

Waking up to Dinosaurs

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I've never been a fan of dinosaurs, in part because I tend to be a contrary person. If something is popular, I'm not interested in it, and dinosaurs are definitely popular. They are everywhere, from breakfast cereal to T-shirts; even my four-year-old grandson, who is of course exceptionally bright, knows the names of several species. But I couldn't see getting too excited about a group of organisms that aren't even around any more—no matter how large, how fierce, how bizarre they may have been. I originally thought the interest in dinosaurs was a fad, and I would just wait it out. But if dino-mania is a fad, it is definitely more long-lived than most.

Last year I was teaching a class in a Science, Technology and Society course, when a question about dinosaurs came up, a question hardly germane to the topic under discussion. Because I believe that it takes a certain amount of courage for a student to raise her hand in class, I think each question should be treated respectfully. So I answered the question about dinosaurs. That led to another question, so I answered that, and then there was another. The class time melted away in a cascade of questions about dinosaurs, which had absolutely nothing to do with engineering, the day's topic. But I didn't mind because almost for the first time in the semester, this

8 o'clock class was awake, aware and interested. Until this point, they had been one of the deadest groups of students I'd encountered in a long time, and even my best jokes (such as they are), my cleverest activities, my most positive encouragement didn't seem to stir them. But dinosaurs did.

After that class, I didn't want to let dinosaurs go. I finagled ways to cover a couple of topics using dinosaurs; after all, many of them were feats of engineering. But to discuss dinosaurs intelligently, I had to learn more about them. I had to stop ignoring them. In the process, I haven't become a dinosaur expert, and I haven't become that much of a convert that I want to be an expert, but I've learned enough to have more respect for these beasts and to begin to see why others have found them so fascinating.

I think part of the attraction of dinosaurs is that they are extinct. If they could still be seen and heard and touched, then they wouldn't be quite as interesting. After all, elephants probably make as much noise as many dinosaurs did, and a blue whale is the biggest animal to ever have lived on earth, yet neither of these animals seems to have gotten as much press as *T. rex*. Stephen Jay Gould quotes a psychologist as saying that the fascination with dinosaurs is due to the fact that they are big, fierce and extinct—they are scary, but safe; no one is going to get trampled by an *Apatosaurus* or ripped to shreds by an *Allosaurus* (Mitchell 1998b).

The Art & Science of Dinosaurs

Not only are dinosaurs extinct, but they've been extinct for a long time—65 million years or so (Alvarez 1997). This means that a great deal has to be left to the imagination in terms of

dinosaur traits and lifestyles. Many of the articles on the most noteworthy dinosaur fossil finds are accompanied by artists' drawings of what these animals might have looked like. Obviously, these drawings are closely based on the physical findings in the fossil record, but that information doesn't take the artist very far. Even for fossils that are considered spectacular because skin or internal organs are preserved, a leap of the imagination is required to go from these remains to what the animal might have looked like when it was alive. Producing such drawings requires close cooperation between scientist and artist—scientific accuracy must be combined with artistic skills—and that's the theme I want to explore in this column.

The first three-dimensional sculptures of dinosaurs were created about a dozen years after the British anatomist Richard Owen first described this group of organisms in 1842. He had reviewed all the fossil reptiles from the Secondary formations and created a major new category, *Dinosauria*, meaning terrible lizard, for the *Iguanodon* and some other forms. The *Iguanodon* was a bipedal, herbivorous dinosaur that could be up to 30 feet long. Huge beasts like the *Iguanodon* caught the public's imagination in Victorian England; the present day isn't the only era to be afflicted with dino-mania. In 1853 George Benjamin Waterhouse Hawkins was hired to construct four life-size dinosaur models for outside the Crystal Palace. This famous edifice was moved to Sydenham Park after the 1851 London Exhibition for which it was built. The dinosaurs were placed on an island in the middle of a lake presumably so they would be safe from molestation by the crowds that visited the park. The sculptures are still there, though the Crystal Palace eventually burned down. After the

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success of the Sydenham dinosaurs, Hawkins was brought to New York to produce similar figures for a proposed Paleozoic Museum in Central Park. But there were arguments over the expense and religious questions about an exhibit that brought evolution to mind, so Boss Tweed, ever the enlightened politician, had some of his henchmen destroy the sculptures, and the project died.

Dinosaur Images

One of the most famous paintings of dinosaurs is at Yale University's Peabody Museum of Natural History. It was done during World War II by Rudolph Zallinger, who was completing his studies at Yale's School of Fine Arts. The museum's board decided that the dinosaur hall needed to be enlivened. Since there wasn't enough money available to hire a famous artist, a competent one was found. The completed mural, called *The Age of Reptiles*, is 110 feet long and 16 feet high. It provides a sequential view of the story of dinosaurs, though for two reasons this isn't obvious when first looking at the mural. First, the transition from one era to another is seamless, and also, the sequence moves from right to left, which is counter to most depictions of events occurring over time.

The Age of Reptiles has become almost the quintessential rendering of dinosaurs, and even though it is now well over 50 years old, it doesn't look very dated (Mitchell 1998a). This is, in part, because so many later paintings of dinosaurs were based on Zallinger's work. But a comparison of the mural with some recent dinosaur images indicates that late-20th-century dinosaurs are more colorful, agile and active than their Yale predecessors. One reason for this change is the debate in the 1970s over whether or not dinosaurs were warm-blooded. This issue got paleontologists to reexamine fossils, and they discovered that a common assumption about dinosaurs—that because of their great size they had to be slow, lumbering creatures—might not necessarily be true. That's when dinosaurs began to pick their tails up off the ground and run rather than plod.

The image change was in part based on new evidence—information like the fact that most dinosaur tracks show

no evidence of tail dragging. But it was also based on a change of emphasis, a change in what evidence was considered important. There was, for example, a greater interest in color. Even with new findings, most decisions about the color of dinosaurs are based on conjecture and artistic license. Some of the best dinosaur images I've seen are in a book by Frank DeCourten (1998) called *Dinosaurs of Utah*, with illustrations by Carel Brest van Kempen. This book has a great deal of information in it, but the art steals the show; it is spectacular. The illustrations produce a very different atmosphere from that created by Zallinger at Yale. It is a sunnier world, with a lot of running and fighting animals. While *The Age of Reptiles* gives an impression of a leisurely, languid world, the Utah dinosaurs are living in a frenetic one. Which of these approaches is correct, or are they both correct? The latter is more likely. The evidence is mounting that dinosaurs were active animals, but whether they were as brightly colored as they are now sometimes rendered is still an open question, and may well remain one. The world of fossils, particularly of those as old as dinosaur fossils, is a dull world in terms of color. There is rarely any hint of coloration.

This basic lack of information makes the artist's job difficult and also essential, but for this work to have scientific validity, there must also be input from scientists. Wonderful examples of this interplay are found in a two-volume set called *Dinosaurs Past and Present* (Czerkas & Olson 1987) produced in conjunction with an exhibition on dinosaurs at the Natural History Museum of Los Angeles County. Though these volumes are slightly dated because dinosaur research is moving so quickly, there is still a great deal of value here, with wonderful articles on everything from making sense of dinosaurs' tracks, to trying to figure out the arrangement of the plates on the back of *Stegosaurus stenops*. Gregory Paul and Stephen Czerkas, who are both paleontologists and artists, have contributions that deal with how their scientific training influences the decisions they make as artists. There is also a piece by the paleontologist Dale Russell on his collaboration with the artist Eleanor Kish in the creation of dinosaur murals for the

National Museum of Natural Sciences in Ottawa, Canada. And there is another superb female artist represented: Margaret Colbert, who created two dinosaur murals and who is the wife of the noted expert on reptile evolution Edwin Colbert (1965). So in this case, the paleontologist/artist collaboration is familial as well as professional. The murals Margaret Colbert created depict the organisms found in the late Triassic Chinle Formation in New Mexico. The first mural was done in 1976 for the Petrified Forest National Park, and the second for the New Mexico Museum of Natural History in 1985. Even in the short period of nine years, a great deal was learned about the Chinle organisms so the second mural gives a much more complete picture of what life was like in this area in the Triassic.

Dinosaurs on the Move

Where to literally draw the line in recreating dinosaurs is a difficult problem, which becomes even more difficult when the images created are in three rather than two directions. In an essay called "Making a Dinosaur Work," William Jordan (1991) describes how life-sized dinosaur models that move are created by a company called Dinamation International. To make the beasts as accurate as possible involves collaboration among an artist, a scientist and an engineer. All three get together for what's called a "new creatures" meeting which begins with the scientific advisor to the project presenting what is known about the animal. Then the artist, often a sculptor, describes what the model might look like, and the engineer, who is responsible for creating the machinery that will make the "dinosaur" go, points out what is or is not feasible about that conception, keeping in mind the kinds of movements the scientist thinks were most likely for the beast. The Dinamation staff had originally thought that spectacular movements would be the most popular with spectators. They found, however, that subtle movements were more intriguing, and that the most important moving parts were the eyes. The fact that small movements are more effective was a relief to engineers, because these moves cause less fatigue in the urethane "skin" the animals wear.

Though I've heard about exhibits of Dinamation creatures, I was never tempted to see one, because I was still choosing to ignore dinosaurs. I am more familiar with the less flashy displays at natural history museums. Recently, I visited the National Museum of Natural History in Washington, DC where there is a life-size *Stegosaurus* made of papier-mâché that has survived several reincarnations of the dinosaur exhibit (Yochelson 1985). It was originally made for the 1904 St. Louis Exposition, so it is a link to Hawkins' 19th-century dinosaur sculptures and shows the enduring fascination with life-size replicas. At the American Museum of Natural History (AMNH) in New York, the dinosaur exhibits consist mainly of skeletons, rather than skin-covered replicas. Some fossils are still partially embedded in rock, a good reminder of how most of these fossils looked when they were first unearthed after millions of years (Cooper 1996).


That's Entertainment?

The first complete dinosaur skeleton to be mounted was created for the Philadelphia Academy of Sciences. It was *Hadrosaurus*, which had been discovered by Joseph Leidy, one of the most noted biologists of the 19th century (Warren 1998). This skeleton was completed by Hawkins in 1868, almost 15 years after his dinosaur sculptures went on exhibit in England, so flesh-covered reconstructions were created before the less imaginative and more scientifically accurate skeletons. This fact and the Dinamation exhibits speak to the issue: is the reconstruction of dinosaurs science or art, serious culture or entertainment? I think the answer to this question lies somewhere between the extremes. The "new creature" meetings indicate that neither science nor art can build a dinosaur single-handedly, that both factual information and an artistic sense are necessary, and that dinosaur exhibits do teach something about these animals while also entertaining spectators.

A trip to any natural history museum today indicates that the line between education and entertainment is blurred if not invisible. In an odd book called *The Mammoth and the Mouse*, Florike Egmond and Peter Mason (1997) argue that such a line is impossible to draw and that this has been the case for a long time. They see connections among several events: Charles Willson Peale's exhuming a mastodon skeleton and exhibiting it in early 19th-century Philadelphia, the creation of Hawkins's dinosaurs, and the exhibition of the skeleton of another large beast: a blue whale that was beached on the Dutch coast in 1827. In all these cases, the exhibitors wanted to make money from science, so they advertised and did their best to make their exhibits attractive to the public. But at the same time, they were scrupulous about presenting scientific evidence as accurately as possible. These examples indicate that it isn't easy to answer questions such as how best to present

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science to the public and when does the replacement of substance by glitz become unacceptable.

Dinosaurs in New York

In the AMNH, there is a spectacular reconstruction in the museum's great rotunda, the Theodore Roosevelt Memorial Hall. It depicts an encounter as it might have occurred 150 million years ago (Norell 1991). The skeleton of a female *Barosaurus* rears up to protect her offspring from an *Allosaurus* ready to attack. This is indeed a dramatic scene, poised between science and entertainment, and some critics think that the balance may have gone too far to the side of entertainment. *Barosaurus*, a herbivore, was one of the largest dinosaur species. Though *Allosaurus* was much smaller, it was a vicious predator, a carnivore that might indeed prey on young dinosaurs, though it wouldn't attack the massive adult *Barosaurus*. Would a reptile protect its young in this manner, or is this a case of playing to the crowd, of creating a scene that draws on human behavior to create human interest in a bunch of bones? Also displaying a *Barosaurus* adult rearing up—to a height of about 50 feet—to protect her offspring is dramatic, but some researchers question whether it is an accurate portrayal of dinosaur behavior; it would have been difficult for its heart—even though it weighed about 800 pounds—to pump blood to such a height.

There are other aspects of this exhibit that also draw as much on art as on science. The bones are not bones at all but polyurethane foam replicas. There are used because the bones are too heavy to mount in the active poses used; a single *Barosaurus* vertebra can weigh up to 200 pounds. Also, the *Barosaurus* skeleton from which the casts were made was only 80% complete. In some cases, bones on one side of the skeleton could serve as models for those on the other side, but the shapes of some missing bones are based on the bones of the closely related *Diplodocus* about which more is known. When it came to the juvenile *Barosaurus*, much more was the result of guesswork because the only juvenile *Barosaurus* bones in the museum's collection were some neck vertebrae and a crushed skull.

The dinosaur halls of the AMNH were completely done over several years ago as part of a large vertebrate evolution exhibit that fills the fourth floor. The exhibit is both overwhelming and exciting because there's so much to see. The museum has a large paleontology research program at the present time and can also draw on the collections made by expeditions of the past. In *Dinosaurs of the Flaming Cliffs*, the AMNH paleontologist Michael Novacek (1996) tells of research he and his colleagues have done in the 1990s in the Gobi Desert of Mongolia, and he also reviews the discoveries made by Roy Chapman Andrews who led a famous AMNH expedition into the Gobi in the 1920s. Novacek blends travelogue with serious discussions of dinosaur evolution and puts his research and that of his colleagues into perspective. For example, he emphasizes the importance of the discovery not only of the large dinosaurs the public most enjoys seeing, but also small dinosaurs and mammals that help to fill in many blank spaces in our knowledge of the past.

More or Less Real

In *The Last Dinosaur Book*, a cultural history of dinosaurs representations, W.J.T. Mitchell (1998b) argues that the more realistic a dinosaur reconstruction is, the less real it becomes and the more it is constructed by the human imagination. Adjacent to one of the AMNH's dinosaur halls are two exhibits from opposite ends of Mitchell's spectrum. In a glass case are fossils recently recovered from a site in Patagonia which is littered with dinosaur eggs; this is such a rich deposit that it's impossible to walk through it without crushing eggs. I had read about this discovery in *The New York Times* last fall—it was a front-page story, complete with a photograph of an extremely well-preserved piece of dinosaur skin found in one of the eggs (Wilford 1998). The *Times* article also described the fine state of preservation of embryos within some of the eggs. In the AMNH exhibit, there are three egg fossils that have been carefully opened to reveal what lies inside. One egg contains the piece of skin pictured in the *Times*; the other two contain bones. To see anything more than pieces of

rock, you have to look through a magnifying glass set into the case over each fossil. The piece of skin is then easily visible, but its tiny size is surprising as are the sizes of the bones of the two embryos. It obviously would take someone with a good eye, the eye of a paleontologist, to spot such treasures.

These bits and pieces of dinosaur eggs are a long way on the real/realistic spectrum from the paintings on the wall just behind them. These are scenes from various stages in geological history, showing what the landscape would have looked like, with an emphasis of course on dinosaurs. Done by Ron Barber, they show what the Earth might have looked like at several points in the age of dinosaurs. These small murals are the latest in a long line of AMNH representations of dinosaurs that include those of Charles Knight who spent many years at the AMNH during the first half of the 20th century (Paul 1996). Several of his murals of the Ice Age have been restored and are now mounted in the museum's Wing of Mammals and Their Extinct Relatives. Though these murals represent times well after the extinction of dinosaurs, the murals do give a sense of Knight's artistry, including his exquisite use of color and sense of composition. Paul Semonin (1997) argues that Knight's 1942 *National Geographic* illustration of two *Tyrannosaurus rex* dinosaurs locked in combat helped to create the modern stereotype of these animals as vicious predators. And W.J.T. Mitchell (1998b) contends that Knight's dinosaurs unite "scientific novelty with kitsch, familiarity, feudalism, and modern technology" (p. 145). Mitchell sees the conflicts between dinosaurs that appear in these paintings as signifying the concept of survival of the fittest in an industrial society.

Scenes from Deep Time

Even before dinosaurs were named, artists had attempted to recreate the landscapes of past geologic eras. These attempts began after people became convinced that the organisms of the past were appreciably different from those of the present; in other words, that extinctions had occurred and old species had been replaced by new. This didn't necessarily mean that evolution

had occurred—new species could have been created along the way—but it did mean that the landscapes of the past couldn't be presumed to be the same as those of today. In 1830, the geologist Henry De la Beche did a famous sketch of "life in ancient Dorset," in which he created a thickly populated scene with *Ichthyosaurs* eating other sea creatures, and even grasping a *Pterodactyl* as it flew above the water's surface. The vegetation consists mostly of palm trees, giving the scene the look of a tropical paradise gone mad.

In *Scenes from Deep Time*, the geologist Martin Rudwick (1992) traces the history of illustrations of past eras and sees De la Beche's image as the forerunner of a long tradition. Though Rudwick ends his review in the 1860s, it can be argued that this tradition continues to the present in paintings such as those of Barber. De la Beche's work remains influential in the sense that present-day paintings are still crowded with animals, to an extent that would probably not occur in nature, and the animals are clearly visible; there is no camouflage or attempt to hide. Also, it's often the case that the dinosaurs are presented in dramatic poses: grasping prey or at least chasing after it. As Rudwick notes, one of the most dramatic scenes from deep time was done by the artist John Martin. His frontispiece for Gideon Mantell's *Wonders of Geology* (1838) is called "The Country of the Iguanodon" and shows three dragon-like dinosaurs attacking each other. The dark and menacing background adds to the sinister tone of the work. This romantic view of dinosaurs influenced many later representations of deep time, where landscapes are often dark, dramatic, and filled with strange beasts engaged in combat. This indicates the powerful influence an artist can have on the creation of scenes that usually appear only in science books and would be more likely to be termed scientific illustrations than works of art. But I should note that for many years after De la Beche's drawing, illustrations of deep time were often confined to frontispieces, because science writers were loathe to otherwise include such images in their work. Illustrations were seen more as art than science and therefore not appropriate for a "serious" work of science.

This is a corollary to the real/realism issue, with science as real and art as creating a sort of false realism. Attitudes on the relationship between art and science have changed considerably since the 19th century. Now the publication in science journals of an important new fossil is often accompanied by an artist's reconstruction of the organism. This does breathe life into a sometimes rather nondescript looking pile of bones—and wakes even people like me up to what's fascinating about dinosaurs.

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