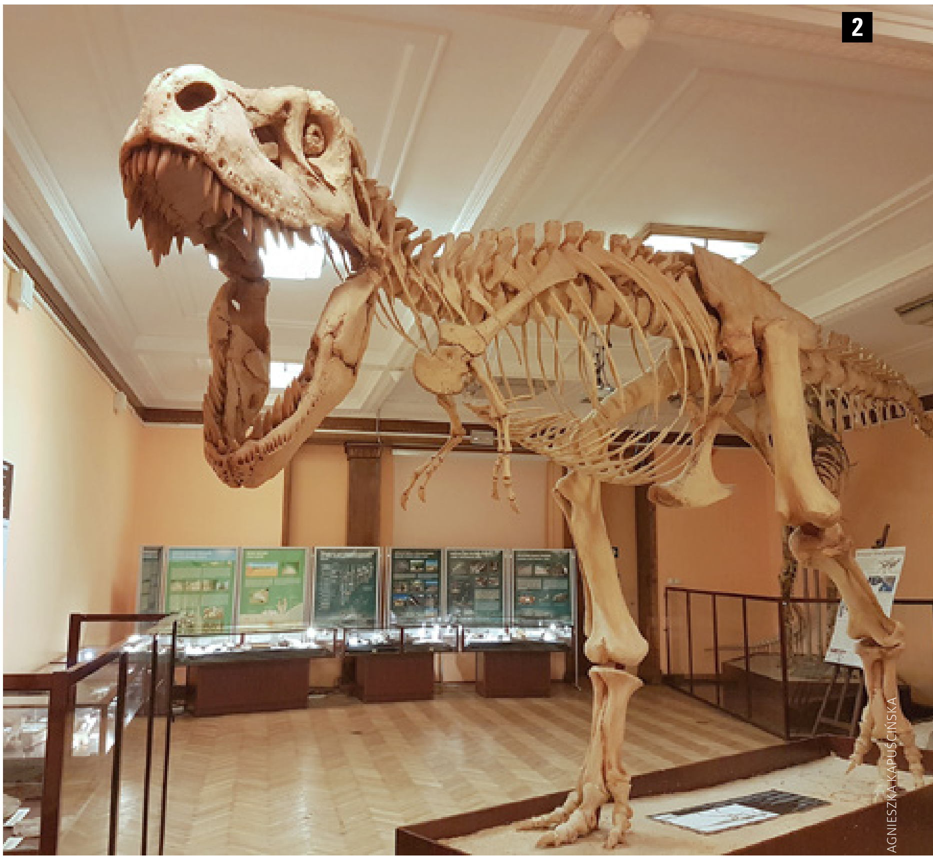
Since the beginning of such discoveries, researchers have tried to envision what dinosaurs really looked like back when they were alive, but they had to face such problems as incomplete remains, a lack of preserved soft tissues, and the fact that dinosaur bones were not similar to those of any known animal – i.e. a lack of comparative material. This resulted in anatomically incorrect and (from today's perspective) sometimes even ridiculous depictions, which have nevertheless continually evolved in tandem with subsequent discoveries and the invention of new research techniques.

As an example of such evolution can be found in story of the effort to reconstruct one of the very first dinosaurs to be scientifically described – the iguanodon, a herbivore reaching 13 m in length, from the Early Cretaceous period (about 128–124 million years ago).

The genus *Iguanodon* was established in 1825 by English physician and naturalist Gideon Mantell on the basis of a find of several teeth. Based on later finds of incomplete skeletons and the similarity of the teeth to those of a modern-day iguana, he concluded that the whole dinosaur was similar to this lizard, only much larger, and illustrated it as such. He treated one of the bones as a "horn" and placed it on the tip of the animal's snout, analogous to the horn on a rhino's nose.

Nearly 30 years later, under the scientific direction of Richard Owen, the artist Benjamin Waterhouse Hawkins created the world's first 1:1 scale carved likenesses of dinosaurs, including an iguanodon resembling a giant iguana with an extra small horn on its nose. In 1854 these reconstructions were presented to the public in Crystal Palace Park in London (where they can still be admired today). Since then, however, thanks to the widespread fascination with dinosaurs, paleontology has advanced in great strides.

In 1878, more than 20 complete skeletons belonging to the genus *Iguanodon* were discovered in a coal mine in Bernissart (Belgium). This made it possible to create a new image of this dinosaur, closer to the truth; its reconstruction was undertaken by a team led


by the Belgian paleontologist Louis Dollo. The pelvic structure reminded paleontologists of a bird, so an emu skeleton was used as a model for the reconstruction. However, birds do not have a long, bony tail, and their forelimbs are wings, so a kangaroo skeleton was used in addition. Reconstructed according to these guidelines, the dinosaur stood upright and supported itself with its tail like a kangaroo. The "horn" previously placed on the nose turned out to be the claw of a forelimb.

In the late 20th century, after careful study of historical and newly discovered skeletons, the assumed appearance of the iguanodon was once again revised. Scientists now concluded that it was a four-legged animal that only occasionally stood on its hind legs, and ossified tendons had made its tail stiff, so that it had to stick out horizontally.

The "kangaroo position" prevailed in reconstructions of many dinosaur species for over 100 years. The Museum of Evolution of the PAS Institute of Paleobiology in Warsaw exhibits an original skeleton of the predatory dinosaur *Tarbosaurus bataar*, belonging to the family of tyrannosaurs, which was assembled in the late 1960s – it also "incorrectly" stands upright. In order to show the correct silhouette of the tarbosaurus while also preserving the historical reconstruction, a new model of the *T. bataar* skeleton was built in2005 under the direction of paleontologist Karol Sabath. Reflecting today's state of the art, it was assembled in a posture with a horizontally aligned spine, the large head being counterbalanced by the tail thrust back horizontally.

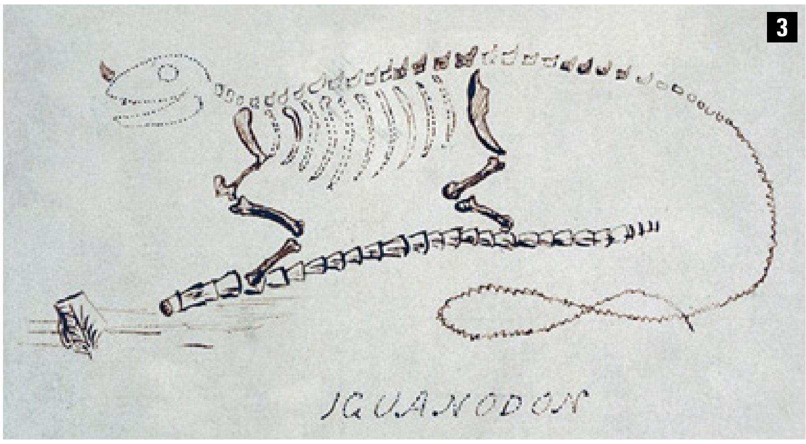
## A new image

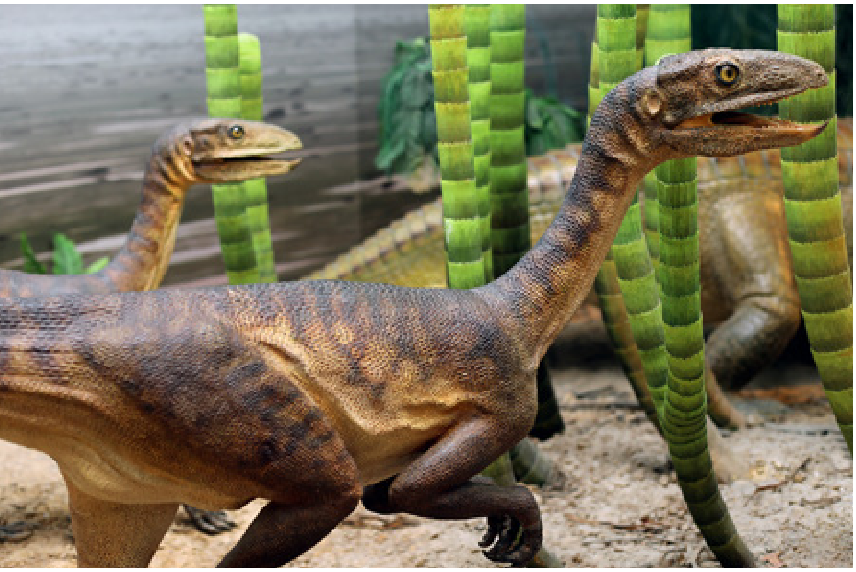
Being classified as "cold-blooded reptiles" meant that for decades, dinosaurs were viewed as slow and sluggish animals. This image was challenged in the 1960s by Robert Bakker, then a student of paleontology at Yale, who under the direction of his supervisor John

1. Illustration showing an iguanodon in "kangaroo position," 19th century, Wikimedia Commons

2. *Tarbosaurus*. New skeletal reconstruction, Museum of Evolution, PAS Institute of Paleobiology

3. The first attempt at reconstructing the iguanodon, 1834 or thereafter, Wikimedia Commons

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*Silesaurus*. Reconstruction by Marta Szubert, Museum of Evolution, PAS Institute of Paleobiology

Ostrom showed that dinosaurs were actually fast and agile, and thus may also have had a fast metabolism. Bakker was a gifted draftsman, so he presented his hypotheses in wonderful illustrations in which tyrannosaurs galloped and giant, four-legged sauropods stood on their hind legs. In 1969 Ostrom described a new genus of small dinosaur, *Deinonychus*, an active and probably warm-blooded predator, and in later publications he also postulated that birds had evolved from predatory dinosaurs (theropods).

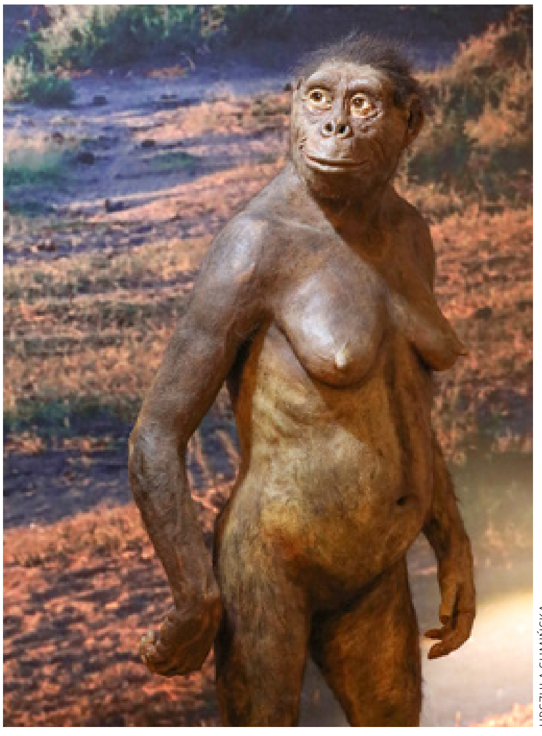
These bold hypotheses sparked a renaissance in dinosaur research. Paleontological exploration has begun on an unprecedented scale in many parts of the world, especially in the United States and China. In the past 25 years, plumage has been discovered in some dinosaur species, and bone histology analysis has pointed to a distinctive kind of warm-bloodedness in many of their genera. Biological analysis (including molecular research) has also further corroborated the hypothesis that birds originated from theropods. All of this, of course, continued to influence the way dinosaurs are depicted. Today, almost all theropods are shown as having been feathered, although there is no paleontological evidence for this.

## The latest revolution: colors millions of years old

Natural body color is not preserved by the fossilization process, so colorful images of fossil animals have been (and mostly still are) the product of artists' imaginations. The real revolution in color reproduction came in 2008, when molecular paleobiologist Jakob Vinther of Bristol University demonstrated that melanosomes are preserved in fossil feathers. These are pigment cells found in the body coverings of animals – in feathers, scales, skin, and hair – that "encode" different colors depending on their shape. They are so small that they can only be seen with an electron microscope (SEM). Since then, people have started looking for melanosomes in fossils, where the remains of feathers, scales or skin are preserved. The coloration of several species of feathered dinosaurs has been reconstructed in this way, and it was discovered that the notorious early bird-like animal *Archaeopteryx* was all black. Even the body coloring of fossil marine reptiles has been deciphered, confirming speculation that they had a light underside and a dark top, much like today's sharks.

The principles used in reconstructing dinosaurs also apply, of course, to other extinct vertebrates. Visitors to the Museum of Evolution of the PAS Institute of Paleobiology in Warsaw can see depictions of Triassic amphibians and reptiles discovered at the site Krasiejów, reconstructed with utmost artistry by the sculptor Marta Szubert, as well as a figure of the australopithecus "Lucy," ho looks upon visitors as if frozen in motion.

However, when viewing museum exhibitions or watching popular science films, it is important to bear in mind that any such reconstruction is only a certain proposal for what extinct animal looked like. As a scientific hypothesis, it may be challenged or revised by subsequent researchers with new evidence at their disposal. The fact that our images of dinosaurs are changing, therefore, is an excellent illustration of how the scientific method itself works, and offers a certain promise that can expect further exciting developments in this subject in the future. ■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Reconstruction of the australopithecus "Lucy" by Marta Szubert, Museum of Evolution, PAS Institute of Paleobiology

Further reading:

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