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A Four-Legged Megalosaurus and Swimming Brontosaurs

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Abstract

Thomas Kuhn in his famous work *The Structure of Scientific Revolutions* laid out the framework for his theory of how science changes. At the advent of dinosaur paleontology fossil hunters like Gideon Mantell discovered some of the first dinosaurs like *Iguanodon* and *Megalosaurus*. Through new disciples like Georges Cuvier's comparative anatomy lead early dinosaur paleontologist to reconstruct them like giant reptiles of absurd proportions. This lead to the formation of a new paradigm that prehistoric animals like dinosaurs existed and eventually went extinct. The first reconstructions of dinosaur made them to look like giant counterparts of their modern cousins. Then in 1841, Richard Owen coined the term dinosaur, and put the newly discovered dinosaurs into a special group based on similar morphological characteristics. He reconstructed them to look like giant elephant like reptiles. They were slow, sluggish, and their tales dragged the ground. Then in 1858, William Foulke and Joseph Leidy discovered the dinosaur *Hadrosaurus* which had morphological characteristics that hindered the animal from being quadrupedal. As a result a new paradigm was formed and some dinosaurs were lifted off the ground. They were reconstructed to look like giant reptilian kangaroos in stance, but they were still considered slow, sluggish, with tails still dragging behind them. This paradigm persisted until the 1960's when paleontologist John Ostrom realized that there was an anomaly within dinosaur paleontology. The environments that dinosaurs inhabited did not match with the reconstructions of swamp dwelling animals, and dinosaur anatomy also did not match those reconstructions. Ostrom's discovery and description of *Deinonychus* with its very bird like skeleton lead him to conclude that dinosaurs were energetic, and probably endothermic. This resulted in a crisis which lead other paleontologist to research this anomaly. More discoveries proved Ostrom's new paradigm and dinosaur paleontology underwent a scientific revolution from the 1960's to the 1980's. Formally termed the dinosaur renaissance this revolution lead to dinosaurs being reconstructed as active, intelligent animals no longer with their tails dragging behind them.

Keywords

Thomas Kuhn, Philosophy of Science, dinosaurs, paleontology, history of paleontology

A Four-Legged Megalosaurus and Swimming Brontosaurs: A Brief History of Paradigm Shifts within Dinosaur Paleontology

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Introduction

Rays of bright sunlight came gleaming through the windows of an artist's studio. The room lay silent and void of all life. Dust particles were gently floating on the air currents in the room flying through the golden beams of light. Paintings hung on the walls while others, draped in white sheets, sat propped up against the wall. In one corner of the room, models of prehistoric beasts, exhibiting both grandeur and curiosity, sat watching, acting as the ever-watchful guardians and protectors of a hoard of treasures. Bottles and tubes of paint seemingly took up most of the space on any table or surface in the studio. In cups scattered about the room, paint brushes were neatly organized by size and shape. Laying on a table, a palette, stained with dried paint of past masterpieces, waited for the artist's gentle hands. In the center of the room, an easel stood holding a blank canvas waiting to undergo a transformation.

The creaking of an opening door and the heavy footsteps of an old man suddenly broke the silence. With every step, the boards of the wooden floor bent to the stress and creaked like the door. The studio then came to life with the melodious sounds of Louis Armstrong coming from a phonograph. Walking over to the table, the man picked up the palette and some tubes of paint. He began smearing the paint across the palette and took a brush from a nearby cup. Mixing the colors together, he was ready to put paint to canvas. Taking another brush, his careful brushstrokes elegantly began to make his imagination awaken on the blank canvas. Three days of painting and his masterpiece was finished. The final touch was signing his name to his work. Charles R. Knight took a step back and he admired what he had created. The mighty *Brontosaurus* was staring at him from the past and grinning as though it actually posed for the painting. It seemed to be swimming in the swamp without a care in the world, probably foraging for the lush vegetation underneath the water. Other brontosaurs were foraging for their next meal in the background, while a *Diplodocus* walked on the banks eating the prolific greens. Knight's paintings sought to convey the prevailing intellectual view of how dinosaurs lived. However, instead of portraying them as the often-pictured sluggish monsters, Knight gave his creations energetic poses.

The Dawn of Paleontology: The Formation of a Paradigm

Little did Knight know that more than fifty years later his earlier paintings of active dinosaurs would turn out to be correct. His works inspired the minds and captured the hearts of future generations of paleontologists. To have an understanding of the current view of dinosaurs—let alone Knight's view—a careful examination of history is required. During the beginnings of paleontology in the late eighteenth century, fossil organisms were discovered that were thought to represent modern life. This became the consensus because of a lack of knowledge of the unexplored world. The blank spaces on the globe made it difficult for strong conclusions to be made about what fauna and flora might exist in those empty expanses. Interpretations of scripture also played an important role in science at the time. Most naturalists who believed in a literal Noahic flood felt that animals found in the present must represent life before the great deluge. In other words, if a fossil organism was found, then it must be similar in form to a present-day organism somewhere in the world. This view was slowly changing due to the recognition of immense thicknesses of strata around the world. James Hutton in his book *Theory of the Earth* heralded in the idea of uniformitarianism. Hutton sought to reconcile the massively thick strata in a framework of natural means. He thought the present processes of sedimentation characterized the sedimentation rates and processes of the past. The thicker the strata, the longer the period of time it represented.

In the midst of this changing view, Baron Georges Cuvier put forth an idea that animals could go extinct. Known as the father of modern vertebrate paleontology, stratigraphy, and comparative anatomy, Cuvier's conclusion for extinction sprouted from his study of elephants. His study of comparing the skulls of modern elephants with those of a mammoth and mastodon led to several different deductions. The first being that the African and Asiatic elephants were not the same species but related to each other like sheep and goats. The second being that the mammoth and mastodon were different from the two modern species of elephants. Also, like their modern counterparts, although extremely different, the two were still closely related. Cuvier's conclusion led him to believe that these two ancient elephant forms vanished from the earth. His argument for extinction was strengthened with the discovery of a skeleton of a strange creature from Paraguay. Cuvier's anatomical comparisons of this creature, which he would call *Megatherium*, had no modern relations. The closest comparison he came up with was that of the edentates, (now renamed xenarthra) which included armadillos, sloths, anteaters, pangolins, and aardvarks (all of which have been reassigned to their own groups). The *Megatherium* shared several characteristics with armadillos, sloths, and anteaters, making it a strange chimera. However, this peculiar beast more closely resembled tree sloths. Cuvier (1796) said this about the new curiosity,

> "It adds to the numerous facts that tells us that the animals of the ancient world all differ from those we see on earth today; for it is scarcely probable that, if this animal

> still existed, such a remarkable species could hitherto have escaped the researches of naturalists."

The lacunae on the map or in the records appeared to suggest the possibility for "large quadrupeds" like the mammoth or *Megatherium* to exist. Cuvier turned to ancient history, exploration, and migration for proof that this idea was no longer plausible. Explorations across the world in places like the African continent seemed to reveal most of the "large quadrupeds" as already described by indigenous peoples. The natives told tales of animals to the explorers who, in turn, sought out the animals described to them. Cuvier also noted that many of the ancient cultures had stories about "large quadrupeds". For example, the Romans became accustomed to seeing animals like the hippopotamus, the rhinoceros, and giraffes in the gladiatorial games. The migration patterns of animals, especially those of "large quadrupeds", made it impossible for them not to have been seen by both explorers and natives. Cuvier's idea of extinction dispelled the notion of undiscovered "large quadrupeds" and that animals existed before the appearance of mankind. The prehumen world that Cuvier created became a fantastic world populated with a variety of mysterious forms.

In this new primordial world, the ideas of Hutton, further propagated by Charles Lyell and Cuvier's concept of extinction, set the stage for Charles Darwin's ideas. When Darwin finally published the *Origin of Species*, most of the scientific community accepted his theory of evolution from a common ancestor. A newer and younger generation of scientists were enthusiastic about accepting Darwin's ideas. Darwin's theory freed them from the old order of believing in the supernatural. Sir Richard Owen, a child of the old school of thought, was caught in the middle of a scientific revolution. Before Darwin published *Origins,* and even before Owen was considered the English Cuvier, the discovery of ancient reptilian fossils began to spark the imagination. Gideon Mantell's discoveries of several large saurian like creatures caught the attention of Reverend William Buckland and Cuvier. One of Mantell's fossil finds was a set of teeth. Cuvier at first glance examined the teeth and determined the source to be a rhinoceros. Mantell's dissatisfaction with Cuvier's response forced him to look elsewhere for answers to the identification of the teeth. This led him to a museum collection where he found the teeth had an uncanny resemblance to those of modern iguanas. He named the animal belonging to the teeth *Iguanodon* and thought it was the forbearer of the present-day iguanas. Mantell reconstructed his newly discovered animal to be a giant counterpart of what he thought was its modern descendent (Figure 1). Comparing the size of the teeth of living iguanas to those of *Iguanodon,* Mantell, Buckland, and Cuvier estimated the size of the ancient ancestor to absurd proportions. Calculations ranged from a modest sixty feet to almost two-hundred feet long. Mantell also discovered a femur belonging to what Buckland would later call *Megalosaurus*. The size estimation for *Megalosaurus* was about sixty-five feet in length and was dwarfed by its counterpart *Iguanodon*. Cuvier's comparison of the skull of Reverend William Conybeare's *Mosasaurus* to that of a monitor lizard placed it into the class reptilia. *Iguanodon* and *Megalosaurus* followed suit and they were placed in the same class.

Enter In Dinosauria: Four-Legged Terrible Lizards

Sir Richard Owen, finally stepping up to the stage, fought against the teachings of Lamarckism and later Darwinian evolution. Jean-Baptiste Lamarck put forth his idea of inheritance through acquired characteristics. According to his thinking, animals survived because certain individuals had better traits for survival. These traits would then be passed onto its offspring. Eventually this would lead to an animal that was more complex than its ancestry. Owen saw an opportunity to snuff out the flames of Lamarckism with the use of Mantell's reptilian beasts. His own comparative study of the *Iguanodon* and *Megalosaurus* led him to a different estimation of size. The calculations came out with more believable sizes. *Iguanodon* went from the preposterous size of two-hundred feet to a humble twenty-eight feet long. *Megalosaurus* also was scaled down to about thirty feet long and this time being slightly larger than its equivalent. Since the animals were, just a little bigger than an elephant Owen reconstructed them as such. *Iguanodon* and *Megalosaurus* became elephantine cold-blooded reptiles (Figure 2). In 1841, Owen put these monsters into his new clade dinosauria. He believed that *Iguanodon, Megalosaurus,* and *Hylaeosaurus* marked the apex of the reptilian class. Owen hoped this was the final nail in the Lamarckian, and even Darwinian evolution, coffin. In Owen's mind,

> "The superiority of the dinosaurs, living in a glorious 'Age of Reptiles', was a direct act of divine Creation. Species did not transmute into one another but were placed on the earth by Design and if they appeared to form a succession, it was a result of divine planning rather than evolution. (Desmond, 1990 pg. 21)"

In light of their obviously complex nature and seemingly apparent superiority as compared to their modern reptilian relatives, dinosaurs should have been better adapted to survive to the modern era. Yet, they did not survive, and the question was why? According to Owen, it was not that they had evolved, but rather were divinely created. Owen's idea would later fall by the wayside as the paradigm shifted from special creation and catastrophism to evolution and uniformitarianism. His new clade of dinosauria would continue to survive, and his concept of elephantine reptiles would endure as well.

Leaping Laelaps: Dinosaurs as Giant Kangaroos

A discovery in the New Jersey marl by William Foulke and Joseph Leidy would completely overturn Owen's reconstructions. Leidy called the new dinosaur *Hadrosaurus* and noticed that his new creature was similar to the *Iguanodon* of England. He also noticed that,

> "The great disproportion in size between the fore and back parts of the skeleton of *Hadrosaurus* leads me to suspect that this great extinct herbivorous lizard may have been in the habit of browsing, sustaining itself, kangaroo-like, in an erect position on its back extremities and the tail. (Foulke, Leidy, 1858)"

After the discovery of *Hadrosaurus* and before the bone wars waged in the western U.S., E.D. Cope found another set of remains among the marl. Cope named his new dinosaur

Laelaps (now *Dryptosaurus*). With his new skeleton Cope noticed that the creature could not have possibly walked quadrupedally. He said this about *Laelaps* posture,

> "They must also have been very much flexed under ordinary circumstances, since the indications derivable from the two humeri, or arm bones, are, that the forelimbs were not more than one-third the length of the posterior pair. This relation, conjoined with the massive tail, points to a semi-erect position like that of Kangaroos, while the lightness and strength of the great femur and tibia are altogether appropriate to great powers of leaping. (Cope, 1868)"

Leidy and Cope's claim of a semi-erect posture of their dinosaurs spread across the pond to Europe, and the four-legged *Megalosaurus* and *Iguanodon* eventually gained the same semi-erect stance. This idea of a semi-erect posture for *Iguanodon* was further supported by the work of Louis Dollo. Dollo's upright posture was based on a comparison of anatomical characteristics with birds of the class palaeognathae (flightless birds). The strongest basis for his argument came from a fossil trackway found within the same strata as *Iguanodon*. The animal that left the tracks walked bipedally. To test his hypothesis, he placed the middle digit of an *Iguanodon* foot into a cast of the fossil tracks, and found that it was a perfect fit. Dollo concluded that the footprints belonged to *Iguanodon*, and that it did not use its tail as a prop like a kangaroo. Instead, the tail dragged along the ground, "and the impression [from the tail] thus formed was certainly very weak because it has not been preserved. (Dollo, 1883)" Dinosaurs took to their feet becoming less like kangaroos, and more like their tail dragging cousins reptiles (Figure 3).

The Start of a Crisis: John Ostrom Questions the Paradigm

Most paleontologists at the time still viewed dinosaurs as cold-blooded lizards in need of tropical climates to thrive. Because of their large size they were considered to be sluggish, dim-witted, and probably swamp-dwelling in the case of many herbivorous dinosaurs. This was primarily due to Owen's creation of the dinosaurian clade within reptilia. His idea that dinosaurs were "terrible lizards" kept them from being seen as anything more than just massive reptiles. This would continue to be the consensus for more than a century. Then in the 1960s, John Ostrom began to "drain the swamps" of dinosaurs. He began with hadrosaurs, which were thought to be snorkeling creatures with a crocodile-like tail that would feed on the abundance of aquatic vegetation. Ostrom used the locations where hadrosaur fossils were found. Most other dinosaur fossils were found in deposits interpreted to be coastal plains with swamps and meandering streams. He found that the fossil flora within hadrosaurian-bearing strata was more consistent with conifer forests than vast swamps with aquatic vegetation. He also noticed that hadrosaurs had an amazing tooth structure and tooth battery. Teeth were constantly being replaced and grinding patterns on the teeth suggested that these animals were eating fibrous materials. Ostrom also found an unfamiliar paper that described the gut contents of a "mummified" hadrosaur *Anatosaurus* (now *Edmontosaurus annectens*). The contents, "revealed the abundant presence of conifer needles…and twigs, seeds, and fruits of other land plants. (Ostrom, 1964)" He also pointed out the ossified tendons that occur in the dorsal and caudal portions would reinforce the tail too much. The tendons would not allow for smooth movement like a crocodile's tail, and in fact, they would restrict its movement. Hadrosaurs became terrestrial creatures, and the lugging around of their bulky tails was finally envisioned as being off the ground. Dinosaurs were slowly changing from lethargic swamp-residing beasts to being more active, but they were still considered cold-blooded lizards.

Ostrom would soon throw another wrench into the debate with the description of *Deinonychus* in 1969. The skeleton of the creature was very similar to that of a bird with its hollow bones, and it had a very strange foot. The foot had two toes that would touch the surface of the ground while the third was like a sickle and retracted from the ground. He said this about the foot,

> "The foot of *Deinonychus* perhaps the most revealing bit of anatomical evidence pertaining to dinosaurian habits and must have been anything but 'reptilian' in its behavior, responses and way of life. It must have been a fleet-footed, highly predaceous, extremely agile and very active animal, sensitive to many stimuli and quick in its responses. These in turn indicate an unusual level of activity for a reptile and suggest an unusually high metabolic rate. The evidence for these lie chiefly, but not entirely, in the pes. (1969 cited by Desmond, 1990)"

The foot of this "terrible claw" seemed to suggest that the animal had an active lifestyle. Having an active lifestyle meant that it was probably endothermic, and the animal had a strange resemblance to birds. Ostrom compared the skeleton of birds like the *Hoatzin* and the chimera *Archaeopteryx* to *Deinonychus.* The hands had very similar features, including the same homology of digits and very similar wrists. Ostrom thought,

> "*Deinonychus* had had a great deal of *birdness* built into its limbs, a *birdness* that would have expressed itself in life by a daily metabolic regime more fitting for a ground bird such as a cassowary than for the orthodox view of any cold-blooded dinosaur. (Bakker, 1986 pg. 312)"

With *Deinonychus* Ostrom concluded that dinosaurs were more closely related to birds. This relationship meant that dinosaurs were possibly endothermic as well. Ostrom's work with hadrosaurs and *Deinonychus* injected a new fervor into dinosaurian paleontology. His work paved the way for his protégé, Robert Bakker, and others to make bold claims about the nature of dinosaurs.

The Dinosaur Renaissance: A Scientific Revolution

From Cuvier to the present, out of all the paradigm shifts only one led to a true scientific revolution within dinosaur paleontology. In order to prove his paradigm correct, Ostrom had to "attract an enduring group of adherents from competing modes of scientific activity. (Kuhn, 1970 pg. 10)" Ostrom saw what Kuhn would call anomalies in how dinosaurs were viewed. They were seen as nothing more than overgrown reptiles spending most of their time in aquatic environments. Ostrom recognized that dinosaurs like hadrosaurs had anatomical characteristics perfect for terrestrial locomotion. He also correlated the depositional environments and flora found within the strata to the lives of those dinosaurs. For Ostrom, the "orthodox view" of dinosaurs did not follow lines of evidence found in the geologic record. Also, with the discovery of *Deinonychus,* with its very bird-like skeleton, proved that dinosaurs were related to birds. As a result of this relationship, they were probably endothermic. His arguments did start a crisis within dinosaur paleontology. Kuhn notes that a crisis leads to the blurring of a paradigm and loosening of the rules for normal science. The anomaly becomes more recognized as a result, and scientists devote more effort into figuring out the anomaly. This was the case with more scientists like Robert Bakker putting more effort into proving that dinosaurs were energetic and possibly endothermic. New discoveries, like John Horner's nesting *Maiasaura* and the ostrich-like dinosaur *Ornithomimus,* gave further credence to Ostrom's paradigm. From the 1960s to the 1980s, the revolution breathed new life into dinosaurs, creating what has come to be known as the dinosaur renaissance. However, the other paradigm shifts did not lead to any scientific revolutions, but they played important roles in the shaping of Ostrom's paradigm. The history is complicated and more people were involved than what was outlined here. Other important figures include Thomas Huxley, Othniel Charles Marsh, and countless others who also tremendously added to Ostrom's ideas. Some of them seemed to peer into the future and conclude the same thoughts and ideas that Ostrom did. This supports Kuhn's idea that from the study of history it is never just one person responsible for a scientific revolution. In studying the ideas that were not as revolutionary, one can gain an understanding of how normal science and scientific revolutions work. The long history of dinosaur paleontology affects every aspect of our current views of dinosaurs.

Conclusion

Paleo Artistry has been greatly affected by the changing tides of paleontology. A few artists can actually predict habits and ideas that current scientific research suggests. Charles R. Knight, the artist "who saw through time," created some of the most realistic dinosaur paintings of his time. His murals now hang on the walls of the Chicago Field Museum. They overlook the vast array of dinosaur skeletons that fill the room and act as the constant reminder of history. Amongst the skeletons, the mighty *Apatosaurus* stands tall above the other puny skeletons below. Behind the magnificent beast is one of Knight's many murals. The depiction is of a *Brontosaurus* walking on the sandy beach towards a deep blue lake. Crocodiles bathe in the sun as the massive beast walks by, dragging its tail in the sand. Other brontosaurs eat leaves from the abundant vegetation on the lake's bank. The *Brontosaurus* faces in the direction of the lake almost as if it is looking into the past—a past that is full of exciting discoveries that defined dinosaur paleontology. Nearby, the skeletal mount of the *Apatosaurus* faces the opposite direction, seemingly looking into the future. The beast in all its fleshless grandeur looks forward to the discoveries that will give humanity an improved view of dinosaurs. This harmonious mixture of the past, present, and future in one room inspired the heart of a young man to pursue his passion for dinosaurs.

Bibliography

Bakker, R.T. (1986) *Dinosaur Heresies.* New York: Kensington Publishing Corporation

Cope, E.D. (1868) The Fossil Reptiles of New Jersey. *In:* Weishampel, D.B. and White, N.A., *The Dinosaur Papers 1676-1906.* Washington: Smithsonian Institution, 326-331

Cuvier, G. (1796) Note on the skeleton of a very large species of quadruped, hitherto unknown, found in Paraguay and deposited in the Cabinet of Natural History of Madrid. *In*: Rudwick, M.J.S., *Georges Cuvier, Fossil Bones and Geological Catastrophes: New Translations and Interpretations of Primary Texts.* Chicago: The University of Chicago Press, 26-32

Cuvier, G. (1815) *Essays on the Theory of the Earth.* digital ed. 2009, Cambridge: Cambridge University Press

Desmond, A. (1990) *The Hot-Blooded Dinosaurs.* 2nd ed. London: Hutchinson Radius

Desmond, A. (1984) *Archetypes and Ancestors*. 2nd ed. Chicago: The University of Chicago Press

Dollo, L. (1883) Third Note on the Dinosaurs of Bernissart. *In:* Weishampel, D.B. and White, N.A., *The Dinosaur Papers 1676-1906.* Washington: Smithsonian Institution, 394-410

Foulke, W.P., Leidy, J. (1858) Remarks Concerning *Hadrosaurus*. *In:* Weishampel, D.B. and White, N.A., *The Dinosaur Papers 1676-1906.* Washington: Smithsonian Institution, 262-266

Leidy, J. (1865) An Excerpt from the Cretaceous Reptiles of the United States. *In:* Weishampel, D.B. and White, N.A., *The Dinosaur Papers 1676-1906.* Washington: Smithsonian Institution, 289-312

Kuhn, T.S. (1970) *The Structure of Scientific Revolutions.* 2nd ed. Chicago: The University of Chicago Press

Ostrom, J. H. (1964). A reconsideration of the paleoecology of hadrosaurian dinosaurs. *American Journal of Science*, *262*(8), 975-997.

Rudwick, M.J.S. (1992) *Scenes From Deep Time.* Chicago: The University of Chicago Press

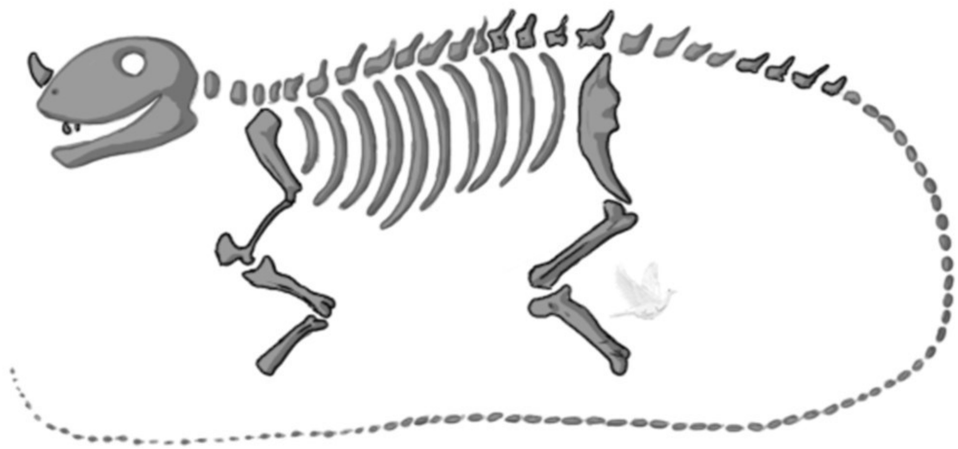

Figure 1: Gideon Mantell's Reconstruction of his *Iguanodon*. Based off the original plate and used by permission of Kristen Veillon.

Figure 2: Richard Owen's reconstruction of *Iguanodon*. Used by permission of Kristen Veillon.

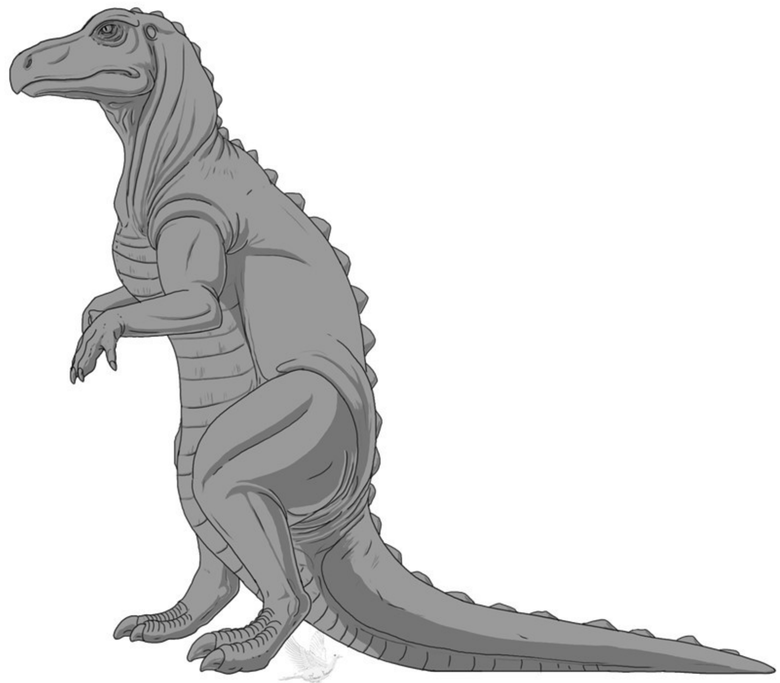

Figure 3: Luis Dollo's reconstruction of *Iguanodon*. Used by permission of Kristen Veillon.

Figure 4: Current reconstruction of *Iguanodon*. Used by permission of Kristen Veillon.