Newtonian Traditions

Mechanism and Materialism. British Natural Philosophy in an Age of Reason. ROBERT E. SCHOFIELD. Princeton University Press, Princeton, N.J., 1970. viii, 366 pp. $9.50.

Schofield has taken for the subject of his book the conceptual development of two opposing views of matter and its action, both deriving ultimately from Newton, and both contending vigorously for the allegiance of British natural philosophers in the 18th century. In the course of his study he has added considerably to our understanding of what it was like to be a "Newtonian" in this complex period and has presented his readers with several provocative theses which should provide the basis for considerable further discussion.

The author distinguishes between two Newtonian traditions: the mechanist and the materialist. The former, ultimately deriving from the mechanical philosophy of the 17th century, maintained that the explanation of natural phenomena was to be sought in the atoms or corpuscles of primary matter (in their sizes, shapes, combinations, and motions) and in the attractive and repulsive forces which determine those motions. The latter (materialist), ultimately deriving in the author's view "from Aristotelean substantial qualities," held, to the contrary, that though such ultimate explanations might in fact exist, the pursuit of them was for the time being futile. Instead, they sought their explanations of physical phenomena in the presence or absence of a material substance which itself carried the necessary properties; the material causes are furthermore generally regarded as imponderable, highly tenuous fluids as in caloric or the famous electrical fluid of Franklin. The dynamic corpuscularians or mechanists claimed direct Newtonian lineage from the *Principia.* The materialists pretended Newtonian legitimacy from Newton's ether speculations in the later editions of his *Opticks,* speculations which as it was reported at the time "surprised [Newton's] physical and theological disciples."

The earlier mechanist tradition is represented in the 18th century by speculative corpuscularians like the Keills, John Freind, and John Rowning, men inspired by the success and model of the *Principia.* However, according to I. B. Cohen and to Schofield in support, Newton's *Opticks* initiated a period of experimentation governed by Newton's own suggestions and speculations. The tension between the aspirations of mechanism—to find the forces among ultimate particles—and the plethora of irreducible experimental data as in electricity provides a major substratum for the transition to materialism.

But the scientific failure of the mechanist program was not the only element in the conceptual change which was to dominate the last half of the century. Schofield suggests that in the crucial period, 1735–1745, several other important changes occurred: alongside a general turn toward incipient Romanticism, a generational shift cut away the hegemony of the mechanists. During the presidency of Martin Folkes (1741–52) the Royal Society "came increasingly to be dominated by dilettantes." More pertinently, the old Newtonians trained at the English universities had by 1744 died, and were increasingly replaced on the scientific scene by those who had been educated in Holland, Scotland, or dissenting academies or were self-taught. This new generation produced a new Newtonianism, characterized by a turn from an emphasis upon "exact" science (after the *Principia*) to one upon "experimental" science (after the *Opticks*). The sentiment for the new Newtonianism supported a revival of the reputation of Bacon; it reflected the influence of Continental (especially Dutch) science; it found its theoretical basis in Newton's own ether hypotheses. "Once the aether, as a special material cause, is adopted," Schofield concludes, "its materiality can be merged with that of other causative substances as these emerge from other sources" (p. 114). The search for other material substrata was on.

The materialist explanations were, according to the author, dominant throughout the second half of the 18th century. Nevertheless, an important group, including Cavendish, Herschel, Priestley, and Hutton, were dissatisfied: "Content with neither the substitution of taxonomy for analysis nor the quantification of quality by conservation of substance, these men returned to the mechanist aspirations of earlier generations" (p. 235). Indeed, Priestley's famous disagreement with Lavoisier was not basically a dispute over phlogiston but rather one between materialism and mechanism. As a chemist "Lavoisier abandoned physical reductionism for the jig-saw puzzle problems of permutation and combination of substances. To Priestley the solution of such problems was comparatively unimportant" (p. 273).

Without question, Schofield has challenged his readers with a consistent and well-buttressed set of views. One may, however, have less confidence than he in the degree of tenacity with which Black and even Lavoisier held a materialist creed, and one may wish for additional analysis, for example, of the importance of changes of state to the calorists. That many of the materialists may have held such a view as an unhappy expedient, as a temporary policy rather than a creed, is borne out by Schofield's own description of materialism as proto-positivistic.

One is struck by the truly strong strain of agnosticism, bolstered by references to Newton's methods, discoverable among many of the materialists; they appear to have taken what they understood to be Newtonian methods of philosophizing (as laid out in the *Rules of Reasoning* and the 31st query) rather more seriously than the need for immediate recourse to corpuscular, dynamic explanations. As with Newton, the search for certitude took precedence. The materialists, faced with a contradiction between Newton's admonitions against groundless hypotheses and the methods required for corpuscularianism, perhaps took a path of little resistance, believing, however, that the future might well resolve that contradiction.

Mechanism and Materialism is a book to be read not only by historians, but by scientists desiring a sound and stimulating entrée into the inner character of 18th-century natural philosophy.

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Studying Muscle

First and Last Experiments in Muscle Mechanics. A. V. HILL. Cambridge University Press, New York, 1970. xvi, 144 pp., illus. $9.50.

A. V. Hill has maintained a boyish enthusiasm for research for over 60 years; he has studied the heat changes and mechanical events in sartorius muscles of the frog in ways that no one else was able to emulate for years, and on top of a steady output of classical papers he has written several books that are fascinating in their accounts of how it really happened. He became a Fellow of the Royal Society and a Nobel laureate at an early age, though he was not quite so meteoric as the book cover suggests, which starts his career ten years after he did himself.

First and Last Experiments in Muscle Mechanics follows Hill's recent book *Trails and Trials in Physiology*. Once again the old master takes us behind the scenes and makes clear how the simple joys of discovery are intertwined with the perplexities of results that didn't fit, of theories that "took, like Charles II, an unconscionable time dying."

The book starts with part of the famous paper of Gasser and Hill on "The Dynamics of Muscle Contraction" (*Proc. Roy. Soc. B* **96**, 398–437 [1924]), which described many of the more intriguing properties of isolated muscle, such as the relation between force and velocity, and the remarkable effects of quick releases and quick stretches. Much of this is still not completely understood. The book finishes with Hill's inaugural address to the Congress of the International Union of Physiological Sciences in Tokyo in 1965 and explains why the book is dedicated to "Ryotaro Azuma—physiologist, oarsman, public servant and friend."

In between Hill presents his last experiments on these problems, which show, for example, that his famous Hill equation does *not* predict the maximum velocity at which an unloaded sartorius muscle can develop tension. He imposed a velocity on the muscle and found that some fibers had very high intrinsic speeds. Some, however, were much slower. He first presented this work at an informal discussion at Churchill College, Cambridge, in December 1967, and it is good to see it finally in print.

In the past, Hill has issued "A Challenge to Biochemists" and "A Further Challenge to Biochemists." After paraphrasing a statement from Horace (*Satires* I, i, 24), "There is nothing to stop you from announcing your results with a laugh," he now asks physiologists to clear up several problems. These include "Will anyone undertake the laborious task of measuring v_0/l_0 and/or ATPase activity in a number of single fibres in a frog sartorius?" and "Will someone please make the experiment in this way?" A section called "The effect of a stretch on a collapsing structure" is followed by, "This seems rather an obscure title: its purpose is to induce someone to try to make the nature of the effect less obscure."

Without doubt, this book should be read carefully by everyone interested in muscle. Parts of it should be of interest to almost everyone else who cares about disinterested research.

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Cellular Relations

Organization and Control in Prokaryotic and Eukaryotic Cells. A symposium, London, April 1970. Published for the Society for General Microbiology by Cambridge University Press, New York, 1970. xii, 460 pp. + plates. $16. SGM Symposium 20.

This is an excellent symposium volume, consisting of 16 original articles, a reprint of E. C. Dougherty's abstract (1957) introducing the terms "prokaryon" and "eukaryon," and a useful glossary of cytological terms. The organizers are to be commended for bringing together a group of outstanding scientists of diverse interests and at the same time maintaining focus on a common theme. Each contributor "does his thing," but with specific regard to the relations between eukaryotes and prokaryotes. R. Y. Stanier's article "Aspects of the biology of cells" provides the framework for the book. Stanier exhibits his breadth of knowledge and unique ability to sense and communicate important problems in biology. After defining the "least common denominators" of eukaryotic and prokaryotic cells in modern terms, Stanier goes on to speculate on the evolution of eukaryons from prokaryons. Stanier's arguments rely heavily on ultrastructure as a source of evidence and inspiration and, in this reviewer's opinion, slight the more fundamental underlying biochemical processes.

The genetic codes of eukaryotic and prokaryotic cells are compared by C. R. Woese. Although the codon catalog is universal, there are interesting differences in the translation machinery of the two cell types. These subtle differences are utilized to derive some thought-provoking, admittedly speculative ideas on the evolution of the genetic code. H. G. Whittman and U. E. Loening present critical reviews on similarities and differences in the structure, function, and biosynthesis of ribosomes. There are five excellent articles dealing with the structural, functional, and possible evolutionary relationship between eukaryotic mitochondria and chloroplasts and bacteria. One fine example is the paper by Hughes, Lloyd, and Brightwell on the distribution of organelles in prokaryotic and eukaryotic microorganisms. In addition, there are some papers on selected aspects of comparative molecular genetics—the quantity, organization, and replication of DNA in prokaryons (Richmond) and eukaryons (Holliday) and the role of mutation (Holliday), diploidization (Raper and Flexer), and bacterial plasmids (Richmond) in evolution. Geneticists will find W. F. Bodmer's article "The evolutionary significance of recombination in prokaryotes" particularly interesting.

This volume is recommended highly to all serious students of cell biology. It is up-to-date, informative, and critical. The challenge, intellectual stimulation, and excitement of current cell biology are all here. At a time when certain molecular biologists claim that the era of discovery is finished, this book points clearly to some fundamental unresolved problems.

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Intellectual History

Eclosion and Synthesis. Perspectives on the History of Knowledge. SALOMON BOCHNER. Benjamin, New York, 1969. xiv, 274 pp. Cloth, $10; paper, $3.95.

This essay "offers an overall characterization of twentieth-century knowledge," on the basis of which Bochner proposes a sharp distinction between present knowledge and "knowledge in preceding centuries." A comparison and contrast are made between the half century 1776–1825, designated as the "Age of Eclosion," when "most of our present-day knowledge evolved into its main organizational divisions," and the 20th century, an "Age of Synthesis."

The main part of this essay deals with science and mathematics (and notably various "aspects of the conception of space"). But there are some "excursions into the social sciences and humanities," so that a test may be made of the thesis "that Eclosion and Synthesis, especially Eclosion, apply to all intellectual pursuits."