Designing the Dinosaur: Richard Owen's Response to Robert Edmond Grant

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IN THEIR PAPER on "The Earliest Discoveries of Dinosaurs" Justin Delair and William Sarjeant permit Richard Owen to step in at the last moment and cap two decades of frenzied fossil collecting with the word "dinosaur."[1] This approach, I believe, denies Owen's real achievement while leaving a less than fair impression of the creative aspect of science. The dinosaur was Owen's brainchild, ushered into the world on a wave of polemic in 1841. The word Owen coined is not important; the dinosaur he created is. For it was emphatically not the beast envisaged by his predecessors, nor was it the inevitable consequence of a string of dramatic fossil finds. Of course, fossils were an essential prerequisite, but they are in themselves bare bones.

I will endeavor to show that Owen molded this colossal beast for his own ends and that this move involved an imaginative leap, conditioned by the scientific climate of the age. There was certainly a good deal more on Owen's mind than the wish to record the existence of some hitherto unknown reptilian "tribe." He did not simply recognize dinosaurs, giving taxonomic expression to the 'objective' fact; more properly, he designed them—invented them, in a sense—paradoxical as this may sound.[2] Even Peter Bowler, in his excellent *Fossils and Progress,* while rightly placing Owen within the progressionist debate, fails to appreciate fully the tactical nature of Owen's move.[3] Only by comprehending Owen's motivation in erecting a novel order of reptiles from scanty fossil remains can we satisfactorily explain why experienced geologists before him (notably William Buckland and Gideon Mantell) missed the "opportunity." What is more important, by examining Owen's motives we can shed light on the guiding preoccupations of the age.

Owen was probably responding to the developmental theories of the anatomist Robert Edmond Grant (1793–1874), Professor of Comparative Anatomy and Animal Physiology at University College London. In Owen's eyes Grant's system, like other pre-Darwinian transmutation theories, was typified by life's unerring ascent toward human perfection, a metaphysical remnant of the otherwise battered chain of being. By upholding Lamarck's materialist hypothesis (characterized, in Owen's

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[1] Justin B. Delair and William A. S. Sarjeant, "The Earliest Discoveries of Dinosaurs," *Isis,* 1975, *66*:5–25.

[2] Adrian J. Desmond, *The Hot-Blooded Dinosaurs* (London: Blond & Briggs, 1975), pp. 7–22.

[3] Peter J. Bowler, *Fossils and Progress* (New York: Science History Publications, 1976), pp. 85–86.

terminology, by a "self-developing energy"[4]) and by impressing the Lamarckian scale onto the fossil record, Grant undoubtedly incensed Owen; certainly they ranged in open conflict during the 1830s.

Their paths may have crossed during the days of Owen's medical apprenticeship. Owen entered Edinburgh University in 1824 while Grant was still in residence, although in the following year Owen transferred to St. Bartholomew's Hospital in London to continue his medical training. In London, Grant, though a Scot, was styled the "English Cuvier" by his colleagues,[5] thus pre-empting Owen's title. He was Owen's senior by eleven years. Yet Owen's rapid rise to fame in both science and society allowed him to wield no little power over his contemporaries, senior or otherwise; and in the mid 1830s, "to Mr. Owen's eternal disgrace,"[6] he blocked Grant's appointment as comparative anatomist to the Zoological Society of London (over whose council Owen held sway). Owen then applied himself to the Lamarckian question, quoting from Grant's University College lectures, "the latest terms in which the transmutation-theory has been promulgated, as supported by Palaeontology."[7] Owen's elaborate refutation of Lamarckism, presented in his "Report on British Fossil Reptiles" to the British Association in 1841, marks his first major incursion into paleontology. Since it was during this polemic that the dinosaur was born, Owen's tactics and use of evidence must be carefully interpreted in light of his opposing ideological stand.

FROM "FOSSIL LIZARD" TO PACHYDERMAL DINOSAUR: WAYS, MEANS, AND MOTIVES

A year in preparation, Owen's speech to the British Association lasted two and a half hours and ran to 144 pages in print. Henry de la Beche held the chair, and the audience, including Adam Sedgwick, William Buckland, and William Conybeare, heard Owen summarize all that was known of the Mesozoic saurians.[8] But primarily Owen spoke of the "Fossil Lizards" figuring so prominently in the works of Buckland and Mantell. His predecessors had regarded these saurians as monstrous lizards (for reasons we shall examine), yet Owen elevated them to ordinal status as *Dinosauria*. Anatomical peculiarities of the sacrum, ribs, and extremities (which "more or less resemble those of the heavy pachydermal Mammals, and attest with the hollow long-

[4] Richard Owen, "Report on British Fossil Reptiles: Pt. II," *Report of the British Association for the Advancement of Science, 1841,* 1842, p. 202. Even in the 1830s, Owen was conscious of the Lamarckian threat, judging by the transparent tactics of his ape papers. Examining the first adult cadavers shipped from Africa, he was relieved to discover that the human-apeing infant chimpanzee sported a bestial, muzzled physiognomy later in life; Owen then used this information explicitly to prise apart man and ape once and for all, and thus forestall Lamarckians in this hyper-sensitive area. Owen's rivalry with Grant and abhorrence of Lamarckism probably motivated his search for an Archetypal alternative to base transmutation in the later 1830s. Richard Owen, "On the Osteology of the Chimpanzee and Orang Utan," *Transactions of the Zoological Society* (London), 1835, *1*:343. For an extended discussion, see Adrian Desmond, *The New Reformation: Darwin and the Reign of Law* (London: Blond & Briggs, in preparation).

[5] *The Lancet,* 1836–1837, *I*:21.

[6] *Ibid.*, p. 766. *The Lancet* printed Grant's full course of 60 University College lectures (1833–1834, Vols. I and II) and publicly backed Grant against the more powerful Owen.

[7] Owen, "Report," p. 197n.

[8] Richard Owen, *The Life of Richard Owen* (London: Murray, 1894), Vol. I, pp. 184–185. John Phillips, late Professor of Geology at Kings College, London, devised the new terminology in 1841 to replace the standard Primary, Secondary, and Tertiary nomenclature. His terminology was based on organic contents, since by the 1840s it was apparent that faunal complexes characterized the major eras of earth history. John Phillips, *Figures and Descriptions of the Palaeozoic Fossils of Cornwall, Devon, and West Somerset* (London: Longman, 1841), pp. 159–161.

bones, the terrestrial habits of the species"[9]), coupled with a fearful size, served to distinguish dinosaurs from living lizards as well as Mesozoic marine saurians (plesiosaurs and ichthyosaurs). In fact, these "gigantic Crocodile-lizards of the dry land," so styled for their juxtaposition of crocodilian and lacertian features, were in Owen's estimation no larger than marine saurians. The dinosaur's importance rested less in anatomical peculiarity or size than in ecology and physiology, and Owen concluded his report with a tortuous leap from anatomy to the dinosaur's overriding ecological importance:

> The Megalosaurs and Iguanodons [the "Fossil Lizards" of Buckland and Mantell: Owen's dinosaurs], rejoicing in these most perfect modifications of the Reptilian type, attained the greatest bulk, and must have played the most conspicuous parts, in their respective characters as devourers of animals and feeders upon vegetables, that this world has ever witnessed in oviparous and cold-blooded creatures. They were as superior in organization and in bulk to the Crocodiles that preceded them as to those which came after them.[10]

Yet this reptilian group to which Owen attaches such importance was known by only three species, and those very imperfectly. More puzzling still—until we fully understand his motives—are Owen's speculations on dinosaurian physiology. Despite referring to dinosaurs as "cold-blooded," he repeatedly likened them to pachydermal mammals. Discussing the Wealden formation, he observed that it "is likewise characterised by the prevalence of those Dinosaurian Reptiles which in structure most nearly approach Mammalia." And in respect of soft anatomy, Owen states: "The Dinosaurs, having the same thoracic structure as the Crocodiles, may be concluded to have possessed a four-chambered heart; and, from their superior adaptation to terrestrial life, to have enjoyed the function of such a highly organized centre of circulation in a degree more nearly approaching that which now characterises the warm-blooded Vertebrata."[11] The boldness of this position was quite apparent. "A too cautious observer would, perhaps, have shrunk from such speculations," Owen admitted.[12] Obviously more than a few anatomical peculiarities led him to abandon caution and declare dinosaurs the apotheosis of the reptilian condition. Such a conclusion becomes compelling when it is realized that it was Owen himself who (in this very report) had reinterpreted dinosaur gross morphology to yield the pachydermal mammal shape. Previously the "Fossil Lizards" had been considered literally that—Brobdingnagian *lizards* closely related to extant forms, and thus their morphological equivalents.

Cuvier had unwittingly set the precedent. He diagnosed the four-foot jaws snatched by the Republican army sweeping north through Holland in 1795 as belonging to a gigantic marine monitor lizard,[13] a diagnosis withstanding the test of time. The Reverend William Conybeare, an English adherent of Cuvierian catastrophism, coined the name *Mosasaurus* (after the Meuse district where the saurian lay interred) for the owner of these prestigious jaws.[14] But Cuvier later fitted nonlacertian saurians into the same monitor paradigm; specifically, the reptile whose fossil bones were unearthed in the early 1820s near Oxford. English geologists deferred to

[9] Owen, "Report," p. 103.
[10] *Ibid.*, p. 200.
[11] *Ibid.*, pp. 203–204 n.
[12] *Ibid.*, p. 204.
[13] B. Faujas-Saint-Fond, *Histoire Naturelle de la Montagne de Saint-Pierre de Maestricht* (Paris, 1799), pp. 59–67. Georges Cuvier, *Recherches sur les Ossemens Fossiles* (Paris, 1824), Vol. X, pp. 119–175.
[14] Cuvier, *Recherches,* p. 175.

Cuvier's judgment, as Buckland's 1824 paper to the Geological Society entitled "Notice on the Megalosaurus or great Fossil Lizard of Stonesfield" makes plain.[15] The paradigm was reinforced by Gideon Mantell's discovery of a saurian herbivore's teeth not far from his Brighton home—teeth which so nearly resembled those of the diminutive iguana that Mantell was embarrassed by the disparity in size, and upon Conybeare's suggestion christened his Mesozoic saurian *Iguanodon.*[16] This afforded independent evidence—not that it was really needed—that the Gargantuan saurians of the Secondary period were merely glorified lizards.

With the lizard paradigm established, size estimates could be easily made. The outcome of such calculations, even though revealing whale lengths for the "Fossil Lizards," were unhesitatingly accepted by Cuvier, Mantell, and Buckland. Buckland said of an isolated saurian finger bone in 1829:

> It is, I believe, the largest metacarpal bone which has been yet discovered; and if we apply to the extinct animal from which it was derived, the scale by which the ancients measured Hercules ("*ex pede Herculem*"), we must conclude that the individual of whose body it formed a part, was the most gigantic of all quadrupeds that have ever trod upon the surface of our planet.[17]

The procedure was simply to scale up the fossil bone using a lizard blueprint. But since femurs were often larger than elephant thigh bones, the ensuing dimensions of dinosaurs from snout to tip of tail were staggering even to Buckland. Introducing *Megalosaurus* to the Geological Society, he exclaimed that "if the total length and height of animals were in proportion to the linear dimensions of the extremities, the beast in question would have equalled in height our largest elephants, and in length fallen but little short of the largest whales." After making allowances, Buckland later settled for a more modest figure of 60 or 70 feet.[18]

Owen was skeptical of the exaggerated lengths claimed for the "Fossil Lizards," insisting that the largest bones would yield results upwards of 200 feet using the lizard blueprint.[19] To circumvent this, he instigated a new procedure. By measuring individual vertebrae, and estimating their total number (using crocodiles and lizards as models), he reduced the overall lengths to a more manageable 28 feet for *Iguanodon* and 30 feet for *Megalosaurus.* However in the process he rendered a gross morphological transformation. Instead of the legs being small and lizardlike, they now assumed mammalian proportions (a relative increase due to the shortening of the trunk). Furthermore, Owen argued that colossal weight militated against a lizardlike carriage, so he reconstructed his dinosaurs standing upright, mammal-fashion, with the stout limbs held under the trunk (in the parasagittal plane) rather than in a reptilian sprawl[20] (see Fig. 1).

[15] William Buckland, "Notice on the Megalosaurus or great Fossil Lizard of Stonesfield," *Transactions of the Geological Society of London,* 1824, Ser. 2, *I*:390–396.

→ Gideon Mantell, "Notice on the Iguanodon, a newly discovered Fossil Reptile, from the Sandstone of Tilgate Forest, in Sussex," *Philosophical Transactions of the Royal Society,* 1825, *115*:179–186. The discovery and interpretation is recounted in Gideon Mantell, *Petrifactions and their Teachings* (London: Bohn, 1851), pp. 224–313. Despite Cuvier's belief that this was a rhinoceros' tooth from overlying deposits, and Buckland's plea not to publish on this account, Mantell doggedly pursued his belief that it was not only a herbivorous saurian, but one of great antiquity.

[17] William Buckland, "On the Discovery of Fossil Bones of the Iguanodon, in the Iron Sand of the Wealden Formation of the Isle of Wight, and in the Isle of Purbeck," *Trans. Geol. Soc. Lond.*, 1835, Ser. 2, *3*:425–432.

[18] Buckland, "Notice on the Megalosaurus," p. 391. See also William Buckland, *Geology and Mineralogy* (London: Pickering, 1837), pp. 234–249.

[19] Owen, "Report," pp. 142–143.

[20] *Ibid.*, pp. 108, 110, 142, 144.

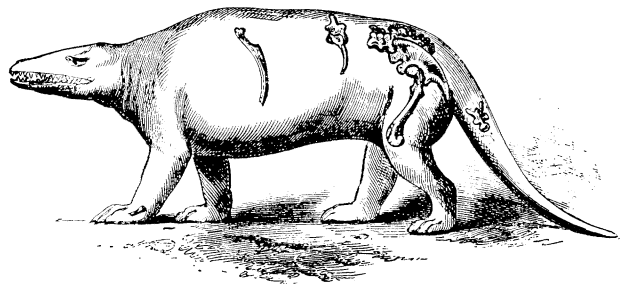

Figure 1. Despite the paucity of fossil bones on which to base his restoration of Megalosaurus, *Owen confidently announced that the beast had a mammallike carriage and restored it with limbs held under the trunk rather than sprawling as in a lizard. (Richard Owen,* Geology and Inhabitants of the Ancient World, *London: Bradbury & Evans, 1854, p. 20, Fig. 7.)*

In transforming "Fossil Lizard" morphology Owen fashioned a dinosaur to pachydermal mammal specifications. This explains why the Crystal Palace lifesize dinosaur restorations, constructed under Owen's supervision from 1852 to 1854, look suspiciously like rhinoceroses.[21] (Notice that he still considers them quadrupeds. Another four years were to elapse before Joseph Leidy exhibited a New Jersey hadrosaur complete with diminutive forelimbs, suggesting that some dinosaurs, including *Iguanodon*—and, it shortly transpired, *Megalosaurus*—were bipedal. This only serves to emphasize the paucity of fossil evidence for Owen's restorations, even in the 1850s.) In 1852 Joseph Paxton's Crystal Palace was transported piecemeal from Hyde Park (where it housed the Great Exhibition of 1851) to the Sydenham suburbs. Here it was re-erected as a permanent showcase for the arts of the nation. Upon Prince Albert's suggestion lifelike restorations of prehistoric beasts were to adorn the grounds and the sculptor Benjamin Waterhouse Hawkins was engaged. With the connivance of Owen, Hawkins modelled an assortment of Mesozoic reptiles—including some remarkably mammallike quadrupedal dinosaurs (see the *Megalosaurus* on the cover)—in the space of eighteen months, housing them on three islands in an artificially created lake.[22] In 1854 Queen Victoria opened this "mausoleum to the memory of ruined worlds"[23] in the presence of 40,000 spectators; and thereafter special trains from the metropolis were laid on, enabling workingmen to journey to the suburbs to witness this Antediluvian spectacle.[24]

Owen, then, scrapped the lizard paradigm, replacing the attenuated lizard by a massive compact pachyderm, stout-limbed and resembling "the large terrestrial quadrupeds of the Mammalian class."[25] Whereas Cuvier, Buckland, Mantell, and

[21] Richard Owen, *Geology and Inhabitants of the Ancient World* (London: Bradbury & Evans, 1854), p. 20, Fig. 7 (reproduced here as Fig. 1).

[22] Desmond, *Hot-Blooded Dinosaurs,* pp. 19–22. Adrian J. Desmond, "Central Park's Fragile Dinosaurs," *Natural History,* 1974, *83*:64–71. B. Waterhouse Hawkins, "On Visual Education as Applied to Geology," *Journal of the Society of Arts,* 1854, *2*:444–449. *Illustrated London News,* 1853, *23*:599–600; *24*:22.

[23] *Quarterly Review*, 1854, *3*:238.

[24] Owen's rhinocerine dinosaurs were the sole survivors after fire gutted the Crystal Palace in 1936.

[25] Owen, "Report," p. 110.

von Meyer all noted isolated anatomical similarities between "Fossil Lizard" and mammal bones, they persisted in using the lizard blueprint for reconstruction.[26] Owen switched the paradigm by his new method of length determination, thus shifting the morphology from lacertian to mammalian. And to highlight the increased importance of dinosaurs, he raised them to ordinal status. Unlike his predecessors, Owen *used* this mammal quality, which he amplified and extended (speculating on dinosaur ecology, soft anatomy, and physiology) in his polemic against the Lamarckians.

In his 1841 report Owen opened his "Summary" (in fact, previously unmentioned theoretical considerations bearing on the distribution through time of fossil reptiles) by dismissing the remarkably resilient diluvial theory. The spatial distribution of reptiles through the rocks militated strongly against a brief inundation. This distribution also permitted Owen to plot the fate of fossil species through time,[27] and it was this practice that allowed him to call into question the Lamarckian ascent in complexity:

> To what natural or secondary causes can the successive genera and species of Reptiles be attributed? Does the hypothesis of the transmutation of species, by a march of development occasioning a progressive ascent in the organic scale, afford any explanation of these surprising phaenomena? Do the speculations of Maillet, Lamarck and Geoffroy derive any support or meet with additional disproof from the facts already determined in the reptilian department of Palaeontology?[28]

Taking Grant's claim of a temporalized scale at face value and assuming a unilinear ascent in reptilian complexity, Owen tested the hypothesis against the "Poikilitic strata." Drawing upon a series of observations, he quickly stood the Lamarckian scale on its head. New Red Sandstone rocks ought to house the oldest and most primitive amphibians, yet the armored crocodilian-faced labyrinthodonts were clearly more advanced than extant salamanders, frogs, and apodans. "Here, therefore, we find the Batrachian making its first appearance under its highest, instead of its lowest or simplest conditions of structure," concluded Owen.[29] Worse still, Owen suggested, the Thuringian monitors were older than the Keuper labyrinthodonts; and lizards *more ancient* than the amphibians which are supposed to precede them hardly squares with the Lamarckian ideal espoused by Grant. But Owen had clearly engineered his newly created dinosaurs as a trump card: "If the present species of animals had resulted from progressive development and transmutation of former

[26] In 1832 Hermann von Meyer had distinguished pachydermal reptiles solely on the basis of locomotor organs, casually listing the "Saurians with Limbs similar to those of the heavy Land Mammalia" in his tabular classification, but giving little explanation. Hermann von Meyer, "On the Structure of Fossil Saurians," *Magazine of Natural History*, 1832, *1*:281. T. H. Huxley persisted in allotting von Meyer the credit for recognizing the dinosaurs, much to Owen's displeasure. In fact, Owen's elaborate and detailed morphological transformation went far beyond von Meyer's in scope and detail.

[27] Owen fortunately had Thomas Hawkins' collection at his disposal. Hawkins was an eccentric amateur who had plundered the Dorset Lias coastline to amass a wealth of ichthyosaurs and plesiosaurs (which, he boasted, "transcends all the collections in the world"). On the recommendations of Mantell and Buckland, the British Museum in 1834 paid Hawkins the princely sum of £1,250 for twenty tons of saurian fossils, indispensable material which enabled Owen to plot the fate of these marine reptiles through time and thus refute Geoffroy's specific evolutionary sequence (see n. 31). Thomas Hawkins, *Memoirs of Ichthyosauri and Plesiosauri, Extinct Monsters of the Ancient Earth* (London: Relfe & Fletcher, 1834) and *The Book of the Great Sea-Dragons, Ichthyosauri and Plesiosauri, Gedolim Taninim of Moses, Extinct Monsters of the Ancient Earth* (London: Pickering, 1840).

[28] Owen, "Report," p. 196.

[29] *Ibid.*, p. 197.

species, each class ought now to present its typical characters under their highest recognised conditions of organization. . . ."[30]

By admitting that at its apotheosis the reptilian condition approached the mammalian (in morphology *and* physiology), while conceding that this happened in the distant Mesozoic, Owen successfully refuted the alleged ascent in complexity. There *was* a progressive approach toward the organization of existing types, "yet not by an uninterrupted succession of approximating steps."[31]

> Neither is the progression one of ascent, for the Reptiles have not begun by the perennibranchiate type of organization [amphibians with vestigial limbs, such as the Congo eel *Amphiuma*], by which, at the present day, they most closely approach fishes; nor have they terminated at the opposite extreme, viz. at the Dinosaurian order, where we know that the Reptilian type of structure made its closest approach to Mammals.[32]

Using Lamarck's own criterion of vascular anatomy,[33] Owen placed his dinosaurs, blessed with a conjectured four-chambered heart, at the apex of the reptilian scale, where they verged on the warm-blooded mammalian condition. What ensued during geological history was a degeneration into the present "swarm of small Lacertians."[34]

DEGENERATION AND THE CASE AGAINST GRANT

Owen's strategy, I suggest, was to vest his dinosaurs with quasi-mammalian attributes in order to raise them to the pinnacle of reptilian perfection according to Lamarck's criteria. Mesozoic saurians constructed to mammalian specifications, with four-barrelled hearts and correspondingly "perfect" circulation, anticipated the warm-blooded classes residing at the top of Lamarck's scale. This ploy demolished the evolutionists' argument for an unabated ascent in fossil complexity through time. The backbone of Lamarck's theory was an escalator or mobile chain fashioned almost entirely from living forms. Professor Grant had impressed Lamarck's living scale onto the fossil record to provide the first truly historical Lamarckism. Since Lamarck's living continuum was characterized by a gradual rise in complexity from

[30] *Ibid.*, p. 200.

[31] Geoffroy, working mainly on anatomy divorced from geological considerations, had outlined a series of evolutionary steps in his monographs of 1833, by which crocodiles passed into teleosaurs and thence into ichthyosaurs. Geoffroy Saint-Hilaire, "Premier mémoire sur les lames osseuses du palais dans les principales familles d'animaux vertébrés, et en particulier sur la spécialité de leur forme chez les crocodiles et les reptiles téléosauriens," *Mémoire de l'Académie Royale des Sciences,* 1833, *12*:1–26. (Four succeeding memoirs were published on this subject, pp. 1–138.) See also Franck Bourdier, "Geoffroy Saint-Hilaire Versus Cuvier: The Campaign for Paleontological Evolution (1825–1838)," in Cecil J. Schneer, ed., *Towards a History of Geology* (Cambridge, Mass./London: MIT Press, 1969), pp. 36–61, esp. pp. 45–51. Geoffroy possessed only isolated fossils and was working out of context of stratigraphical considerations. Owen commanded a broader understanding of the geological issues. Not only did he demonstrate that the ichthyosaur preserved its characters throughout the immense series of Mesozoic strata, but that it quit "the stage of existence as suddenly as it entered it in the lias, and with every appreciable osteological character unchanged" (Owen, "Report," p. 199). Throughout the record, ichthyosaurs, plesiosaurs, and teleosaurs remained quite distinct as species. Thus Owen refuted the single example of transmutation instanced by Geoffroy, noting in addition that whereas teleosaurs disappeared in the Oolite (Jurassic), both plesiosaurs and ichthyosaurs persisted into the Chalk (Cretaceous). "How the transmutation theory is to be reconciled to these facts is not obvious," added Owen.

[32] Owen, "Report," p. 202.

[33] Lamarck divided his fourteen classes into six fundamental "stages," culminating in birds and mammals, using the triple criteria of nervous, respiratory, and vascular structures. Mammals, possessing a brain filling the cranium and a heart with two ventricles pumping "warm" blood, showed an obvious improvement over the reptilian stage, where the heart had one ventricle pumping "cold" blood. J.-B.-P.-A. Lamarck, *Philosophie Zoologique* (Paris, 1809; reprinted Weinheim: Englemann, 1960), p. 280.

[34] Owen, "Report," p. 202.

monad to man, Grant suspected that the same would hold for the actual history of life as revealed by the rocks:

> Geology alone can inform us how far this successive course of development may have been followed by nature. When all the races of animals, whose remains are contained in the crust of the earth, have been better ascertained than at present, and their situation better known, when we have discovered at what period of the earth's formation any species of animals makes its appearance for the first time, we shall then be able to draw conclusions, more or less accurate, concerning the order of succession. The doctrine of petrifactions, even in its present imperfect condition, furnishes us with accounts that seem in favour of Mr. Lamarck's hypothesis. . . .[35]

Owen, armed with his renovated dinosaurs, now argued that degeneration rather than unabated progression characterized the reptilian fossil record.

Degeneration was the cornerstone of the paleontological riposte. So long as evidence for Development was sought in an ascending fossil series (as it was by Grant, and later by Robert Chambers), paleontologists could convincingly demolish the argument at its strongest point with one or two well-chosen examples of retrogression. This presented geologists like Adam Sedgwick and Hugh Miller with something of a problem. They acknowledged the successive introduction of classes culminating in man; they even needed it. Louis Agassiz, for example, put a transcendentalist interpretation on this stepwise ascent to prove that man—as the final or complete term of the series—was in the Creator's mind at the outset. But to this state of affairs they had to reconcile the retrogression *within* classes. This was equally necessary to demonstrate that the process was not an inflexible upward march fashioned by some self-sufficient (Lamarckian) law. So they arrived at a position which Bowler calls "Discontinuous Progression." As he explains, most paleontologists "took the high status of the early members of some classes as evidence that the advance of life has been a step-by-step process. Each class was supposed to have appeared as a sudden discontinuity, and once created would continue to stay at the same level of organization or even decline. Since there was no general progressive trend to link them, each of the classes could only have been formed by the direct, miraculous intervention of the Creator."[36] So while the classes appeared in progressive succession, the members of each might degenerate through time; therefore, there

[35] Anonymous, "Observations on the Nature and Importance of Geology," *Edinburgh New Philosophical Journal,* 1826, N.S., *1*:297–298. This paper has been tentatively attributed to Grant, e.g., by Loren Eiseley in *Darwin's Century* (New York: Anchor Books, 1961), p. 146. However, no copy is bound in Grant's personal volume of offprints, housed in the D. M. S. Watson Natural Sciences Library at University College London (see *Grant on Zootom. Subjects,* classification: Zoology, rare books). Nonetheless, I believe that circumstantial evidence does point to Grant as the author. The paper was written while he was still Jameson's pupil/colleague at Edinburgh and was published in Jameson's *Journal.* Moreover, Grant is known to have espoused the ideas presented in this paper, not only from internal evidence (analysis of his other works), but from Darwin's explicit testimonial. As an old man writing his *Autobiography*, Darwin cast his mind back to one fleeting moment (between 1825 and 1827) when Grant startled him. "He one day," remembered Darwin, "when we were walking together burst forth in high admiration of Lamarck and his views on evolution." Nora Barlow, ed., *The Autobiography of Charles Darwin* (New York: Norton, 1958), p. 49. The reason for anonymity seems plain enough. In the 1820s those professing evolutionary beliefs were suspected of materialist (and atheist) inclinations. Evolution was invariably taken to mean self-sufficiency on nature's part; hence Owen derides the "self-developing energy" inherent in Lamarckism. (I suspect that the main thrust of Owen's assault was against the materialism implicit in Grant's theory, rather than his evolution *per se.*) It would have been foolhardy for a young M.D. like Grant about to seek a professorship in the 1820s to openly espouse such heresy. For the materialist milieu in which Grant developed his "evolution" and discussion of the opposing materialist and transcendental ideologies in Darwin's day, see my forthcoming *The New Reformation.*

[36] Bowler, *Fossils and Progress,* p. 79.

was no overall progression between the members of any two adjacent classes. This, anyway, was the position orthodoxy sought to establish.

A recalcitrant Grant, however, argued in his *General View of the Characters and the Distribution of Extinct Animals,* a sixty-page tract published in 1839, that in fact life *was* a continuous succession, not a sequence of disjunct creations:

> . . . the zoological productions, like the physical features of our globe, have been subjected to constant and progressive changes from the period of the oldest Cambrian and Silurian rocks, entirely destitute of organic remains, or presenting only a few forms of fuci and the simplest marine invertebrata, to the recent alluvial deposits containing the first traces of human relics; and the order of distribution of animal forms, in the strata of the earth, is in perfect accordance with the ordinary laws of animal development, and with the order of creation described in Holy Writ. The unity of the plan of organization, and the regular succession of animal forms, point out a beginning of this great kingdom on the surface of our globe, although the earliest stages of its development may now be effaced; and the continuity of the series through all geological epochs, and the gradual transitions which connect the species of one formation with those of the next in succession, distinctly indicate that they form the parts of one creation, *and not the heterogeneous remnants of successive kingdoms begun and destroyed.* . . .[37]

This was in fact a response to Cuvier's catastrophism. Grant was greatly favored by Cuvier, and until the baron's death in 1832 he spent part of each summer vacation studying in Paris at Cuvier's invitation. But given Grant's avowedly Lamarckian bent (expressed in the above statement by "the gradual [*sic*] transitions which connect the species of one formation with those of the next"), he was also implying that the classes were not as disparate as contemporaries might imagine. Indeed, he had already instanced a particular case of one class shading into another. Advanced invertebrates (crustaceans and mollusks), he had suggested in his lectures, present characteristics that are retained by the most primitive fishes: "you might necessarily expect," he told his students early in 1834, "that we should find traces of the shell itself of the invertebrated classes still lingering" in the vertebrates, "especially in that class [cartilaginous fishes] which is at the bottom of all the vertebrated series."[38] In the sturgeon, he remarked, "the exterior of the body is covered with dense white plates." Since these are not "in the least analogous to any part of the internal articulated skeleton of the vertebrata," they must be "entirely a remnant of the superficial shells of invertebrated animals." Grant had only living fish to compare with crustaceans and mollusks, hence his use of the sturgeon.

His position should have been immeasurably strengthened by the discovery in the 1830s of heavily armored arthrodires like *Coccosteus* and *Pterichthys.* The bony plates of these tanklike fossil fishes had been unearthed in abundance from Old Red Sandstone (Devonian) rocks in Caithness and Orkney by the Scots journeyman-mason Hugh Miller.[39] Roderick Impey Murchison, at least, believed that Miller's *Pterichthys* would fall midway between fish proper and crustaceans, as would *Cephalaspis,* an Old Red Sandstone form more familiar to him.[40] But Miller sensed the evolutionary danger to his own brand of fervent Christianity, which rested largely (and conservatively) on a miraculous base. (In his eyes the danger became acute after

[37] Robert Edmond Grant, *General View of the Characters and the Distribution of Extinct Animals* (London, 1839), p. 60 (my emphasis).

[38] Robert Edmond Grant, "Lecture 12. On the Development of the Skeleton of the Vertebrated Classes, and on the Osteology of Fishes," *The Lancet,* 1833–1834, *1*:537.

[39] Hugh Miller, *The Old Red Sandstone; or, New Walks in an Old Field* (1841; 7th ed., Edinburgh: Constable, 1858).

[40] *Ibid.*, p. 73 n.

Chambers published his *Vestiges of the Natural History of Creation* anonymously in 1844.) To thwart the evolutionists Miller demanded that these bizarre Devonian arthrodires were not the simplest but some of the most complex fishes, with a high relative standing. He argued persuasively that from Devonian times fish had degenerated into today's lightly scaled forms.[41] Likewise Owen, in his Hunterian Lecture to the Royal College of Surgeons for 1844, denounced Grant's "exaggerated expressions" and raised the sturgeon and armored *Cephalaspis* in rank, placing them just below *Lepidosiren* and the sharks, which he considered the most advanced fish.[42] Thus he reinforced Miller's argument that in many cases fish had degenerated since their Paleozoic introduction. (Owen explained the sturgeon's "scale-armour" as a purely adaptive feature, arguing that since the fish was a bottom-grubbing scavenger, it needed a good deal of ballast.) The implication was clearly that for any form of progression to occur, life would have to pass through the lowly forms first. Therefore the shelled mollusks and crustaceans could not have transmuted into either the armored arthrodires or sturgeons, because these stood high on the piscean scale. Any similarity in structure was a parallel adaptation. Since Devonian fish could not be "transmuted Crustacea," the two classes were separated by an abyss.

The argument for degeneration reached a pitch with Adam Sedgwick's and Hugh Miller's moral crusade against the hapless *Vestiges.* Such was the ambiguous evidence of the fossil record that, said Miller, "It would be an easy matter for an ingenious theorist, not much disposed to distinguish between the minor and the master laws of organized beings, to get up quite as unexceptionable a theory of *degradation* as of development."[43] Faced with the threat of the *Vestiges,* Sedgwick and Miller overturned the "natural ascending scale"[44] on which the transmutationist's case rested, laid bare its degrading materialism, and triumphantly reinstated design and morality to the universe. Miller's insistence on degradation, though based specifically on fish and reptiles, remained well in keeping with man's fall prior to the second coming. The limbless snake, symbolic of all that was lowly in creation, epitomizes Miller's scheme. The "ill omened birth" of this pitiful beast, long after the departure of the dinosaurian "monarchs," he wrote in *Foot-Prints of the Creator,* "took place when the influence of their [reptile's] house was on the wane, as if to set such a stamp of utter hopelessness on its fallen condition, as that set by the birth of a worthless or idiot heir on the fortunes of a sinking family."[45]

CONCLUSION

The point I wish to make is this. Degeneration was a theme common in Owen's day; it was fast becoming the standard response to transmutation. Thus, given Owen's vendetta against the University College professor, and his abhorrence of Grant's historical Lamarckism, together with this accepted manner of disposing of it, he possessed both the means and the motive for overhauling "Fossil Lizard" morphology to add one more nail to the transmutationist coffin. It will now be apparent why Owen created the dinosaur and Buckland or Mantell did not. One really cannot

[41] Hugh Miller, *Foot-Prints of the Creator: or, The Asterolepis of Stromness* (1847; London: Johnstone & Hunter, 1849).

[42] Richard Owen, *Lectures on the Comparative Anatomy and Physiology of Vertebrate Animals: Pt. I—Fishes* (London: Longman, 1846), p. 149. Of Owen's eleven orders, eighth in position (that is, three from the top) was the Ganoidei, containing among others the sturgeon and *Cephalaspis* (p. 50).

[43] Miller, *Foot-Prints*, p. 165.

[44] [Adam Sedgwick], "Vestiges of the Natural History of Creation," *Edinburgh Review,* 1845, *82*:31.

[45] Miller, *Foot-Prints*, p. 158.

talk of "missed opportunities" on their part; the opportunity was never present, because the conditions that determined the necessary motivation were lacking.

Talk of "missed opportunities" tacitly assumes that science is a search for transcendental truths; timeless truths which, being everpresent, passively await the man perspicacious enough to recognize them. It is more profitable, however, to view science as a culture-bound, inherently creative activity. Problems only arise under certain conditions; it is these problems peculiar to the age which call forth novel responses, and it is this relationship which we call science. So although Buckland knew of the degeneration argument,[46] he was perhaps less conscious than Owen of the more immediate danger of a materialistic transmutation. Owen, after all, was Grant's neighbor in the metropolis and knew only too well Grant's unfortunate leanings.

One must also bear in mind that Owen's idiosyncratic temperament may have largely determined his belligerent actions. He possessed a shockingly arrogant nature and developed an intense suspicion of anyone caught trespassing on what he fondly imagined to be his domain. It is probable that he saw Grant as a threat to his own standing in the academic community. Certainly Owen later watched with mounting horror as a brash young T. H. Huxley rose smartly through the ranks. Huxley has left us ample (albeit biased) evidence of the skirmishes, as well as the ensuing political and scientific wranglings. Unhappily, in Grant's case, we know little of the machinations.

If my reconstruction of events is essentially correct, it explains why Buckland was quite happy with his "Fossil Lizards." And "Fossil Lizards" they would have remained, for no telling how long, had Owen not stepped in to meet the transmutationist challenge.

[46] Buckland, *Geology and Mineralogy,* Vol. I, p. 294.