Book Reviews

Steady-State vs. Empirical Views of Biological History

The Meaning of Fossils. Episodes in the History of Palaeontology. MARTIN J. S. RUDWICK. Macdonald, London, 1972, and Elsevier, New York, 1973. xii, 288 pp., illus. $18.50. History of Science Library.

Geology in general, and paleontology in particular, held the center stage of scientific interest for much of the period from 1500 to 1900. Rudwick's history of paleontology is a story of why paleontologists came to accept the conclusions they held. As times passed, philosophical attachment to particular world views resulted in changes "in the choice of problems to be tackled and in the kinds of solution that were regarded as satisfactory" (p. 155). In its emphasis on the way theory influences the collection and interpretation of "fact" Rudwick's book is a significant departure from others in the field.

The text is divided into five chapters of nearly equal length, each of which is illustrated with an excellent choice of figures from publications of the appropriate period. The first two chapters consider the period from 1500 to 1800, and the way in which the question "what is a fossil?" was answered. Let us grant a prevailing world view that saw correspondences between things earthly and things heavenly and that presumed a unity between shapes of things alive and shapes in inanimate nature. Let us admit the undeniable gradation of stones that look like stones and stones that look like faces, or animals. Given these circumstances, Conrad Gesner (1516–1565), Athanasius Kircher (1602–1680), Martin Lister (1638?–1712), and other scholars could hold a "correct" view that "the stones that resembled animals and plants [owed] those resemblances to their bonds of affinity with various organisms, and not to their origin as the remains of those organisms" (p. 34). Indeed, Rudwick continues, "With such powerful alternatives available, no single observation or specimen, however striking, could be decisive in favour of a wide-ranging theory of the organic origin of fossils" (p. 45).

The view that overthrew these Neoplatonic and Aristotelian notions, and in so doing admitted different interpretations of the origin of fossils, saw the understanding of natural history "solely as one of efficient causation" (p. 51). This was developed most fully in the 1660's by Niels Stensen ("Steno," 1638–1686) in Florence and Robert Hooke (1635–1703) in England, following the 1644 publication of Descartes's *Principles of Philosophy*. Like Darwin and Mendel centuries later, Steno focused on the characteristics of individuals. Crystals of nonbiological origin had different structures from those of shells that contained organisms.

Hooke, Steno, and their 18th-century scientific descendants interpreted faunal changes in the context of a directional historical model that synthesized biblical events (especially the Flood), human history (fossil elephants were attributed to the remains from Hannibal's expeditions), and field observations. But by 1800, it was realized that an immense fossil record preceded man and lay below the Diluvian deposits. Human history was then separated as a distinct topic. Accordingly by the start of the 19th century the major paleontological debate had shifted from the nature of fossils to the nature of the fossil record. Most of Rudwick's last three chapters deal with the alternative explanations of a strictly historical world view and one that presumed some sort of steady state (to use Rudwick's phrase).

In 1800, the major paleontological question was whether the fossil record gave true evidence of extinction. On the one hand, J. B. de Lamarck (1744–1829) viewed the patterns of morphological change as a continuum, like a stream that changes imperceptibly along its course from a tiny brook to a vast river. This view negated extinction altogether and perpetuated a steady-state natural theology. On the other hand, for Lamarck's French colleague Georges Cuvier (1769–1832), the functionally stable mechanical machines of life that happened to inhabit the skins of mastodons, mammoths, and other species could not have been changed by environmental differences because these same machines could have continued in operation by migrating to another area. Some more or less drastic, but probably local, event must have been responsible for their disappearance. The subsequent origin of new faunas was perhaps explained simply by migration from other areas, but, in any event, for Cuvier little evidence was available. As Rudwick stresses, the question of origin was of secondary interest since the pressing issue was the fate of prior forms. By 1830, the reality of extinction as a general feature of the fossil record was widely documented, and the steady-state view was defeated.

During this period stratigraphic studies also suggested a directional and progressive change in the history of life which was thought to parallel "a directional development of the inorganic environment" (p. 147). Invertebrates preceded vertebrates; fish preceded mammals; and more primitive mammals preceded hominoids. Similarly, the existence of fossil tropical plants in places that in modern times have temperate floras illustrated a progressive cooling of the earth.

Only in geology can the term "epoch-making" be applied in its literal sense. As Rudwick states in his fourth chapter, it applies in both senses to the developing world view of Charles Lyell (1797–1875). In the first edition of his *Principles of Geology* (1830–1833), Lyell launched both an attack against the view that geological data and fossils in particular had to conform with historical statements of the scriptures (à la Buckland) and a vigorous counterview that the earth maintained a steady state which "admitted none but clear and distinct natural causes" (p. 188). Lyell defended Cuvier's conception of the discreteness of species, but he sought to interpret faunal changes as the "piecemeal production and extinction of individually stable species" (p. 177). And in his new steady-state earth history

Lyell did not permit any direction or progression in the history of life. He argued that all evidences of progression, such as the "late" appearance of mammals, were illusory and would be rendered inoperative as soon as older deposits were searched more thoroughly. Change yes, but progression no.

By the 1840's, the vindication of a progressionist viewpoint was assured, and with it the second victory of empiricism over a narrowly held type of steady-state view. This was due to many workers, but particularly to Roderick Murchison (1792–1871) and Adam Sedgwick (1785–1873), who were describing the oldest fossils then known. By 1841, their Cambrian-Silurian faunas were recognized from many places in the world; they were always the same, quite distinct from younger faunas, and clearly indicated a directional and progressive change in the history of life. Lyell, however, clung to his steady-state vision at least until the early 1850's. A more flexible view of what a steady state might involve was apparently not possible for him because to grant a directional change might have the effect of endorsing the chief mechanism of adaptational change then considered, that is, the hand of the Creator. Lyell, according to Rudwick, was motivated above all else by his desire to remove geology from theology.

But why was some form of evolutionary theory not acceptable within a steady state? Rudwick notes that some, most prominently H.-G. Bronn (1800–1862), were able to set aside the theological point, since no one doubted that God could act through secondary laws, such as gravity. Thus it would have been possible to insist upon "natural laws" without directly implicating a higher being. The question for Lyell, however, was how to explain the "designfulness" of adaptation. And in the 1840's, there was the additional all-important issue of the origin of man, for if man evolved by chance "he could not be held morally responsible for his actions, and the whole fabric of society was thereby threatened" (p. 207).

A particularly influential "natural" law was widely promulgated by the comparative anatomist Richard Owen (1804–1892). Owen combined functional insight with an explanation of the origins of structure in looking for homologous development as variations on archetypal themes. Since the various archetypes were recognized in the oldest rocks then known, their origin was essentially unknowable. Hence the diversification of functional themes could be studied without concern with the origin of the archetypes themselves. By 1850 this view of a historical progression of particular forms was widely accepted.

Within the framework provided by Owen, scientists (epitomized by Bronn) returned to the question whether regularities in the pattern of species appearance could "explain" the observations from nature. To derive various empirical "laws," not unlike the later Cope's law or various ecological laws, was held to be the goal of the paleontologist.

It was by shifting attention away from such empirical summaries to the cause of change in individuals that Charles Darwin (1809–1882) recast the issue before paleontologists. Rudwick supports the view that Darwin's barnacle monograph was indeed a test of the power of the evolutionary hypothesis to explain both morphologically "retrograde" and "advanced" lineages and not the simple empirical study it has often been claimed to be. Darwin also found, as had been emphasized by paleontologists for many years previously, and indeed is often emphasized today, that typical faunas of fossil barnacles (or brachiopods or trilobites or snails) give "no positive evidence for slow trans-specific evolution" (p. 234). The fossil record was a liability to Darwin, and he made the most of its admitted gaps in defending his theory. Through the 1860's and 1870's the paleontological input to the evolutionary argument shifted from a search for the origin of species to illustrating the succession of genera, as for example in the evolution of horses, and to drawing attention to those significant intermediate forms which did exist, such as the reptile-like bird *Archaeopteryx*. Natural selection as the sole or even the most important causative factor in species evolution seems to have been increasingly deemphasized by the 1870's. The term "mutation" was coined by the paleontologist W. Waagen (1841–1900) in describing rapid morphologic changes observed in a vertical sequence of Jurassic ammonites, and other, equally "natural" forces, also not clearly understood in mechanism, were offered to explain the paleontological fact of successive morphological change.

On this note, Rudwick closes his narrative in 1870, when the major modern theoretical lines in paleontology had been cast. The view in ascendancy then is probably also dominant today, namely that the empirical summation of the "facts" of the fossil record is the way to derive paleontological laws. Now, a century later, this conception of the fossil record is being questioned for yet a third time, again by presentation of equilibrium models (D. M. Raup, *Science* **177**, 1065 [1972]; D. M. Raup, S. J. Gould, T. J. M. Schopf, D. S. Simberloff, *J. Geol.* **81**, 525 [1973]).

Rudwick has interspersed through the book many comments about the changing degree of professionalism in science in general, about the way in which nationalism and internationalism have influenced changes, about the role of translations and review articles in giving publicity to points of view, and about the importance of personality and academic standing in determining the flow of events. This book is rich in ideas and has abundant anecdotes to illustrate particular points.

But why be concerned with our history? As Rudwick so correctly emphasizes, "The loss of historical perspective would lead to conceptual impoverishment" (p. 266). In moving ahead, one forgets why one is there. Rudwick has now provided us with an excellent book which will indeed bring historical perspective to the recurring debate about the use of equilibrium vs. historical models in paleontology.

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Origins of the Newer Sciences

Foundations of Scientific Method. The Nineteenth Century. Papers from a conference, Bloomington, Ind., Nov. 1970. RONALD N. GIERE and RICHARD S. WESTFALL, Eds. Indiana University Press, Bloomington, 1973. x, 306 pp. $10.

This book is a collection of 11 essays prepared for a conference marking the tenth anniversary of the founding of the department of history and philosophy of science at Indiana University. The conference had two prime aims: to re-emphasize the mutual dependence of philosophical and historical approaches to science, and to contribute to the understanding of the growth of scientific methodology in the 19th century. These aims have been reasonably fulfilled. The book is most distinctive by virtue of its range, from