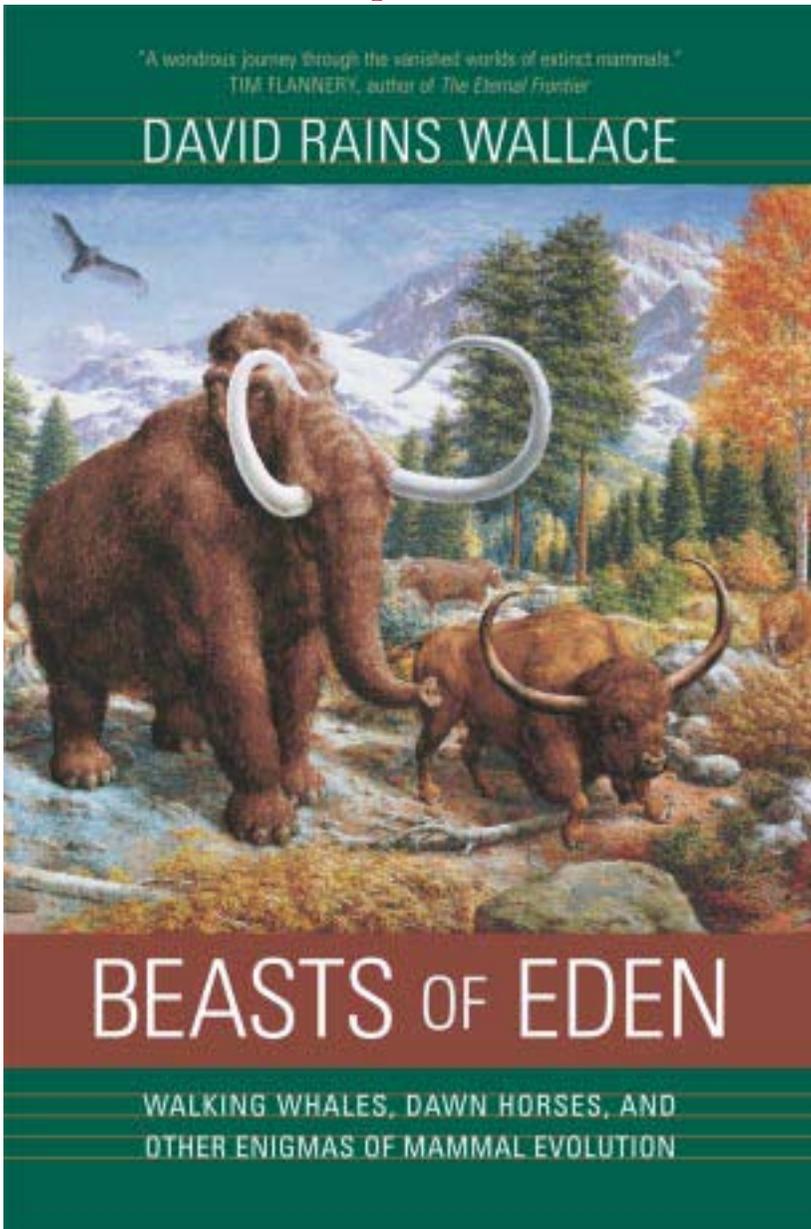


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PROLOGUE

The Fresco and the Fossil

If there is a Sistine Chapel of evolution, it is Yale University's Peabody Museum. Of course, the Peabody's neo-Gothic brick edifice is less august than the Vatican's papal shrine. Past a dim corridor off the museum's vestibule, however, a painting as breathtaking as the Sistine murals covers the wall of a soaring room with an immense landscape of rosy cliffs, exotic vegetation, and life-sized dinosaurs. This is Rudolph Zallinger's *Age of Reptiles*, and, like Michelangelo's murals, it is a fresco, brushed on plaster day after day over a period of years. Like the Sistine's biblical vision of human creation and judgment, it shows the beginning and end of a world, that of the great saurians that left their bones in western North America.

Comparing a big dinosaur picture to Renaissance painting's supreme achievement seems presumptuous, to be sure, and Rudolph Zallinger is not considered a titan even of modern art. Born to Siberian refugees in 1919, he attended Yale's School of Fine Arts on scholarships during the Depression, when it was training illustrators, and taught there after graduation. The Peabody hired him to paint the mural in 1943 at \$40 a week, because the director felt its Great Hall "resembled a dismal barren cavern devoid of color." Zallinger took a crash course in paleontology and finished the job in 1947. Three years later, abstractionists purged illustrators from Yale's art school, and Zallinger might have spent his career doing ads in his home

town of Seattle if the Peabody had not appointed him “artist in residence,” a position he held—teaching elsewhere—until his death in 1995.

The art historian Vincent Scully was speaking outside the mainstream when he complained in 1990 that Zallinger’s work is not “valued as it ought to be by modern critics.” Most critics aren’t aware it has artistic value. In a way, however, Zallinger had more in common with Michelangelo than do the modernists who have prospered from critical and commercial patronage. Great noncommercial institutions—religion, science—patronized both muralists, with similar parsimony, and both murals have become icons, endlessly reproduced in popular media. In one stamp issue alone, the U.S. Postal Service printed six million copies of scenes from the *Age of Reptiles*. And although the modernist canon excludes Zallinger’s mural, its status is more than popular. Scully called it “abundantly entitled” to a “distinguished position among contemporary mural paintings.” Soon after its completion, the art historian Daniel Varney Thompson, a fresco specialist, said “that wall is the most important one since the fifteenth century.” It won the Pulitzer Prize in 1949. W. J. T. Mitchell, a University of Chicago art critic and cultural historian, recently described it as “a modern monument” that displays prehistoric life’s evolution as “a single, unified landscape panorama, a symmetrical tableau of stately reptilian demigods in a peaceable arcadian kingdom.”

“I was moved nearly to tears by the Zallinger fresco in the Great Hall when I visited there as a callow college senior,” one dinosaur scientist, Peter Dodson, wrote in 1999. “This portrayal of the history of 350 million years of life on land is familiar to every paleontologist and to every reader of natural history books, one of the high-water marks of natural history illustration in the 20th century.” Another dinosaur scientist, Robert Bakker, traced his vocation to seeing the picture in a *Life* magazine article at his grandfather’s house in 1955.

Such enthusiasm is justified when one sees the “arcadian kingdom” across its hall of dinosaur skeletons. Yet the eminence of *The Age of Reptiles* illuminates something strange about it, an oddity so ingrained in our attitude toward evolution that it seems normal. What if, rather than painting the biblical story in the Sistine Chapel, Michelangelo had painted the Hellenic one—with Zeus, not Jehovah, presiding over the earth? It would still be great art, but it would not be about *us* in the way that it is. A Hellenic Sistine Chapel would have left out the mythology that mainly formed Western civilization. Zallinger’s *Age of Reptiles* does something similar. It presents a core vision of evolution that is not really about *us*, and in doing

so, it reflects a blind spot in our view of life that seems to have grown, oddly, the more we have learned.

In the past century, as we have understood life's history and functions better, we increasingly have told ourselves, in part of our minds, that evolution is something that happened to creatures so unlike us—dinosaurs—that they not only are long extinct, but have left no heirs. (And even if they have left heirs in the form of birds, as is now widely believed, comparing a tyrannosaurus and a chicken seems to mock the very notion of evolutionary descent.) A glance in any bookstore or library will demonstrate this. Dinosaurs prevail overwhelmingly in evolution sections. They are so prevalent that W. J. T. Mitchell called them the “totem” of industrial civilization, “*the* animal image that has, by a complex process of cultural selection, emerged as the global symbol of modern humanity's relation to nature.” The media's obsession with dinosaur size and strength supports this. Movie dinosaurs have as much in common with machines as organisms, and the sense they convey of human *non*relationship to nature's evolutionary past is part of their appeal.

Of course, many people believe that evolution has been happening to creatures like us since dinosaurs first evolved. The Great Hall's mural gives a nod to the existence of such warm-blooded, hairy animals during the reptile age. At its end, next to Zallinger's signature, a tiny, long-snouted mammal named *Cimolestes* crouches underfoot of tyrannosaurs and hadrosaurs. The fact largely seems relegated to a smaller, dimmer part of our minds than dinosaurs occupy, however, and the Peabody Museum also demonstrates this. Mitchell wrote that Zallinger “never produced any work that came remotely close to his masterpiece either in scale or ambition or in cultural impact,” and this is true in the sense that he never painted a bigger or more famous picture. Yet there is another mural full of marvelous animals in evolution's Sistine, past the Great Hall in a smaller, dimmer room at the back.

I first saw this other picture in a Time/Life book, *The World We Live In*, when I was ten years old. It was called *The Age of Mammals* and showed the life that inhabited western North America in the sixty-five million years after the dinosaurs' demise. Zallinger's *Age of Reptiles* occupied the preceding pages, and his dinosaurs impressed me, of course. But the *Age of Mammals* fascinated me, although its attractions were less obvious. The mammals' earth-colored pelts blended with the background instead of standing out like the celestially colored saurians. Many were confusingly small, and even the big ones seemed fuzzy compared to the crested, armored dino-

saur. They and their forest and prairie settings had a familiarity, however, that appealed to me more than the otherworldly tree ferns and pinnacles of the dinosaurs' world. If the *Age of Reptiles* was an Olympus of "reptilian demigods," then the *Age of Mammals* seemed an Eden—not a monument to a dead world, but the embryo of the living one. At the picture's lush beginning, a giant serpent dangled from a bough as though offering something—perhaps the fruit in its tree, perhaps the secret that would eventually transform prehistoric mammals like *Barylambda*—a flat-skulled, thick-tailed, almost dinosaurian beast—into horses and elephants.

The two pictures seemed so unlike that I had assumed that they were by different artists until I read Mitchell's book in 1998. In fact, Zallinger painted both murals, although he had to wait to do the smaller one until Yale could raise funds in the 1960s. (The reproductions in *The World We Live In* were not of the murals themselves but of "cartoons," preliminary studies with some differences in content and execution.) It is as though Michelangelo had finished covering the Sistine Chapel with Hellenic mythology, and then, years later, stepped into an antechamber to paint the biblical story.

The book's dinosaurs and mammals were on the same scale, so the contrast in the murals' size and location surprised me when I first saw them in October 2000. "This room is a kind of annex to the reptile hall," Mary Ann Turner, the collections manager, said as we stood in the windowless gloom before the mammal mural, recessed above display cases in its low-ceilinged chamber. "If there's a reception or other event that involves food, they have it in here." I had hoped that someone could explicate the painting, but no early mammal expert was available, and although Turner was helpful and got a technician to floodlight it, she couldn't tell me much. She wasn't even sure whether it was a fresco, painted on plaster like the *Age of Reptiles*. She thought it might be on canvas. My artist wife suspected other technical differences. Once floodlit, the richness of the mural's colors struck us—its scarlet and gold Ice Age foliage echoed the glorious Indian summer morning outside—and we wondered if Zallinger had used a new kind of paint. But Turner wasn't sure about that either.

More than physical obscurity surrounded the *Age of Mammals*. Unlike the reptile hall's newly remounted dinosaur fossils, the annex's few mammal skeletons had a forgotten air. A wolf-sized, massive-skulled one under the mural looked as though it belonged to one of the painted early mammals, but it was labeled differently from any of them, *Synopolotherium*, and that was all the label said. Turner said nobody paid much attention to *Syn-*



Figure 1. O. C. Marsh's *Dromocyon* skeleton, now named *Synoplotherium*. Courtesy American Museum of Natural History Library.

oplotherium—it was “not one of the more popular animals, research-wise.” It seemed a kind of paleontological unclaimed body, although she added that it had been the first skeleton mounted in the museum after its founder, Othniel C. Marsh, America’s first paleontology professor, died in 1899. A man of legendary possessiveness, Marsh disapproved of fossil reconstructions, except in drawings or papier-mâché, because they took bones out of his collection drawers.

This apathy toward one of the first fossils to be reconstructed seemed typical of present popular attitudes to our own evolutionary branch. “The class entered the museum’s great hall,” began a 1999 description of a visit by kindergartners to the Peabody. “Here was . . . *Triceratops* . . . *Chasmosaurus* . . . *Mosasaurus* . . . The children moved from fossil to fossil mesmerized by the massive skulls with their spooky, vacant eye sockets and menacing sharp teeth. . . . The next room was filled with mammal fossils. . . . But the children walked past these hard-won treasures quickly. After all, they were not dinosaurs.”

This hasn’t always been so. A lavishly illustrated 1910 book by Henry Fairfield Osborn, Marsh’s successor as America’s reigning paleontologist, prominently displays a photograph of the Peabody’s *Synoplotherium* skeleton, resoundingly—if confusingly—labeled “*Dromocyon vorax*, a mesonychid creodont from the Upper Eocene epoch.” The same page shows a dramatic reconstruction by a famed scientific artist, Charles R. Knight, of a “similar form,” snarling over the carcass of a uintathere, a primitive herbi-



Figure 2. Charles Knight's restoration of Cope's *Mesonyx*. Courtesy American Museum of Natural History Library.

vore. A few pages later, in describing the Eocene epoch, Osborn says, even more confusingly: "Here also the skulking and swift-footed *Mesonyx* (or *Dromocyon*, Mesonychidae) is represented."

Osborn's 1910 book was a scientific tome, but the public knew about "the skulking and swift-footed *Mesonyx*." Knight's reconstruction had originally illustrated a vivid 1896 Osborn article on early mammals in *The Century*, a popular magazine. "The next animal one sees is among a grove of young sequoias, standing over the skull of a uintathere," Osborn says of *Mesonyx*. "He has a very long, low body, somewhat like that of a Tasmanian wolf, terminating in a powerful tail, short limbs, and flattened nails. . . . The wide gape of his mouth exposes a full set of very much blunted teeth, which proves that this huge flesh-eater could hardly have killed the uintathere, but has driven away another beast from the carcass. Perhaps, like the bear, he had a taste for all kinds of food."

Once upon a time, people paid attention to the fossil beneath the fresco. It began with O. C. Marsh's arch-enemy, Edward D. Cope, who spent his career fighting Marsh's bid to monopolize paleontology. Their feud became nineteenth-century America's great scientific scandal, culminating

in 1890, when they spent a month accusing each other of theft and plagiarism in the *New York Herald*, then the nation's leading newspaper. Famous for fighting over dinosaurs, they fought longer and harder over mammals, starting in 1872 with a Cope expedition that Marsh tried, not unsuccessfully, to wreck. Among Cope's finds were two fragmentary skeletons of blunt-toothed, flat-nailed creatures that he named *Synoplotherium* ("joined hoof beast") and *Mesonyx* ("half claw"), although he later dropped *Synoplotherium* after deciding both fossils belonged to the genus *Mesonyx*. When Marsh acquired a similar skeleton in 1875, he ignored Cope's names, and called it *Dromocyon* ("swift running dog"). Neither man accepted his hated rival's names if he could help it. Naming fossils has a magical side, because it is the first step in "resurrecting" extinct organisms, and Cope and Marsh jealously clung to their necromantic incantations. When they died, their three mesonychid genera were among hundreds of fossils, similar or identical, to which they had given different names.

Henry Fairfield Osborn took Cope's side in the feud, but later found it a "painful duty" to devote thirty years "to trying to straighten out this nomenclatural chaos." His confusing use of *Mesonyx* and *Dromocyon* in his 1910 book shows his dilemma. For a while, it seemed that they were the same beast, whose name then would have been *Mesonyx*, because Cope's discovery had preceded Marsh's. But then Osborn's colleagues J. L. Wortman and W. B. Scott decided that *Mesonyx* and *Dromocyon* really were different genera, in which case the Peabody skeleton would have kept its Marsh name. But then another Osborn colleague, W. D. Matthew, decided that *Dromocyon* and Cope's long-discarded *Synoplotherium* were the same, and, since *Synoplotherium* preceded *Dromocyon*, it became the valid name of the Peabody' reconstructed skeleton. Cope's name for Marsh's mesonychid fossil finally prevailed in Marsh's museum.

That would not have amused the professor, and neither would another historical happenstance. It was no accident that *The Century* almost always captioned Charles Knight's illustrations for Osborn's articles with Cope names—and it infuriated Marsh. Knight's *Mesonyx* in the 1896 *Century* seemed familiar to me, and I realized why the next time I looked at the *Age of Mammals* cartoon. Zallinger adapted his own snarling *Mesonyx*, right down to the long, banded tail, from Knight's illustration, simply reversing the image and skewing the angle to make it seem more three-dimensional. *Mesonyx* also appears in the Peabody mural, almost directly over the *Synoplotherium* skeleton, although Zallinger further modified the beast, which would have had trouble standing with the hind legs Knight gave it. So

Cope's mesonychid names ended by trumping Marsh's not once, but twice, in the Peabody Museum.

"Gad! Gad! *Gad! Godamnit!*" an eavesdropper once heard Marsh cry when comparing a Cope paper with some of his own fossils. "*I wish the Lord would take him!*"

Mesonyx's background is typical of Zallinger's *Age of Mammals*. Controversy involved most of the mural's central figures, so it is implicitly a historic as well as a prehistoric tableau. Whereas Charles Knight had his *Mesonyx* snarling over a uintathere carcass, Zallinger showed his snarling at a live uintathere, which brandishes saberlike tusks in defiance. As it happened, uintatheres were the flashpoint of Cope's and Marsh's first pitched battle, fought just after Cope's beleaguered 1872 expedition. Zallinger's confrontation implies a prehistoric reincarnation of their feud. A little earlier in the mural, two hippolike beasts roaring at an enemy belong to a genus, *Coryphodon*, discovered in the 1840s by the pioneer English paleontologist Richard Owen, who spent five decades fighting over mammals with early evolutionists. Farther along in the painting roars an even bigger herbivore, a brontothere, which fueled a twentieth-century debate between Henry Fairfield Osborn and younger paleontologists, including one of the greatest and most contentious, George Gaylord Simpson.

Zallinger's oblique references to the old bone hunters remind me of the figures of saints and prophets that lend brawny individuality to the Sistine Chapel's cosmic dramas. Not that men like Marsh and Cope were saintly—they were indeed like snarling beasts sometimes. Yet there was much in them of Michelangelo's larger-than-life visionaries. They saw things that normal humans did not, things that many still find incredible, but that nevertheless, on the evidence, seem true. They were hard on each other and on their assistants and colleagues, but they were hardest on themselves, spending health and wealth on work that brought them little more than the peculiarly human power of seeing deep into time.

Zallinger's mammals also resonate with recent controversies. When Cope described *Mesonyx* in his *Vertebrates of the Tertiary Formations of the West* (called "Cope's Bible," because it is nearly a foot thick and weighs over ten pounds), he noted its strangeness. "The flat claws are a unique peculiarity, and suggest affinity to the seals, and an aquatic habit," he wrote. "The teeth, moreover, show a tendency in the same direction, in the simplicity of their crowns." He guessed that *Mesonyx* had fed largely on the freshwater turtles common in Eocene sediments. But the seallike features puzzled Cope, because, as he wrote: "The structure of the ankle forbids the sup-

position that these animals were exclusively aquatic, as it is the type of the most perfect terrestrial animals.”

Mesonychids continued to puzzle scientists. In the 1960s, a paleontologist, Leigh Van Valen, noted similarities between their teeth and those of primitive whales, but the connection seemed far-fetched. Then, in 1979, Philip Gingerich, a University of Michigan researcher hunting early mammals in Pakistan, found a 50-million-year-old fossil with teeth resembling those of *Mesonyx*, but whalelike ear bones. He named it *Pakicetus* (“Pakistani whale”), but as more of its coyote-sized skeleton emerged, it became clear that it had looked and acted more like a mesonychid than a whale. Able to run fast, but also to swim well, it had probably spent its life wandering beside rivers and estuaries, eating whatever land or water prey came its way. In 1992, a 48-million-year-old Pakistani fossil turned up that had similarities to *Pakicetus* but had clearly lived a more aquatic life, since it had short, sprawling legs, webbed feet, and an otterlike tail. Its discoverer, Gingerich’s student Hans Thewissen, named it *Ambulocetus* (“walking whale”), and guessed that it had behaved like a crocodile, feeding on fish, but also lurking in the shallows to catch drinking animals. It even had an elongated, crocodilelike snout, and it had grown to four hundred pounds. The discovery of other, successively whalelike genera implied that the outlandish creatures had been part of a sequence that led from mesonychids to whales as relatives of Cope’s “perfect terrestrial animals” gradually traded legs for flippers.

Doubts later arose as to whether mesonychids were whale ancestors. Some researchers proposed a closer relationship between whales and artiodactyls, “even-toed” beasts, the largest group of hoofed animals, or ungulates. (Camels, pigs, deer, sheep, goats, antelope, and cattle are artiodactyls—the other living ungulates are the “odd-toed” perissodactyls, including horses, rhinos, and tapirs.) Most modern artiodactyls are specialized herbivores, of course, but many earlier ones had more omnivorous habits, which might have extended to fish-eating. *Pakicetus*’s teeth and ankle bones were different enough from those of mesonychids to suggest that the genus had another ancestor, one “not inconsistent” with an artiodactyl connection. In particular, researchers saw a link to one semi-aquatic artiodactyl, the hippopotamus.

Still, the ongoing controversy doesn’t vitiate a fundamental insight. “Evidence suggests,” Gingerich wrote in 1983, “that *Pakicetus* and other early Eocene cetaceans represent an amphibious stage in the gradual evolutionary transition of primitive whales from land to sea.” Such a transition is

an example of macroevolution, the evolution of one group of organisms whether mesonychids or artiodactyls—into another, whales. Anti-evolutionists have been even less willing to acknowledge this than microevolution, the transition from one species to another, since it gives evolution an even greater role in life's history. But *Pakicetus* and *Ambulocetus* allowed Gingerich to say: "Fossils contradict the notion that whales suddenly appeared full-blown, without intermediate forms. Intermediates, missing links, are everywhere."

Such insights permeate Zallinger's mammal mural, because fights over mammal fossils have probably played a greater part in the growth of evolutionary ideas than any other paleontological phenomenon. It is one thing to think that dragonlike beings such as dinosaurs lived in the faraway past. Humans have had such ideas since the first recorded myths, and no evolutionary explanations are necessary. It is another thing entirely to think that beasts similar to, but also different from, present ones lived long ago. Although they have vanished too, their similarities to the living raise deep implications.

Cope's and Marsh's squabbles may have been unseemly, but they also epitomized the chief opposing evolutionary camps of their time. Marsh's work on the mammals in the Peabody murals provided the best support then known for Charles Darwin's evolutionary ideas, which came, of course, to be generally accepted. But Cope's work on the same mammals provided support for challenges to Darwin that seemed compelling to many scientists at the time, and that still remain partly unanswered. Mammals have continued to provide major support for, and challenges to, the various paradigms of how life has changed through time. In this sense, the mammal mural may represent a stronger evolutionary vision than the reptile one.

The mammal mural may also be a more accurate vision. Zallinger's plodding dinosaurs look stiff compared to the galloping ones in recent reconstructions, because when he painted them in the 1940s, science rejected the idea—first posed by pioneers like Cope and Marsh—that dinosaurs' similarities to birds meant that they also had high body temperatures and led active lives. Robert Bakker traced his conversion to the revival of this "hot-blooded dinosaur" paradigm to standing in the Great Hall and thinking: "There's something very wrong with our dinosaurs." The mammal mural also has anachronisms, such as *Planetetherium*, a lemurlike beast that glides like a frisbee through the forest canopy. Before my Peabody visit, I'd

stopped at Pittsburgh's Carnegie Museum, where Mary Dawson and Chris Beard, early mammal authorities, told me research has shown that *Planetetherium* was not a glider, but a hedgehoglike creeper. Yet we need not wonder whether *Planetetherium* was "warm-blooded" and gliding mammals like the living Asian colugos did inhabit North America. This difference between the murals may seem paradoxical, since Zallinger drew on Charles Knight's paintings for both, but he may have drawn more on Knight's mammals, because his dinosaurs look too active for 1940s ideas of sluggish saurians.

It is hard to draw conclusions about the murals' creation, however, because their past is murky. Documentation is sparse even on the reptile one, largely consisting of Zallinger's technical account of its execution. Of the other, he said only that the Museum's director, Carl O. Dunbar, "had always wanted the mammal mural and was primarily responsible for making it happen." Dunbar did shed some light on the mammal cartoon's origin shortly before his death in 1979, writing that he had chosen "the richly fossiliferous formations of the Rocky Mountain region and the adjacent Great Plains" for the subject because it contained "the finest record of evolution of the mammals." Dunbar "drew a linear profile to be developed into an idealized landscape" and called in Joseph Gregory, the Peabody's curator of vertebrate paleontology, and Rowland Brown, curator of paleobotany at the Smithsonian, as advisers. "Then as Rudy blocked out the landscape, we spent many hours searching the literature for precise data (size, special structure, etc.) for the animals to be shown. For the next eight months I looked over Rudy's shoulder almost daily as we conferred about details."

Zallinger worked so hard on the cartoon that he once fell asleep on his feet while they conferred. This was about the only detail of its execution that Dunbar mentioned, however, and he had nothing to say about the mural, painted after his 1959 retirement. When I asked Joseph Gregory and his successor as Zallinger's advisor, Elwyn Simons, about it, they were so reticent that I wondered whether the mural's painted confrontations reflected more than historical squabbles. But then, none of the mammal specialists I asked about it had much to say, in contrast to Dodson's and Bakker's eloquence about the *Age of Reptiles*. One said only that he preferred the reptile painting's colors.

This raises the question of whether, as W. J. T. Mitchell implied, the *Age of Mammals* is simply not as good a picture as its famous neighbor. There certainly is a unique sense of discovery in the reptile painting. Zallinger

was said to have known so little about dinosaurs when offered the job that he went home and looked them up in the encyclopedia. An excited naïveté synergizes with a huge space to generate its Olympian plenitude.

The mammal mural lacks this serendipity, yet Zallinger's increased knowledge of anatomy and botany—and skill in drawing, modeling, and color—give it a supple liveliness. (The Peabody hired him again in 1951 to do the mammal cartoon, at the instigation of *Life* magazine, so he had had over a decade to develop the mural.) There is a sense of animal movement in habitat that compares favorably with the reptile mural's stateliness. It is a little as though my hypothetical Michelangelo, in the years between painting his Hellenic murals and his biblical ones, had developed a style closer to Raphael's illustrative brilliance than his original stony grandeur. The liveliness has worked against the mammal mural's artistic reputation. As Mitchell observed, illustration is not considered fine art today, and the reptile mural's stiffness, which prompts comparisons with medieval muralists like Giotto, has enhanced its artistic cachet. But there are stirring rhythms in the mammals' deftly rendered musculature. It is not just a painting of warm-blooded animals—it is a warm-blooded painting.

Anyway, I find the Peabody murals more alike than different. A colleague of Zallinger's told me that he had painted both on plaster, with the same pigments, and simply used more cadmium, magenta, and vermilion to “jazz up” the mammal one. A characteristic quality imbues both, an unforgettable sense of animal life “assembling” in landscape, as Mitchell put it. “Zallinger was essentially not allowed to ‘invent’ at all,” wrote Vincent Scully. “But he had to find cunning ways ‘to discover things not seen’ and to present ‘to plain sight what does not actually exist.’” I think he did so in both paintings. Again, there are Sistine parallels. Michelangelo had advisers (not least two popes), and was certainly not expected to “invent.” He also made artistic borrowings, drawing from Hellenic as well as biblical iconography. Both painters used old stories and pictures in new ways, however, integrating them into narratives that allow contemplation, not simply of framed events, but of life's continuous flow. This sets them apart from contemporaries. Botticelli's and Perugino's murals in the Sistine, and Charles Knight's in the American and Field museums, are blown-up easel paintings by comparison. The other painters give us pieces of mythic deep time. Michelangelo and Zallinger guide us into its current.

Zallinger did leave one clear expression of his artistic aims. “In natural history museums,” he wrote, “the traditional convention for painted restorations of ancient animals made use of a single animal or a group of one

or perhaps a few species, which strictly observed a geological time frame and locations . . . I ultimately proposed a different convention, that of using the entire available wall . . . for a ‘panorama of time,’ effecting a symbolic reference to the evolutionary history of the earth’s life.”

This book will invoke his panorama as I try to do for prehistoric mammals what dozens of books have done for dinosaurs—tell the story of their discovery and evolution. In some ways, it is a better story than that of the dinosaurs. It is a Cinderella story. Although mammals first evolved at about the same time as dinosaurs, during the Triassic Period, which ended over 200 million years ago, they remained small and inconspicuous during the next 150 million years, as dinosaurs ascended to spectacular gigantism. Only after the great Mesozoic dinosaurs vanished did mammals evolve the strikingly large forms of Zallinger’s mural, not only ungulates, like horses and deer, but more exotic living beasts, like proboscideans, and even stranger extinct ones, like mesonychids and uinatheres. And then some mammals—whether mesonychids or artiodactyls—evolved into the largest animals ever—the whales, which surpass the greatest dinosaurs in size.

It is also a mystery story. The origin of mammals was one of the nineteenth century’s great enigmas. Henry Fairfield Osborn’s last conversation with Cope, on his friend’s deathbed, was an “animated” argument about “this most coveted of all relationships.” And although we now know what kind of animals mammals evolved from, other details of their origins remain unclear, and much of their later evolution is even less well understood.

The reason for the mammals’ Mesozoic eons of apparent “arrested development” is still one of paleontology’s problems, provoking much argument. The reason for their Cinderellalike transformation at the Mesozoic’s end is even more mysterious. Dinosaur-age mammals were not only small and inconspicuous. They were so unlike modern ones that it is unclear how and why animals like Zallinger’s tiny *Cimolestes*, much less even older, stranger creatures with names like “triconodonts” and “panotheres,” evolved into the amazing diversity of living beasts. Early mammal fossils, especially Mesozoic ones, are usually teeth and bits of bone, seldom whole skeletons, and very seldom traces of hair, internal organs, or other soft parts, so we may never be sure exactly how the transformation occurred. But the enormously accelerated research of the past few decades is beginning to shed light, sometimes in surprising ways, on the origins of living beasts: the monotremes that lay eggs—platypuses and echidnas; the

marsupials that give birth to fetal young and nourish them externally—possums, kangaroos, and wombats; the placentals that nourish their fetuses internally—elephants and manatees . . . anteaters and armadillos . . . rabbits, squirrels, and humans . . . shrews, bats, lions, rhinos, giraffes, and dolphins.

Of course, dinosaurs are wonderful, and I don't mean to slight them. Paleontology is wonderful. Fossils indeed seem, as our ancestors saw them, a kind of divine revelation, the sculpture of eternity. But mammal evolution has a special claim on our attention because, as Zhe-xi Luo, another early mammal specialist at the Carnegie Institute, pointed out during my visit there, it resonates in our daily lives. "We all go to the dentist because mammals alone, of living vertebrates, have permanent teeth," Luo told me, sitting in an office stacked with exquisitely preserved, newly discovered fossils of dinosaur-age mammals. "The reason is that mammals have a determinative growth pattern."

Other living toothed vertebrates, from fish to crocodiles, keep growing throughout their lives and keep replacing their teeth as old ones wear out, a pattern that allows for a steady supply of healthy teeth. But it has a drawback. The disposable teeth are not very specialized and don't allow very efficient food-processing. Crocodiles can't chew each bite even once, let alone the nine times of nursery admonitions. They *have* to gulp their food, because they lack molars to chew with. On the other hand, mammals' permanent teeth have evolved into a complex set of shears, slicers, piercers, crushers, and grinders that processes food with unique thoroughness—until they break, decay, or wear out. (Some mammals have continually growing permanent teeth, but these are secondary adaptations that humans, anatomically primitive in many ways, unfortunately lack.)

Fillings, crowns, and worse can seem a high price to pay for fancy teeth, but the first mammals' dental gamble also led to some of the things we value most. The jaw and palate adaptations that evolved with them helped our ancestors to taste, smell, and even hear better, and to process their food efficiently enough to become increasingly active and perceptive. Although we still don't understand fully how they evolved, those unique qualities of our small early relatives are why we are here today.