Bringing Dinosaurs Back to Life

Exhibiting Prehistory at the American Museum of Natural History

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ABSTRACT

This essay examines the exhibition of dinosaurs at the American Museum of Natural History during the first two decades of the twentieth century. Dinosaurs provide an especially illuminating lens through which to view the history of museum display practices for two reasons: they made for remarkably spectacular exhibits; and they rested on contested theories about the anatomy, life history, and behavior of long-extinct animals to which curators had no direct observational access. The American Museum sought to capitalize on the popularity of dinosaurs while mitigating the risks of mounting an overtly speculative display by fashioning them into a kind of mixed-media installation made of several elements, including fossilized bone, shellac, iron, and plaster. The resulting sculptures provided visitors with a vivid and lifelike imaginative experience. At the same time, curators, who were anxious to downplay the speculative nature of mounted dinosaurs, drew systematic attention to the material connection that tied individual pieces of fossilized bone to the actual past. Freestanding dinosaurs can therefore be read to have functioned as iconic sculptures that self-consciously advertised their indexical content.

During the second half of the nineteenth century, American natural history museums developed into hybrid institutions that sought to satisfy a set of very different, at times conflicting, goals: scientific research, public education, and popular entertainment. For example, when the American Museum of Natural History (AMNH) was incorporated in 1869, its trustees proudly announced a devotion to “en-
couraging and developing the study of Natural Science,” thereby “advancing the general knowledge.” However, they were also committed to offering “popular instruction and recreation.” Besides wanting to uplift and edify a large number of people, they felt it was important to attract a sizable audience because doing so helped to justify New York City’s decision to underwrite the museum’s construction and maintenance costs. Thus, while their Annual Report for the year 1875 made it clear that the trustees were anxious to have their museum recognized as “an institution with high scientific aims,” they were equally proud to announce that an average of fifteen thousand people a week had visited its public galleries that fall.1

By the first decade of the twentieth century, the museum’s status as a truly hybrid institution was, if anything, even more entrenched. When a 1907 article in Science criticized the AMNH for catering too much to popular tastes, the anthropologist Franz Boas penned a response that explicitly defended the museum’s institutional heterogeneity. The AMNH, Boas argued, had to engage in more than just specialized scientific research. It was also responsible for creating “healthy and stimulating surroundings” where ordinary New Yorkers could “employ their leisure time,” thereby serving to counteract “the influence of the saloon and of the race track.” To succeed on this score, museum exhibits must, “first of all, be entertaining.” Few among the city’s idle masses would seek out the genuine moral and educational benefits of natural history, he suggested, had these not first been carefully sugarcoated and made widely palatable: “The people who seek rest and recreation resent an attempt at systematic instruction while they are looking for some emotional excitement.” Given that the AMNH had unveiled the world’s first freestanding Brontosaurus just two years before, it is no surprise that Boas singled out dinosaurs as an especially valuable public relations asset. “When the installation of a new immense mounted skeleton of some extinct animal is announced,” he wrote, “people will flock in crowds to the museum to see the specimen.”2

In what follows, I explore how the goals of scientific research, educational high-mindedness, and popular spectacle mapped onto the AMNH dinosaur hall (see Figure 1) during the first two decades of the twentieth century. As Boas clearly understood, mounted dinosaurs had an uncanny power to capture people’s imaginations and thus ensured a steady stream of visitors to the museum. However, their construction relied on a great deal of contested knowledge about the anatomy, life history, and behavior of strange and long-extinct animals to which curators had no direct observational access. This meant that, in addition to being extremely rewarding objects for display, dinosaurs posed a substantial risk to the museum’s authority as a credible research institution. Museum curators capitalized on the appeal of dinosaurs while mitigating the risk of mounting them by developing an exhibition strategy in which fossils were incorporated into dense mixed-media installations. The resulting sculptures functioned as iconic representations of the past, providing visitors with imaginative access to a bygone world. At the same time, curators ensured that dinosaurs would impress the public and fellow scientists as a secure


source of reliable knowledge by systematically downplaying their iconicity in favor of their indexical elements.

My argument draws on a distinction between indexical and iconic representations first articulated by Charles Sanders Peirce. Although curators at the American Museum did not employ Peirce’s terminology explicitly—a terminology that has since gained widespread currency in art history and film studies—it nonetheless provides an extremely useful way to parse the epistemic commitments that shaped how dinosaurs were mounted for public display. For Peirce, indexical representations are those “whose relation to their objects consists in a correspondence in fact.” In contrast, icons function as likenesses, representing their signified by “a mere community in some quality.” For example, a snow angel indexically represents the motions of a child at play, but it is an iconic representation of

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biblical creatures. Paintings represent historical events iconically, whereas casts made from life are indexical. Another way to formulate the distinction—one that is perhaps more intuitive than Peirce’s own—uses the language of causation: an index stands in a relatively straightforward causal relation to its referent, whereas icons do not. That is, a weather vane represents which way the wind blows just because the wind exercises causal power over it. A portrait, on the other hand, looks like the person sitting in front of me because I intended to fashion a representation of my subject. Of course, there is a sense in which even Picasso’s cubist painting of Daniel-Henry Kahnweiler is causally related to its subject, the famous Parisian art dealer. As Peirce himself pointed out, “the appearance of [a subject] made a certain impression upon the painter’s mind and that acted to cause the painter to make such a picture as he did.” The crucial difference between icons and indexes thus cannot be articulated using the notion of causation alone. Rather, it consists in whether or not a signified exercises its causal power via the intervention of human consciousness.

Although curators at the American Museum recognized the power of icons to induce a vivid imaginative experience, they were loath to display products of human consciousness. Curators worried that icons were vulnerable to distortion by the subjective and perhaps even erroneous beliefs of whoever had fashioned them, thereby calling the museum’s authority to speak for prehistoric nature into question. In contrast, indexical representations were seen as nothing more than a material trace of the past, immune to the effects of human intervention. At a time when so much remained unknown about dinosaurs, museum curators put a great deal of stock in the power of indexical displays. As Henry Fairfield Osborn, the museum’s chief paleontologist, observed, “The best books, written by the best scientific men, soon become out of date.” A bare “fact of nature,” on the other hand, “will be the same for thousands of years.” For this reason, he promised, the AMNH was “scrupulously careful not to present theories or hypotheses, but to present facts.”

The preference for indexical over iconic representations was not confined to natural history museums. As Lorraine Daston and Peter Galison have shown, deep-seated misgivings about icons were pervasive among scientists engaged in the production of representational artifacts at the time. Among other things, this manifested itself in a widespread enthusiasm for technologies of the index like photographs, X-rays, and the camera obscura. These and other means of mechanical reproduction were adopted in what Daston and Galison describe as a “near-fanatical effort to create . . . images that were certified free of human interference.” The widespread appeal of “mechanical objectivity” during the late nineteenth century can thus be understood as an attempt to “extirpate human intervention between object and representation.” This stands in stark contrast to

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7 In this, Peirce’s distinction roughly corresponds to Grice’s theory of natural and non-natural meaning. For Grice, if _p_ naturally means _q_ then _p_ implies _q_, whereas if _p_ non-naturally means _q_ then _p_ only implies someone believes _q_. See H. P. Grice, “Meaning,” _Philosophical Review_, 1957, 66:377–388.


an earlier period, one in which the personal experience and intuition of learned naturalists was celebrated as the hallmark of trust. Prior to the rise of mechanical objectivity, technical illustrations were expected to represent the essence of natural phenomena. This required image makers to abstract away from the idiosyncrasy and variability of individual observations and present an expression of an object’s underlying unity. The resulting illustrations were recognized to represent ideal types, something inaccessible to direct observation yet still more real than the multitudinous, imperfect, and familiar manifestations that abound in the world of experience. Besides being an indictment of individual judgment, the turn to mechanical objectivity during the late nineteenth century thus signaled a shift in ontological commitments. As variation came to be seen as a real and significant feature of the natural world, “the most a picture could do was to serve as a signpost, announcing that this or that individual . . . stands in the domain of the normal.”

Because a limited number of images could never capture the full range and complexity of natural variation, though, the rise of mechanical objectivity had the effect of transferring the burden of interpretation from the illustrator to his or her audience.

Dinosaur displays differed from the kinds of scientific illustration Daston and Galison describe in that they were intended for a diverse audience, many of whom were not trained scientists. Casual visitors to the museum were not judged sufficiently competent to make sense of a fragmentary piece of fossilized bone. “Few persons are able to form any adequate idea of an animal from its skeleton,” Osborn lamented in 1901. Indeed, “even trained specialists are too apt to consider a skeleton in itself instead as the framework of a moving and feeding creature.” For this reason, dinosaur bones had to be articulated into something that resembled a living, breathing animal. Doing so was an elaborate and drawn-out process involving large teams of technicians working in collaboration with scientists. It also required the use of several materials besides fossils, including shellac, plaster of Paris, paint, and iron or steel. All of these were indispensable because only thus could dead bones be brought back to life. As we have seen, though, dinosaurs had to do more than just provide a vivid imaginative experience. They were also supposed to impress visitors and fellow scientists as a trustworthy window onto the past. Mounted dinosaurs therefore evinced a desire to have it both ways. They were iconic sculptures designed to evoke a lifelike conception of prehistory in the mind’s eye of visitors while simultaneously staging the epistemic virtues of mechanical objectivity.

Dinosaurs and other museum displays have not escaped the attention of historians and science studies scholars. Broadly speaking, two schools of thought can be identified in...
the literature. The first views exhibits as a species of cultural performance. As Barbara Kirshenblatt-Gimblett has argued, they are “fundamentally theatrical, for they are how museums perform the knowledge they create.” In a similar vein, Tim Lenoir and Cheri Ross develop a semiotics of authenticity to unpack the “manner in which ‘nature’ comes to stand as the author and legitimator of socially constructed practice.” “In the case of natural history museums,” they write, the “signifying practices amount to the very production of nature.” And in a recent essay, Michael Rossi demonstrates that “authenticity” is not an intrinsic feature of natural history displays but, rather, the product of laborious intervention by museum scientists and artists. What unites these authors is a shared emphasis on the artificial, constructed quality of museum displays, whose authority rests on a richly choreographed cultural performance.

The second trend in the literature situates the history of museum displays in the context of model-based science. Lynn Nyhart, for example, argues that taxidermy in early twentieth-century Germany is best understood as a kind of remnant model, because “actual parts of original animals, plants, or landscapes form a prominent and necessary feature of the display.” The value of natural history specimens derived primarily from their status as physical pieces of the natural world: “When a family stands before a natural history diorama or walks around a free-standing biological group, they are in the presence of ‘the real thing.’ No matter how complex the process of reconstruction, this experience of authenticity depends on the fact that the skins and feathers of the animals displayed once covered living creatures.”

In what follows, I use dinosaurs to develop a third reading, one that regards natural history displays as mixed-media installations. They were, I would like to suggest, a kind of collage or assemblage. Curators and their assistants literally cobbled these creatures together from a large number of disparate materials. Each material had its own representational capacities, strengths, and shortcomings. Together, they were used to construct an icon of the natural world, but one that systematically downplayed its own iconicity. Curators did so by highlighting the indexicality of certain materials (such as fossils) over others (such as plaster). But the indexicality of these elements did not scale up by itself.


The task of creating an authoritative exhibit was therefore laborious and hard won. As such, dinosaurs show us a way to take seriously the notion that natural history displays were a kind of performance without discounting the fact that they did contain material fragments of the natural world.

This essay focuses primarily on the first decades of the twentieth century, a time during which dinosaurs gained widespread currency as a museum display of the first order. However, it should be noted that dinosaurs are hardly the only, nor even the first, extinct animals to capture the public’s imagination. During an earlier period in the history of American museums, mammoths and mastodons ruled supreme as show specimens. This was to a large extent due to their status as distinctly American creatures, symbols of the young republic’s might and power vis-à-vis Europe. Consistent with the widespread valorization of the American wilderness, these creatures were routinely characterized as ferocious carnivores roaming the Great Plains in search of their prey. An advertisement for Charles Willson Peale’s Philadelphia museum, for example, described them as having been “cruel as the bloody Panther, swift as the descending Eagle, and terrible as the Angel of Night.” Recognizing that the public’s fascination would translate directly into greater earnings for his museum, Peale charged fifty cents for admission to the “Mammoth Room” in addition to the twenty-five-cent fee required to enter the regular collections. Just like Peale’s mammoth at the start of the nineteenth century, the exhibition of dinosaurs at the start of the twentieth century captured the public’s attention with remarkable tenacity, and audiences flocked to the American Museum of Natural History in droves. But unlike Peale’s museum, the AMNH prided itself on its status as a genuine research institution. For this reason, it had to do more than just mount a spectacular exhibition. It also had to invest its display with the epistemic virtues that characterized science around the turn of the twentieth century.

TEA WITH THE BRONTOSAURUS

The American Museum of Natural History initiated its long-standing and highly successful program in vertebrate paleontology when it hired the Princeton University professor Henry Fairfield Osborn in 1891. Osborn was attracted to the AMNH because it supplied him with the means to carry out an ambitious program of fieldwork, scientific research, and public exhibition. At first, he concentrated on his own specialty of mammalian paleontology. Accordingly, many of the earliest fossils put on display were Titanotheres


and other perissodactyl ungulates like horses, rhinos, and tapirs. A primary purpose of these exhibits was to provide the public with visual evidence for the theory of common descent.\textsuperscript{19} However, in addition to such explicitly didactic displays, the AMNH also exhibited larger and more overtly spectacular specimens, such as the \textit{Mastodon}, \textit{Megalatherium}, and \textit{Megaloceros}. Thus when a young collector named Barnum Brown discovered a quarry rich in dinosaur bones while digging for mammals in Wyoming during the summer of 1897, Osborn decided to broaden the department’s field program and moved to devote considerable resources to collecting reptilian in addition to mammalian fossils.\textsuperscript{20}

The AMNH exhibited its first dinosaur fossils on long tables and in glass cases for individual inspection.\textsuperscript{21} However, by the late 1890s the hind limbs of two large sauropod dinosaurs and one theropod—\textit{Brontosaurus}, \textit{Diplodocus}, and \textit{Allosaurus}—had been mounted upright along the east wall of the museum’s Hall of Fossil Vertebrates. This arrangement was intended to give visitors an accurate sense of dinosaur osteology and functional anatomy. However, the powerful impression such displays made on the public was of no less importance. “The fore and hind limbs of these monster reptiles will furnish subjects of great interest,” Osborn wrote in the museum’s 1898 \textit{Annual Report}.\textsuperscript{22} Still, Osborn and the AMNH had something more ambitious in mind: fully articulated, free-standing skeletons of their largest and most spectacular finds.

Almost immediately after his field crew had discovered saurian fossils in 1897, Osborn began pushing museum trustees to fund the construction of a new Hall of Fossil Reptiles. The move to devote an entire hall to these creatures appears to have been motivated by the broad public appeal they were expected to command. Osborn explained that although they were “more difficult to find and more expensive to collect” than mammals, dinosaurs would easily repay the initial investment. They promised to become the museum’s biggest draw, “representing more ancient and less known types of life, more widely different from those of the present day, and in many respects far more extraordinary than animals shown in the Hall of Fossil Mammals.”\textsuperscript{23} If \textit{Megatherium} and \textit{ Glyptodon} were regarded as strange

\textsuperscript{19} Rainger, \textit{Agenda for Antiquity} (cit. n. 12), pp. 55, 69. In 1902, nearly half of the Hall of Fossil Vertebrates was devoted to the display of perissodactyl ungulates. See William Diller Matthew, \textit{The Hall of Fossil Vertebrates} (Guide Leaflet no. 3), pp. 2, 12, rpt. from \textit{Amer. Mus. J.}, 1902, 2(1). Osborn’s stated objective for the Department of Vertebrate Paleontology from the very first was to marry research and public education. In the Department of Vertebrate Paleontology’s first \textit{Annual Report} in 1891, he set out the mission for his new department: “to collect for exhibition and scientific purposes a complete series of fossils, showing the evolution and succession of mammalian life.” See \textit{Annual Report of the Department of Vertebrate Paleontology}, 1891, p. 3, 1:1, Box 1, Archives of the Department of Vertebrate Paleontology, American Museum of Natural History, New York (hereafter cited as \textit{Archives of the DVP, AMNH}). It should be noted that although deeply committed to the theory of common descent, Osborn was at this point still on the fence about the \textit{cause} of evolution. See Henry Fairfield Osborn, “Are Acquired Variations Inherited?” \textit{American Naturalist}, 1891, 25:191–216.

\textsuperscript{20} Many of the first mounted specimens on display, including the \textit{Megatherium}, were plaster cast reproductions purchased from Ward’s Natural Science Establishment in Rochester, New York. See Matthew, \textit{Hall of Fossil Vertebrates}, pp. 13–16. Regarding Osborn’s increasing interest in reptilian fossils see Brinkman, \textit{Second Jurassic Dinosaur Rush} (cit. n. 12), pp. 35–38.

\textsuperscript{21} Initially the bones of \textit{Brontosaurus} were “mounted separately, and . . . laid out on a series of tables in as nearly as possible their natural relations, giving a much more vivid idea than has heretofore been possible of the gigantic size of these animals.” See \textit{Annual Report of the Department of Vertebrate Paleontology}, 1901, 1:1, Box 1, Archives of the DVP, AMNH.

\textsuperscript{22} Henry Fairfield Osborn, “Fore and Hind Limbs of Carnivorous and Herbivorous Dinosaurs from the Jurassic of Wyoming,” \textit{Bulletin of the American Museum of Natural History}, 1899, 12(11); and \textit{Annual Report of the President} (New York: American Museum of Natural History, 1898), p. 17 (quotation). Writing about two dinosaur displays that went on exhibit at the same time, Matthew announced that they “attract much attention and comment from visitors.” See \textit{Annual Report of the Department of Vertebrate Paleontology}, 1898, 1:1, Box 1, Archives of the DVP, AMNH.

\textsuperscript{23} \textit{Annual Report of the President} (New York: American Museum of Natural History, 1904), p. 17. Already
and ponderous beasts that seemed almost as if they had lived in a mythical past, then Brontosaurus would be truly out of this world.

Osborn could not have known with certainty the extent to which dinosaurs would capture the public’s imagination, but neither was his confidence a pure shot in the dark. An Iguanodon had already attracted considerable attention in Brussels, Belgium, during the 1880s. In addition, life-size models of dinosaurs sculpted by Benjamin Waterhouse Hawkins had been on display at the Crystal Palace in Sydenham, outside of London, since the mid 1850s. Their influence traveled beyond the United Kingdom when, in 1866, the natural history dealer Henry Augustus Ward decided to sell miniature versions of these sculptures through his supply house in Rochester, New York.

Around the same time, the city of New York decided to build a Paleozoic Museum, featuring North American dinosaurs, in Central Park, inviting Hawkins to spearhead the project.

In order to familiarize himself with the appearance of North American dinosaurs, Hawkins visited the Academy of Natural Sciences in Philadelphia. During his time there, he cast the academy’s star specimen—Hadrosaurus foulkii—in plaster of Paris. When it was put on display in 1868, Hadrosaurus was a huge success and attendance at the academy’s museum nearly doubled. Indeed, the dinosaur proved so popular that it caused no small amount of annoyance among members of the academy, some of whom complained that huge crowds were forced to “move in nearly continued streams through the narrow intervals of the cabinets, affording little opportunity for the examination of the specimens.” Such a state of affairs was unacceptable, they argued, in that it made life difficult for “those who would really wish to examine the collections.”

The ability to examine specimens closely was of signal importance because it distinguished the academy’s museum from places of public amusement such as P. T. Barnum’s establishment in New York. As curators pointed out a few years later, their collections were primarily intended “to facilitate the labors of students and the investigations of naturalists.” And, as an exhibition guide from 1876 made abundantly clear, the Philadelphia academy was “not a place in which are exhibited chiefly animal monsters and effigies of strange things, . . . in a word, whatever a wondermonger can collect to allure the curious and idle many to amusement at small individual cost to them but lucrative to the showman.”

In contrast to the Academy of Natural Sciences, the AMNH was not above engaging in popular spectacle to attract visitors. When the doors to the new dinosaur hall were thrown open in 1905, Osborn made sure Brontosaurus would draw the lion’s share of attention. In his Annual Report of that year, he described the unveiling of this specimen as “the most noticeable event in the work of this department.” Measuring “nearly 70 feet in length and

in 1898, Osborn was angling for an appropriation from the board of trustees: “The Curator [i.e., Osborn] will continue to subscribe $2,000 to the Fossil Mammal Hall in the hopes that some member of the board of Trustees will endow the work of filling the Fossil Reptile Hall.” See Annual Report of the Department of Vertebrate Paleontology, 1898, 1:1, Box 1, Archives of the DVP, AMNH.


over 15 feet in height,” it “occupies the center of the new Hall.” Not surprisingly, the giant reptile “attracted a great deal of attention in the press.”27 Regardless of whether Osborn was being humble or disingenuous when he wrote these lines, they are at least somewhat misleading. It was no lucky accident that Brontosaurus became the public relations coup that it was. Rather, the AMNH actively courted newspapers and even staged a lavish publicity stunt to ensure an appropriately grandiose reception for its newest star specimen.

On 15 February 1905, the day before Brontosaurus was unveiled, the New York Times ran a full-page spread to announce the new exhibition. Some five hundred New York notables, including the mayor and prominent business leaders, had been invited to celebrate the event. As museum curators walked about answering questions, their wives served tea beneath the monstrous creature towering above. In the days that followed, throngs of visitors made their way north along Central Park West to witness the city’s latest public spectacle with their own eyes. Attendance at the AMNH shot up an astonishing twenty-five percent, an increase the museum chalked up to “the opening of several striking exhibits, particularly the huge Brontosaurus.”28 Despite this success, the immense popular appeal of these exhibits also threatened to ignite tension at the AMNH. Newspaper coverage provides a fleeting glimpse of the complex and varied reactions elicited by Brontosaurus. In one article, the Times quoted an enthralled if apprehensive boy who wondered, “How many little fellers like me do you think he could swaller at a gulp?” The same article also reported a conversation in which a “professor with large glasses [insisted] to another of his kind that the tea party was an absurdity, in bad taste in a place devoted to science.” The professor’s companion apparently had a more sanguine view, saying that even though “I don’t like [the spectacle], I must excuse it” for having “drawn all these people here, being a splendid bit of advertising.” Just exactly what all those people got out of their visit was up for debate. The Times reporter clearly had the impression that expert knowledge was, if anywhere, near the bottom of the list: “The poor beast if alive would not have recognized his scientific name in the many variations it took among the callers. Some wanted to see the ‘dino,’ others the ‘diorso,’ and among other designations were ‘the octopus,’ and ‘His Nibs, Old Boney.’” Everyone seemed to take away from the exhibit just what suited his or her fancy. A butcher, for example, speculated that such an animal would “burst the Meat Trust in a week.”29

Dinosaurs had immense appeal in part because they could register on several levels at the same time. This was a boon for museums whose exhibits were intended to satisfy the

28 “Five Hundred to Drink Tea under Big Dinosaur,” New York Times, 15 Feb. 1905, p. 9; and Annual Report of the President (New York: American Museum of Natural History, 1905), p. 29. Coverage in the New York Tribune inadvertently stressed the conjectural nature of dinosaur restorations. “The work of preparing a specimen of this kind for scrutiny by both the initiated and uninitiated calls for a rare combination of mechanical skill, anatomical knowledge and special familiarity with Ancient forms of life,” the Tribune reported. Lest visitors conclude that the AMNH would exhibit anything that had not been thoroughly established as scientific fact, however, readers were reassured that “Professor H. F. Osborn, curator of vertebrate paleontology at the American Museum of Natural History, and his assistants possess these qualifications in such a measure as to justify confidence in the product of their labor.” See “Brontosaurus Receives a Tea to Celebrate Opening of Fossil Hall,” New York Tribune, 17 Feb. 1905, p. 1. The decision to host such an event is likely to have been inspired by historical precedent: both Peale and Hawkins had put on similar shows to commemorate the exhibition of their mammoth and dinosaur sculptures, respectively. See Secord, “Monsters at the Crystal Palace” (cit. n. 24); and Sellers, Mr. Peale’s Museum (cit. n. 18), p. 147.
demands of everyone from professional paleontologists to working-class families “looking for some emotional excitement,” as Franz Boas would put it in 1907. However, it also posed a danger, because visitors’ experiences were not easily controlled. It was difficult to ensure that the public would engage with dinosaurs as educational objects rather than pure spectacle. Worse still, there was a risk that visitors would view these outlandish creatures as a mere fiction or fantasy. As one curator of paleontology lamented, to the casual visitor the world of dinosaurs, no matter how real, “yet remains . . . somewhat of a fairy-tale, a fanciful imaginative world peopled with ogres and dragons and belonging to the unreal ‘once upon a time.’”

ARTICULATING THE PAST

Part of the problem the AMNH faced was that speculation and conjecture pervaded every corner of its dinosaur hall. There were at least three dimensions along which the credibility of dinosaurs was called into question among professional paleontologists. First, the articulation of fossil bones rested on controversial theories about the functional anatomy of strange and long-extinct animals. Second, even relatively complete and pristine fossils were usually missing many of the bones required to make a freestanding mount. Hence, at least some of the objects on display were not fossils but simulacra, usually fashioned in plaster of Paris. Finally, the association of individual bones to make a complete specimen was also a point of contention. Because it was rare to find a specimen that was sufficiently complete to make a full mount, most displays were composites of several distinct individuals. In some cases, they were cobbled together from pieces that did not even belong to the same genus.

AMNH curators were well aware that much of the work required to mount fossil dinosaurs rested on conjectural knowledge. William Diller Matthew, a student of Henry Fairfield Osborn and curator of vertebrate paleontology at the AMNH, was candid about the process involved. Writing about Brontosaurus in a leaflet guide distributed to visitors, he freely admitted that “the proper articulating of the bones and the posing of the limbs were . . . difficult problems, for the Amphibious Dinosaurs . . . disappeared from the earth long before the dawn of the Age of Mammals, and their nearest relatives . . . are so remote from them . . . that they are unsatisfactory guides.” In other words, not only had Brontosaurus gone extinct, but all of its closest relatives had done so as well. Museum curators thus had no access to direct observational evidence about the functional anatomy of this animal or anything even remotely like it. However, Matthew was careful to point out that Brontosaurus’s pose was not just a flight of fancy. In fact, curators took pains to ensure that their displays would be accurate. For example, if the articulating surfaces of a bone did not prove a sufficient guide for its assemblage, as was the case with the limbs of Brontosaurus, curators resorted to more involved methods (see Figure 2 and cover). A particularly interesting technique relied on three-dimensional modeling. Again, Matthew described the process in some detail, stressing the fact that a final decision was made on the basis of manipulating material evidence rather than armchair theorizing.


31 William Diller Matthew, The Mounted Skeleton of Brontosaurus in the American Museum of Natural History (Guide Leaflet no. 18), pp. 6–7, rpt. from Amer. Mus. J., 1905, 5(2). “Amphibious Dinosaurs” refers to the Sauropoda, which were thought to spend most if not all of their time half submerged in water.
Figure 2. AMNH preparators posing the limbs of Brontosaurus (1904). Image no. 17506, American Museum of Natural History Library.
The Brontosaurus’ limbs were . . . provisionally articulated and posed, and the position and size of each muscle were represented by a broad strip of paper extending from its origin to its insertion. The action and play of the muscle . . . could then be studied, and the bones adjusted until the proper and mechanically correct pose was reached. . . . The skeleton as it stands is believed to represent, as nearly as study of the fossils enables us to know, a characteristic position that the animal actually assumed during life.32

Despite the care taken by AMNH curators to find a believable pose for their dinosaur skeletons, controversy erupted over the end result. Most contentious was the question of whether sauropod dinosaurs held their limbs erect under the belly, as elephants do, or if the humerus ought to be articulated on a horizontal plane relative to their bodies, as it is in crocodiles and most lizards. The received view, which was largely followed by the AMNH in mounting Brontosaurus, had its roots in the work done by Othniel Charles Marsh during the late nineteenth century.33 In a series of articles published not long after Brontosaurus went on display, Oliver Perry Hay, a paleontologist affiliated with the U.S. National Museum in Washington, D.C., accused his peers of having followed Marsh’s example “almost slavishly.” A 1908 publication, for example, questioned whether the matter could ever be settled conclusively, in part because the “head of the femur and the acetabulum were doubtful invested with much cartilage, so that we can not now be wholly certain about their form and fitting.” Hay went on to cite the “weight of Diplodocus and Brontosaurus” as “a strong argument against their having had a mammal-like carriage,” concluding that “our museums which are engaged in making mounts and restorations of the great Sauropoda have missed an opportunity to construct some striking presentations of these reptiles that are truer to nature.”34 Two years later he published an expanded version of his argument, complete with an illustration (see Figure 3) that depicted sauropod dinosaurs in a distinctly reptilian pose and with amphibious habits. These and similar concerns resulted in a flurry of activity, as paleontologists engaged in a heated argument over the accurate depiction of these large, herbivorous animals.35

32 Ibid., pp. 7–8.
33 Othniel Charles Marsh, The Dinosaurs of North America, extract from Sixteenth Annual Report of the U.S. Geological Survey, Pt. 1 (Washington, D.C.: Government Printing Office, 1896), Plate 42. A mammalian pose had also been proposed by Richard Owen. See, e.g., Richard Owen, Report on British Fossil Reptiles, Pt. 2 (Report of the British Association for the Advancement of Science) (London: R. and J. E. Taylor, 1842); and Owen, Geology and Inhabitants of the Ancient World (London: Crystal Palace Library, 1854). The AMNH Brontosaurus followed the received view in broad strokes, but not in all its details. In a communication to his peers, Osborn described how the mounting of the skeleton had induced AMNH curators to revise some earlier ideas about sauropod locomotion: “Messrs. Matthew and Granger made a complete restoration of the muscles of the shoulder girdle and of the neck on the basis of dissections of the alligator and lizard. As a result, two important modifications of previous restorations have been made, first, the scapula is considerably more depressed below the level of the back than in previous restorations, thus allowing space for the cartilages between the ribs and the caracoid, second, the elbows are considerably everted.” See Henry Fairfield Osborn, “The Skeleton of Brontosaurus and Skull of Morosaurus,” Nature, 1890, 73:282–284, on p. 283.
34 Oliver Perry Hay, “On the Habits and Pose of the Sauropodous Dinosaurs, Especially of Diplodocus,” Amer. Nat., 1908, 42:672–681, on pp. 676, 678, 679, 679–680, 681. It is worth noting that Hay’s research position at the AMNH had recently been terminated by Osborn. The latter cited budgetary constraints as having forced his hand, but Hay believed he had been ill treated insofar as Osborn had failed to deliver on the promise of a more permanent position. See Henry Fairfield Osborn to Oliver Perry Hay, 19 June 1907, and Hay to Osborn, 19 June 1907, Box 43, Folder 52, Archives of the DVP, AMNH.
The subsequent publication of two articles by Gustav Tornier raised the stakes of the debate even further. Tornier was based in Germany, so he did not have access to the fossils themselves; instead, he primarily argued by way of analogy. Having descended from a crocodilian reptile, Tornier averred, it stood to reason that sauropod dinosaurs like *Brontosaurus* and its close relative *Diplodocus* would have adopted a classically reptilian rather than a mammalian posture. This prompted the director of Pittsburgh’s Carnegie Museum of Natural History, William J. Holland, to respond with a vituperative counter-attack. Holland insisted that the possibility of a reptilian pose had not escaped him or his peers at the AMNH. Indeed, not long after mounting the *Brontosaurus*, AMNH curators experimented with articulating a scale model of the skeleton in a crocodilian manner. The result was carefully examined by attendees of the 1906 American Society of Vertebrate Paleontology meeting, who, “by common consent,” judged it “to represent the impossible.” Having dismissed Tornier as a mere “closet-naturalist” with a “brilliantly illuminated imagination,” Holland proceeded to list some of the reasons that *Diplodocus* and *Brontosaurus* could not possibly have crawled on the ground as lizards do. For one thing, he noted that the hip and leg bones of sauropod dinosaurs resemble those of birds (which have an upright posture) more than those of lizards. For another, if the femur were inserted


into the hip socket to lie on a plane approximately parallel to the ground, then its head would stand “in no relation whatever to the articulating surfaces of those portions of the pubis and the ischium . . . which enter into the composition of the acetabulum.” Indeed, fitting the femur into its hip socket the way Tornier advised would require “smashing the ilium or breaking the femur to jam the head of the latter into the position demanded for it by the learned professor.”

As the coup de grâce, Holland went so far as to mount a life-sized plaster cast of Diplodocus in the pose advocated by Tornier and Hay with the hope of showing just how unlikely the end result really was (see Figure 4).

Besides issues of functional anatomy, the authenticity of mounted fossils came into question as well. One reason was that the AMNH routinely sculpted replacements for missing bones in plaster of Paris. Again, Brontosaurus provides a striking example. Although the specimen discovered by AMNH collectors in Wyoming during the late 1890s was remarkably complete, it was missing a skull. Not content to mount a headless dinosaur, Osborn had his chief preparator, Adam Hermann, model a replacement (see Figure 5).

The task with which Hermann had been charged was no simple matter, owing to the fact that nothing approaching a reasonably complete skull for Brontosaurus had ever been found. Fragments did exist in Marsh’s collection at Yale University, but these did not suffice to give a definitive picture. AMNH curators thus resorted to the use of a close relative—Morosaurus—to guide Hermann’s hand. In so doing, Osborn relied on a well-entrenched tradition, dating back to the earliest illustrations of Brontosaurus published by Marsh in the 1880s and 1890s. Other parts missing from the fossil skeleton were modeled in plaster as well, including the scapula, humerus, radius, and ulna. The Department of Vertebrate Paleontology’s official position was to justify this practice on the grounds that “filling in missing parts is essential if the skeleton is really to look like the framework of a living animal and clearly to convey the impression of a living organism.” At the same time, the department also recognized that the inclusion of fake bone in the mounted skeletons could stir controversy, as the “public wants to see originals, in natural history as in art.”

37 William J. Holland, “A Review of Some Recent Criticisms of the Restorations of Sauropod Dinosaurs,” Amer. Natur., 1910, 44:259–283, on pp. 260–261, 267, 269, 263. Holland even speculated that the attempt to mount a scale model in a crocodilian pose at the Society of Vertebrate Paleontology meeting inspired Hay’s ideas about sauropod posture in the first place. See William J. Holland to Osborn, 22 Nov. 1909, General Correspondence, Box 44, Folder 13, Archives of the DVP, AMNH.

38 The controversy appears to have settled down somewhat after W. D. Matthew published a careful review of the arguments and concluded the AMNH Brontosaurus had been mounted correctly. That said, it is important to note that Matthew did not dismiss Hay’s arguments out of hand but, rather, viewed them as a genuine point of debate. Indeed, the question was not conclusively settled until 1938, when Roland T. Bird discovered Brontosaurus tracks in Glen Rose, Texas, that proved the animal could not have dragged its belly along the ground. See William Diller Matthew, “The Pose of Sauropodous Dinosaurs,” Amer. Natur., 1919, 44:547–560. For his personal views on the merits of Hay’s argument see W. D. Matthew to Hay, 27 Jan. 1911, General Correspondence, Box 43, Folder 52, Archives of the DVP, AMNH. For more on the discovery that finally settled the controversy see Roland T. Bird, “We Captured a ‘Live’ Brontosaur,” National Geographic Magazine, 1954, 105:707–722.

39 Morosaurus has since been synonymized with Camarasaurus. For more on the choice of skulls see Annual Report of the Department of Vertebrate Paleontology, 1904, 1:1, Box 1, Archives of the DVP, AMNH.


41 Rachel Nichols, “Skeletal Restorations in the AMNH,” n.d., 1:8, Box 2, Folder 5, Archives of the DVP,
Osborn’s decision came into question in 1909, when a paleontologist from the Carnegie Museum discovered the remains of a *Brontosaurus* that appeared to include a reasonably complete skull. Upon closer examination, this skull looked nothing like Hermann’s model. Instead, it bore a much closer resemblance to the slender and gracile head of *Diplodocus*. This prompted the Carnegie Museum’s director, William J. Holland, to publish a short article in which he cast doubt on Hermann’s use of the robust *Morosaurus* skull as a guide in mounting *Brontosaurus*. “The problem is naturally perplexing, and in certain aspects amusing,” Holland noted, using the occasion to take a jab at his institutional rivals in New York. “My good friend, Dr. Osborn, has in a bantering mood ‘dared’ me to mount the head,” Holland recounted. Although he insisted that he was “inclined to take his ‘dare,’” in the end Holland did not do so. The long, tapering neck of sauropod dinosaurs ensured

AMNH. This view about authenticity only hardened with time. An even stronger sentiment was voiced by the AMNH paleontologist George Gaylord Simpson in the 1950s. In an internal memorandum, Simpson expressed himself in no uncertain terms: “the exhibition of casts when originals are present is rightly resented [by visitors] and throws doubt on the authenticity of the museum’s whole exhibition.” See G. G. Simpson to A. E. Parr and M. F. Harty, 12 May 1953, 1:8, Box 2, Folder 10, Archives of the DVP, AMNH.

that skulls would always be found some distance away from the rest of a skeleton, so the interpretation of Holland’s discovery remained something of an open question. Rather than risk public embarrassment should he turn out to be wrong, Holland preferred to mount the Carnegie’s *Brontosaurus* with a missing head. This state of affairs persisted until 1936, when, shortly after Holland’s death, the Carnegie Museum finally placed a *Morosaurus*-like skull modeled in plaster on its *Brontosaurus*. And thus it stood until 1978, when David Berman and John McIntosh revisited the question and concluded that Holland had been right all along. Not long thereafter, both the AMNH and the Carnegie Museum revised their *Brontosaurus* displays, furnishing them with skulls that resembled *Diplodocus* more than *Morosaurus*.

Figure 5. Adam Hermann modeling the Brontosaurus skull (1904). Image no. 45615, American Museum of Natural History Library.

The authenticity of original fossils rather than simulacra modeled in plaster was called

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into question as well. Nearly all mounted dinosaurs were a kind of chimera, cobbled together from fragmentary pieces. For example, no fewer than three different individuals besides the principal Nine Mile Quarry specimen were called on to supply material for the AMNH Brontosaurus.\footnote{Matthew, Mounted Skeleton of Brontosaurus in the American Museum of Natural History (cit. n. 31), pp. 11–12.} In many cases, the identification of individual fossils was sufficiently certain that no serious question arose about whether a humerus, say, rightfully belonged to the same kind of animal as the other bones with which it had been assembled. In other instances, however, there was no doubt that curators had in effect invented a new organism, one that never lived in the flesh. For example, in 1907 the AMNH decided to exhibit a Permian fin-backed lizard, \textit{Naosaurus}. This specimen was built up out of several individuals collected by different people in geographically distant locales. Moreover, some of the bones used in the mount were known not to have belonged to \textit{Naosaurus}, but hailed from an allied genus, \textit{Dimetrodon}, instead. In a description intended for fellow scientists, Osborn defended this practice and stressed that although “the assemblage is largely composite,” it would nonetheless serve to provide visitors with “an adequate conception of the unique and imposing characters of these great extinct forms.”\footnote{Henry Fairfield Osborn and Charles Hazelius Sternberg, “A Mounted Skeleton of Naosaurus, a Pelycosaur from the Permian of Texas,” \textit{Bull. Amer. Mus. Nat. Hist.}, 1907, 23:265–270, on p. 265. Osborn’s sanguine comment notwithstanding, it is clear that curators generally felt extremely uneasy about the construction of such composite mounts. For example, in a letter to Sternberg some ten years later, Matthew complained about the fact that Sternberg’s latest shipment of fossils was so incomplete as to preclude making anything but a similar composite: “I am extremely reluctant to combine different individuals in this way, but no one of your specimens seems to be anywhere near to being a mountable skeleton.” Matthew to Charles Hazelius Sternberg, 9 Oct. 1918, General Correspondence, Box 93, Folder 29, Archives of the DVP, AMNH. It is not insignificant that the announcement of the new \textit{Naosaurus} exhibit in the popular \textit{American Museum Journal} did not make mention of its composite nature. See “The Naosaurus, or ‘Ship-Lizard,’” \textit{Amer. Mus. J.}, 1907, 7(3):36–41.}

As with functional anatomy, the scientific community was divided over the role restoration should play in the articulation of fossil dinosaurs. Discussions turned on the point of whether, to what extent, and the purposes for which museum displays could legitimately deceive or mislead the public. Matthew, for example, advocated that bones modeled in plaster of Paris be labeled as such, either by outlining the restored portions in red or by marking the entire bone with an “X.”\footnote{In an early leaflet guide for visitors, Matthew explained that extinct vertebrates were articulated and mounted “as much as possible like skeletons of modern animals.” However, he admitted that doing so was “a very difficult matter” owing to the fact that such “skeletons are rarely perfect” and thus required restoration. So as not to deceive the visitor, the “outlines of restored parts of bones are marked off with red lines, while entire bones modeled in plaster are marked with a red cross.” See William Diller Matthew, \textit{The Collection of Fossil Vertebrates: A Leaflet Guide to the Exhibition Halls of Vertebrate Paleontology in the American Museum of Natural History}, p. 9, rpt. from \textit{Amer. Mus. J.}, 1903, 3(5).} It is not clear how consistently Osborn put Matthew’s suggestion into practice, but the AMNH appears to have adopted a two-pronged strategy: providing sufficient visual cues for fellow scientists to distinguish fossil from plaster, but making sure these were subtle enough to escape the notice of more casual visitors. An internal report indicates that although efforts were made to “differentiate restoration enough so that no doubt arises under close examination,” preparators used plaster of a “harmonizing color that will not leap to the eye and give a patchy appearance.”\footnote{Nichols, “Skeletal Restorations in the AMNH” (cit. n. 41).} Scientists working outside the AMNH criticized exhibits designed to fool the casual visitor. Oliver Perry Hay, for example, excoriated the AMNH for its failure to distinguish adequately between real and fake bone: “beauty ought not to be secured at the expense of
truth,” he admonished his peers in the pages of *Science*. Even Matthew’s “device of a thin red line” did not satisfy Hay, who judged it to be “hardly visible at a distance and . . . not understood readily by the visitor.” “It is futile and mischievous to attempt to hide the nature of the restoring materials,” he continued, as this “is sooner or later detected and suspicion is thrown on the whole exhibit.” Even more egregious, he judged, was the practice of building “up a fossil skeleton out of the bones of various individuals.” Doing so resulted in the production of hybrid forms he described as veritable “monsters.” Visitors should thus not be blamed if they come to view paleontological displays as nothing more than “products of the unchastened scientific imagination.”48

By far the most vociferous attack on the authenticity of museum displays had been directed at Othniel Charles Marsh some two decades earlier. In a piece for the *American Naturalist*, a disgruntled former laboratory assistant, Erwin Barbour, charged that Yale’s fossils had been “restored to deceive rather than instruct.” Barbour was especially incensed by the fact that even professional paleontologists would have had a hard time authenticating Marsh’s specimens. To illustrate just how difficult it was to be sure about any particular bone, he summoned a fictional naturalist whose only recourse was to go through the museum wielding an imaginary sponge with which “to wash the purity of a truth out of the blackness of a falsehood.” Barbour went on to report that during his tenure in Marsh’s laboratory, he and his colleagues had developed a technique of mixing “bone-black, and gum acacia,” into the plaster used for restoration. This, he claimed, rendered a simulacrum that was practically indistinguishable from the real thing. Thus, even a trained scientist would not have been able to “distinguish between the rusty, frost-cracked, weather-beaten, moss and lichen effects, craftily wrought in the plaster, and the conditions wrought by time on the specimens themselves.”49

**CONSTRUCTING THE DINOSAUR**

Far from having been mere remnants of the natural world, then, dinosaur skeletons were the manufactured products of human ingenuity. At the same time, real fossil bones were an integral, indeed essential, element of the museum’s exhibit. We can reconcile the Janus-faced nature of dinosaurs—their paradoxical status as pieces of nature constructed in the museum’s preparation lab—by thinking of them as elaborately conceived mixed-media installations. Mounted dinosaurs were sculptures whose execution required a wide range of materials, ranging from fossilized bone to wrought iron, steel, shellac, plaster, and much else besides.

What went into making the *Brontosaurus*? We have already seen that some sections

49 Erwin Barbour, “Notes on the Paleontological Laboratory of the United States Geological Survey under Professor Marsh,” *Amer. Natur.*, 1890, 24:388–400, on pp. 388–389, 392. Barbour’s claim that Marsh’s restorations were designed to deceive was not unique. In a review of H. N. Hutchinson’s popular book *Extinct Monsters*, a naturalist who identified himself only by the initials H.G.S. charged that “Prof. Marsh draws an animal so as to give one type the maximum height to which the bones can be hoisted; while another is given the maximum length to which the remains can be extended.” See H.G.S., “Review of Extinct Monsters by H. N. Hutchinson,” *Nature*, 1893, 47:250–251. Still, it is worth keeping in mind that Barbour had a well-known falling out that led to the termination of his employment for Marsh; it is thus significant that his criticisms were published in the *American Naturalist*, which at that time was edited by Marsh’s bitter rival, Edward Drinker Cope. See Mark Jaffe, *The Gilded Dinosaur: The Fossil War between E. D. Cope and O. C. Marsh and the Rise of American Science* (New York: Crown, 2000); and David Rains Wallace, *The Bonehunters’ Revenge: Dinosaurs, Greed, and the Greatest Scientific Feud of the Gilded Age* (Boston: Houghton Mifflin, 1999).
of the skeleton, including the skull, were entirely modeled in plaster. This suggests that it could be decomposed into two parts, one of which was authentic whereas the other was not. As a matter of fact, it was rarely possible to make such clear-cut distinctions, neatly separating authentic from artificial elements of a display. This is because dinosaur bones were never simply transferred from the field directly into the museum’s gallery. A series of curatorial interventions—excavation, preparation, assembly, and mounting—were critical in shaping these objects for public consumption.

*Brontosaurus* already began undergoing intensive treatment out in the field. Dinosaur bones can be very brittle and crumble to pieces when exposed to the air. Adapting a method developed by Marsh in the late nineteenth century, AMNH collectors hardened fossils by soaking them in shellac as they were taken out of the ground. The procedure was continued at the preparation lab back in New York. In an instruction manual, AMNH chief curator Adam Hermann explained that “a solution of shellac or gum [arabic] . . . will toughen and harden the specimen . . . so that a very soft and crumbly bone becomes strong enough to handle safely.” Once they had been sufficiently hardened, fragments of bone could then be removed from the surrounding rock matrix. This was done using a variety of tools, including a hammer and chisel, awl, electric drill, dental lathe, and, in some cases, chemical solutions like hypo-acetone. Describing his early days at the AMNH during the 1890s, the celebrated dinosaur artist Charles R. Knight recalled how the paleontological laboratory always seemed to have “hummed with the sound of drills, scrapers and mallets” (see Figure 6).

Cleaning fossils was an intense process, but it was just one in a series of steps required to mount a freestanding skeleton. Once the various pieces of bone had been removed from the rock matrix, they had to be assembled and cemented together. According to Hermann, individual bones could be so badly fragmented that working with them was like trying to solve a “Chinese puzzle” (see Figure 7). Moreover, pieces of fossil were often lost or destroyed, so the overall shape of a bone was unclear and had to be restored. Since it was rarely possible simply to fill in the gaps, more than just plaster was needed to give the end product its desired shape. Hermann recommended that “wire netting of the proper size . . . should be fashioned to shape the part to be restored.” In extreme cases, the fossils out of which a mounted skeleton was

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50 Matthew described “soaking the exposed surfaces repeatedly with thin ‘gum’ (mucilage) or shellac, channeling around and between the bones until they stand out on little pedestals above the quarry floor.” See Matthew, *Dinosaurs, with Special Reference to the American Museum Collections* (cit. n. 30), p. 119.


constructed would have contained greater parts of plaster, metal, and shellac than petrified bone.

Once all the individual bones had been assembled—with those parts entirely missing from the skeleton either cast from specimens housed in other museums or modeled freehand—they were articulated in what was believed to be a natural pose. In addition to uncertainties about functional anatomy, articulating the skeleton represented a difficult engineering problem, as dinosaur bones are too heavy and fragile to support themselves under their own weight. A metal scaffold was therefore required. According to Hermann, each vertebra had to be placed on a wooden frame shaped to approximate “the curvature of the backbone in the living animal.” This way, the whole column could permanently be set in place by pressing each bone into a long strip of clay, reinforced with an iron or steel rod. A more sophisticated technique was developed for especially rare or valuable specimens, in case museum curators ever wanted to detach an individual bone from the mount for closer inspection. As before, a metal rod was used as a brace for the backbone, with removable pins extending outward that could either be bored into the center of each bone or split to form an exterior clamp. Limbs and other appendages, such as the neck and skull, could then be attached individually to the central backbone support. In every case, the primary criterion for success was that any and all supporting materials—clay, plaster,

*Mechanics*, the process is described in vivid detail: “As dug out of the ground, the bones are cracked and splintered by the several million winter frosts they have undergone. The pieces are carefully wrapped and packed and shipped home. Arrived there, they are laid out and joined together, like matching up a jigsaw puzzle, and then with plaster of Paris, hammer and chisel, drills and steel rods, the work of assembling the parts into a whole bone begins.” See “‘World Apart’ Yields Giant Bones,” *Popular Mechanics*, 1925, pp. 941–943.

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**Figure 6.** Otto Falkenbach preparing a duckbill dinosaur skull with a motor attached to a wire brush (ca. 1907). Image no. 17563, American Museum of Natural History Library.
wire mesh, and iron—be as inconspicuous as possible, lest they draw attention to themselves and away from the fossils. As such, Hermann judged the duckbill skeleton shown in Figure 8 as exemplary, owing to the fact that it had “the least noticeable support of any we have had so far.”

Hiding the metal supports was considered crucial for a dinosaur mount to succeed in conveying the impression of a living animal. After the Carnegie Museum of Natural History put a Diplodocus on display, William J. Holland explicitly praised his staff for having made a mount that combined “absolute safety together with a lifelike pose.” Holland especially singled out his chief preparator, Arthur Coggeshall, for the “great ingenuity” with which he had “devised a system of steel supports conforming themselves to all the sinuosities and rugosities of the under surface of the vertebrae” (see Figure 9). This made it possible to fashion a support system that was “so reduced in size [as not to] offend the eye by a display of ‘open plumbing work,’ which has heretofore been very much in evidence in the mounting of dinosaurian remains.” For his part, Hermann concurred with Holland, writing that he considered the Carnegie Museum’s technique a “neat style of mounting,” although it did have the disadvantage that “lower surfaces of the centra of the vertebrae are more or less covered by metal and their view is somewhat obstructed.”

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MAKING THE PAST COME ALIVE

A lively pose was an important feature of mounted dinosaurs. As we have seen, museum curators and trustees valued these exhibits in part because they brought large numbers of visitors into the exhibition hall. Clearly, depictions of animals interacting with one another and their surroundings made for a more spectacular exhibit than individual pieces of unadorned fossil. In addition, elaborate displays also allowed curators to communicate more information about dinosaurs and the world they inhabited. Both goals required
inducing a detailed and vivid imaginative experience in the mind’s eye of visitors. Following on the unprecedented success of *Brontosaurus*, the AMNH thus began to experiment with diorama-like installations that conveyed facts about dinosaur ecology, life history, and behavior in addition to their functional anatomy.\textsuperscript{56}

\textsuperscript{56} In 1907, the Department of Vertebrate Paleontology explicitly stated that its newest displays had been

\begin{figure}
\centering
\includegraphics[width=\textwidth]{image}
\caption{Serafino Agostini welding the backbone support for Diplodocus at the Carnegie Museum of Natural History (circa 1904). Image no. 970, Big Bone Room, Archives of the Carnegie Museum of Natural History.}
\end{figure}
The group of freestanding duckbills whose mount was praised by Adam Hermann furnishes a particularly good example. It combined two dinosaurs with remnants of their ecology, incorporating fossil “shells, leaves, and other plants of this period” into the “matrix” near the animals’ feet. As Figure 10 illustrates, one of the animals was posed with its head low to the ground, thus giving the impression of feeding on plant material below. In the 1908 Annual Report, the AMNH praised Hermann’s work as a significant “step forward in methods of exhibiting fossil vertebrates,” primarily because it was seen to add “greatly to the realistic effect . . . of the skeleton.”

A notable feature of the duckbill display is that it hinted at the existence of a whole world beyond what was depicted in the actual mount. For instance, the second individual shown in Figure 10 was not in a feeding position, but stood upright with its head held high in the air. In a leaflet guide, Matthew encouraged visitors to interpret this pose as an indication that the animal had sensed the presence of danger somewhere off in the distance: “This group takes us back in imagination to the Cretaceous period. . . . Two members of the family are represented here as feeding in the marshes that characterized that period, when one is startled by the approach of a carnivorous dinosaur, Tyranno-

modeled on habitat dioramas: “Our methods of installations are . . . progressing along the same lines of development as may be seen in recent zoological exhibits, such as the new bird group in this museum.” See Annual Report of the Department of Vertebrate Paleontology, 1907, Archives of the DVP, AMNH. For more on the history of zoological group displays see Nyhart, Modern Nature (cit. n. 12); and Karen Wonders, Habitat Dioramas: Illusions of Wilderness in Museums of Natural History (Acta Universitatis Upsaliensis, N.S., 25) (Uppsala: Almqvist & Wiksell, 1993).

57 Annual Report of the Department of Vertebrate Paleontology, 1908, 1:1, Box 1, Archives of the DVP, AMNH; and Annual Report of the President (New York: American Museum of Natural History, 1908), p. 31.
saurus, their enemy, and rises on tiptoe to look over the surrounding plants and determine the direction from which it is coming.”

Leaflet guides formed an integral part of the museum’s exhibit, instructing visitors on how to think about the freestanding skeletons on display. This was important, because the meaning of a skeleton was not self-evident. The fossilized skull of a dinosaur simply did not have the expressive capacity to indicate that it was on the lookout for predators. Leaflets were thus one way to make dinosaur bones come alive. However, the medium of printed text suffered from severe limitations in that it did not contribute directly to the visual and material spectacle of the dinosaur hall. Moreover, curators could not be sure visitors would actually consult the guides, as doing so required a special effort. Hence, leaflets alone could not be counted on as a reliable means to provide the public with an appropriate understanding of the exhibited fossils. The medium of choice for this latter purpose was not printed text but oil on canvas.

Figure 11 depicts a pair of duckbill dinosaurs painted by Charles R. Knight. A striking feature of Knight’s painting is how closely it mirrored the pose of the two mounted skeletons alongside of which it was shown. We do not know precisely where this particular canvas was hung, but generally speaking Knight’s work was placed directly beside or just beneath the skeleton it was intended to complement. Figure 1, for example, shows another such painting, this one of Brontosaurus, placed just under the base of that animal’s extended neck. According to Knight, their placement allowed visitors to “look from one to the other and thereby glean perhaps some idea of the life which flourished so

58 Matthew, Dinosaurs, with Special Reference to the American Museum Collections (cit. n. 30), pp. 83–85.
vigorously on our planet in ages past.” Knight thus explicitly hoped that his paintings would function as “an explanation of the skeletons themselves.”

Given their proximity to one another, and the fact that paintings and mounted skeletons usually depicted their subject in exactly the same context and pose, Knight’s illustrations functioned more as the backdrop of a habitat diorama than as a portrait. This is not to disparage the quality of Knight’s work, nor to devalue his contribution to the AMNH dinosaur hall, but, rather, to suggest that his paintings are best understood as an extension of the AMNH’s mixed-media installation strategy. Much as an iron or steel scaffolding allowed curators to turn a jumble of bones into a vivid display, Knight’s paintings made it possible to project their theories about dinosaur life history and behavior onto the fossils.

Knight’s work excelled at its intended function, which, in his own words, was “to put life into the dead bones.” However, the fact that Knight was a trained artist rather than a paleontologist meant that his output suffered from a deficit in scientific credibility. For this reason, Osborn always made sure to stress that Knight’s work was not an artistic achievement alone. Rather, his paintings and illustrations were consistently described as the outcome of an intense collaboration between art and science. For example, magazine reproductions of Knight’s work always included a caption indicating that the original had been executed under Osborn’s direct personal supervision. Knight made sure to convey this message as well. In his autobiography, he explicitly singled out Matthew as an important “consultant and adviser on matters of pose and difficult bone structure.” Or, when giving a radio interview, he declared adamantly that “no hokus-pokus” was required to restore long-extinct reptiles to life. “It is all done along strictly scientific lines and only after long consultation with . . . men who are experts in this particular field,” he said.

It is telling that even decades into their collaboration, Osborn never trusted Knight to produce illustrations that could pass scientific muster without a museum curator’s help.

Charles Knight, “American Museum’s Murals of Prehistoric Animals,” Charles R. Knight Papers, Box 8, Folder 1, Rare Books and Manuscripts Division, New York Public Library, New York (hereafter cited as Knight Papers). This pairing of paintings with specimens echoes an earlier practice, dating back to 1893, in which the AMNH included two labels for each fossil in the mammal hall. The first showed visitors a fully articulated skeleton of the specimen, whereas the second provided a restoration in which the animal was clothed in flesh. In a departmental report, Osborn expressed confidence that such pairings “will be very effective in attracting attention and giving instruction.” See Annual Report of the Department of Vertebrate Paleontology, 1893, 1:1, Box 1, Archives of the DVP, AMNH.

Indeed, early in his career, Knight painted some backdrops for AMNH habitat dioramas. See Charles R. Knight to Hermon C. Bumpus, 28 Dec. 1908, Record Group 249, Central Archives, AMNH.

For an indication of how Knight collaborated with paleontologists to produce his murals see, e.g., C. R. Knight to S. C. Simms, Charles R. Knight Contract for Paintings for Ernest R. Graham Hall, 1926–1981, Folder 6, File 2, Archives of the Field Museum of Natural History, Chicago.

At one point, e.g., Osborn mused that the production of an early mural depicting a number of woolly mammoth and reindeer had “caused me so much time and supervision” that “I think I shall call it the Osborn-Knight restoration without any injustice to Mr. Knight.” See Osborn to Frederic A. Lucas, 2 May 1915, Record Group 249, Central Archives, AMNH.

“The Career of Charles Knight,” Curator, 1961, 4:352–367, on pp. 364–365; and “Transcript of Knight interview with Miss Eslajean Geyer for ‘The Hour of Living Art,’ a radio broadcast on W.F.A.S.,” n.d., Box 8, Folder 5, Knight Papers. The precise nature of these relationships is well documented in the archives. When Knight was hired to execute a painting of Triceratops for the Carnegie Museum of Natural History in Pittsburgh, the paleontologist John Bell Hatcher agreed to pay him $200 for the job, specifying that “you furnish your own canvas, colors, etc, and I . . . give you all possible necessary data regarding the proportions of various parts of the animal to be restored, and the character of the flora and probable physical conditions of the surrounding country.” See John Bell Hatcher to C. R. Knight, 23 Mar. 1904, Box 1, Folder 2, Knight Papers.

Voicing his dismay that Knight had been commissioned to execute a series of mural paintings for the Field Museum of Natural History in Chicago, Osborn wrote, “While Charles is supreme in painting living animals it is impossible for him to paint extinct animals without guidance by myself or some other lifelong student of the
For this reason, Osborn developed an efficient workflow that ensured he would retain absolute control over Knight’s creative output. For example, Osborn insisted that Knight sign a legal contract forcing the artist to defer on all matters of technical interpretation. Besides standard clauses pertaining to mundane features such as canvas size and price, these agreements explicitly mandated that Knight choose his “subject matter and composition . . . in consultation with . . . Osborn.” Having agreed to a basic plan, Knight next had to submit a detailed sketch of the painting for curatorial inspection. Finally, the contract stipulated that the museum could withhold payment for work that Osborn judged to differ from the approved sketch in any point of content, composition, or color.65

For a time, this arrangement worked remarkably well. But over the years Knight’s relationship with Osborn grew increasingly strained. For one thing, both men became more and more unwilling to compromise when a difference of opinion arose. An especially telling point of contention that cropped up time and again was whether Knight would execute his work at the museum or in a private studio. Predictably, Osborn wanted to keep the artist close by. In part, this was to ensure that Knight would be in constant contact with the physical remains of his subjects. In 1916, for example, Osborn tried to insist that Knight execute his paintings in the same room as “the objects from which you should work, and to which you should constantly refer.” About a decade later, Osborn raised the possibility of commissioning a set of murals to replace the dinosaur paintings Knight had executed earlier in his career. Again, he insisted that Knight work from the “mounted skeletons which best represent the true proportions and size” of these animals.66

In every instance, though, the artist preferred the autonomy of his own studio and steadfastly refused to work in the museum.67

THE VALUE OF INDEXICALITY

Dinosaur displays were elaborate mixed-media installations. As such, we should be able to distinguish the various strengths and weaknesses of each medium. Paintings, for example, functioned as purely iconic representations of prehistory. Their strength lay in the almost unlimited control they promised curators eager to communicate aspects of dinosaur anatomy and behavior to visitors. This, together with Knight’s celebrated mastery of the medium, is what gave them such enormous expressive potential. However,

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65 The AMNH archives contain many copies of contracts between the museum and Knight. The formal arrangement between the two parties evolved to become increasingly rigid over the years. For a representative example of the mature version see Lucas to C. R. Knight, 27 Apr. 1922, Record Group 249, Central Archives, AMNH. Regarding the workflow intended to control Knight’s output see Marianne Sommer, “Seriality in the Making: The Osborn-Knight Restorations of Evolutionary History,” *History of Science*, 2010, 48:462–471. For a fascinating history of how patrons exerted legal control over the content of commissioned artworks in Renaissance Italy see “Conditions of Trade,” in Michael Baxandall, *Painting and Experience in Fifteenth-Century Italy: A Primer in the Social History of Pictorial Style*, 2nd ed. (Oxford: Oxford Univ. Press, 1988), pp. 1–23.

66 Osborn to C. R. Knight, 7 Feb. 1916, Record Group 249, Central Archives, AMNH; and Osborn to George H. Sherwood, 5 July 1925, Record Group 1262, Central Archives, AMNH.

67 “I am . . . sorry that you have gone to the trouble of having the place fixed up for me in the Dinosaur Hall,” he wrote Osborn. “I thought I had made myself clear as to the impossibility of doing my work under conditions which prevent productions to the best of my ability.” Osborn’s response was that Knight had no choice in the matter: “Your apartment is entirely too small to assemble all the objects needed in the studies for these great murals.” See C. R. Knight to Osborn, 23 Nov. 1925, and Osborn to A. Knight, 24 Nov. 1925: Record Group 1262, Central Archives, AMNH.
precisely because oil on canvas is such a supple and flexible medium, a painting was only as trustworthy as the person responsible for its execution. This is why the museum took so much care to advertise the involvement of professional scientists in Knight’s creative process. Leaflet guides, which projected the voice of curators onto the exhibition floor, were another way to bring the authority of research science out from behind the scenes and into the public gallery. As we have seen, though, controversy over even relatively straightforward aspects of dinosaur biology existed within the curatorial ranks. An exhibit’s credibility could not, therefore, rest entirely with scientists and their speculative theories. Rather, the mark of truth had to reside in the fossils themselves.

Leaflet guides were enlisted to fulfill a second function, besides broadcasting the voice of curators into the exhibition hall. Whenever possible, they made sure to direct visitors’ attention to indexical features of the display. Describing the alert, upright pose of a duckbill, for example, one guide instructed viewers to imagine that “the erect member of the . . . group had already had unpleasant experiences with hostile beasts, for a bone of its left foot bears three sharp gashes which were made by the teeth of some carnivorous dinosaur.” Or, in the case of a mounted Allosaurus shown preying on a section of Brontosaurus tail, the guide explained that several Allosaurus teeth had been found mingled with the bones of Brontosaurus at the dig site in Wyoming. Several years later, this message was reinforced on a label mounted beside the specimen. Visitors were instructed to “note that the spines of the tail vertebra are scored and bitten off and somewhat torn apart—as they were found in the quarry. Beside them were discovered several broken teeth of Allosaurus and the marks on the bones correspond with the spacing of the teeth in the jaws of this animal.”

Indexicality was such a prized feature of fossils that the AMNH was willing to spend considerable sums of money to secure specimens capable of engaging visitors’ imaginations without having to be augmented by too many additional media. A particularly striking example was discovered by the freelance collector Charles Hazelius Sternberg and his two sons near Lusk, Wyoming, during the summer of 1908 (see Figure 12). This specimen is noteworthy because it was found in a truly exceptional state of preservation. It was so good, in fact, that its skin had even left a distinct impression on the surrounding rock matrix, causing it to be christened the “dinosaur mummy.” Sternberg immediately recognized its significance, and he wasted no time writing to Osborn and offering to part with it for the right price.

Although a number of factors contributed to its value, the mummy’s most important features were its remarkable completeness and the fact that it was perfectly articulated. For this reason, it could be mounted just as it had been found. That is, without significant restoration in the museum’s preparation lab, Sternberg’s dinosaur mummy resembled a real, live animal. As he put it in a letter to Osborn, “In all my experience of fossil hunting I never saw a specimen in [such a] natural position. . . . The front limbs are stretched out as if

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68 Matthew, Dinosaurs, with Special Reference to the American Museum Collections (cit. n. 30), p. 85; William Diller Matthew, “Allosaurus, a Carnivorous Dinosaur and Its Prey,” Amer. Mus. J., 1908, 8(1):2–5, on pp. 4–5; and “A Carnivorous Dinosaur and Its Prey,” Rachel Nichols Files, 1:8, Box 1, Folder 10, Archives of the DVP, AMNH.

struggling for life. He lies on his back. The hind limbs doubled up against the body. . . . The skull is magnificent with every bone . . . in natural position. [It is] as perfect a restoration [as]
can be made if in life with [the] exception of color.”

Sternberg was right to think that the layout of this animal’s bones would impress curators, who coveted the mummy for its ability to cast an air of authenticity over the whole dinosaur hall. He understood their exhibition strategy well, and he was not shy about profiting from their anxieties. In another letter to Osborn, Sternberg called attention to the fact that “no two preparators have ever mounted any [dinosaurs] exactly alike, showing that they were an authority to themselves, and had not real authority.” In contrast, his dinosaur mummy “was prepared right by its creator and will be the standard always by which this genus will be mounted.” It will “give a correct restoration as in life,” he assured Osborn, “not as in the imagination of the preparator.” Fortunately for Sternberg, he had sized up his negotiation partner perfectly, and it was not long before Osborn agreed to purchase the dinosaur mummy for $2,000, roughly equivalent to $50,000 today. The sale represented a windfall for Sternberg, whose other fossil discoveries tended to bring in only a few hundred dollars apiece.跨越式

Sternberg to Osborn, 30 June 1908, General Correspondence, Box 93, Folder 28, Archives of the DVP, AMNH.

The modern purchasing power of $2,000 earned in 1908 was calculated on http://www.measuringworth.com/ (accessed 6 Oct. 2010). The Sternberg correspondence is extensive, much of it taken up by negotiations over the price of various fossil discoveries. For example, in 1905 the AMNH succeeded in talking Sternberg’s initial offer of a cretaceous marine lizard (*Platecarpus*) from the Kansas Chalk from $800 down to $650. See Sternberg to Osborn, 26 Nov. 1904, General Correspondence, Box 92, Folder 26, Archives of the DVP, AMNH. Earlier still, Sternberg had attempted to sell a giant turtle (*Protostegagigas*) to Osborn for some $550. He
Natural history museums like the AMNH were hybrid institutions that had to satisfy the diverse and at times conflicting demands of different constituencies. On the one hand, the dinosaur hall was designed to attract large numbers of people by putting visitors in touch with the fantastic, violent, and ponderous creatures of a bygone age. On the other hand, the AMNH was proud of its status as an elite research and educational institution whose exhibits could pass muster even among professional paleontologists. Hence, it did not suffice simply to offer a vivid picture of the world in which dinosaurs lived. Rather, it was crucial for the displays to be seen as providing access to the actual past. The strategy developed to exhibit dinosaurs around the turn of the twentieth century reflected the museum’s institutional hybridity. Iconic representations born of the artist’s imagination were carefully paired with mounted skeletons. This was done to make dead bone come back to life, but it also served to render the paintings more credible: the indexicality of fossils grounded dinosaurs in the actual past rather than just the imagination of curators.

Individual pieces of fossilized bone served as a material trace of prehistory. They were prized as a direct link connecting the world of museum visitors to a distant past populated by strange and monstrous reptiles. As we have seen, though, a whole series of curatorial interventions were required to assemble these into something like the freestanding *Brontosaurus*. In the course of this essay, we have encountered several elaborate measures the AMNH devised to mitigate the impact of these interventions and preserve their fossils’ indexicality. For example, although curators felt compelled to include subtle indications that would allow trained naturalists to distinguish real fossils from fake bone “under close examination,” more casual visitors would almost certainly have been fooled by the decision to use a “harmonizing color that will not leap to the eye.”\(^{72}\) Similarly, it was considered vital to hide the “plumbing work” on a freestanding mount, because its presence served as a reminder that, on the whole, *Brontosaurus* was as speculative as anything executed by Charles Knight. In the final analysis, mounted dinosaurs were a kind of mixed-media sculpture deliberately fashioned to occupy an interstitial space between theory and reality, artifice and authenticity, epistemology and ontology.

\(^{72}\) Nichols, “Skeletal Restorations in the AMNH” (cit. n. 41).

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continued to reduce his asking price until John Bell Hatcher finally purchased it for the Carnegie Museum of Natural History in Pittsburgh for about half of what Sternberg claimed it was worth (roughly $300). See Sternberg to Osborn, 29 Oct. 1903, 16 Mar. 1904, General Correspondence, Box 92, Folder 26, Archives of the DVP, AMNH; as well as the letter exchange between Sternberg and Hatcher, 8 Dec. 1903, 23 Dec. 1903, 29 Dec. 1903, J. B. Hatcher Papers, Archives of the Carnegie Museum of Natural History.