Book Reviews

Emotional Lines in Modern Physics

Einstein and the Generations of Science. LEWIS S. FEUER. Basic Books, New York, 1974. x, 374 pp. $12.95.

Historians of science have tended to believe that the influence of the general culture on scientific ideas decreases as science specializes. While one readily concedes that 17th-century science derived much from contemporary philosophy, in which its founders were trained, one has shied from supposing that the ideas of modern mathematical physics owe anything important to developments outside science. Recently the cogency of this last assumption has been attacked persuasively by Paul Forman (*1*), who has tried to link characteristics of quantum mechanics to dominant political and social themes in the early Weimar Republic. Forman's essay is noteworthy for its documentation as well as for its thesis: it relies upon contemporary letters, academic addresses, biographies, and manifestos in professional journals, as well as upon the technical literature.

In the book under review, which covers more ground than its title suggests, Lewis Feuer seeks to overwhelm entirely the assumption of internalist history of modern physics. He does not succeed so well as Forman, for although Feuer has wide reading in history and biography and a resourceful synthetic imagination, he too often takes refuge in the dogma of Freudian psychology and ignores altogether the pertinent literature of physics. This last is a disability in a writer purporting to explain the social roots of the work of Mach, Einstein, Bohr, Heisenberg, and de Broglie.

There are two phases in Feuer's analysis. The first seeks the psychological motive power for the sustained work of scientific revolution in "generational conflict." It is Oedipus in the service of Prometheus. The fathers and teachers of Mach and Einstein thought them dull and wayward; both grew up despising authority and conventional knowledge, and eager to destroy them. In the case of the young Mach, who had his early education from monks, a chance peek down a low-necked dress suddenly released generational energies which liberated him from, among other things, the atomic theory, which (according to Feuer) he associated with testicles and domination. Heisenberg's generational revolt centered on his rejection of the controlled classicism of his father, a professor of Byzantine history, and of the complacent materialism of his father's generation, which had brought Germany into a disastrous war. Heisenberg became an enthusiastic member of the White Knights, a romantic, nationalistic anti-Semitic youth group that hoped to rebuild the Fatherland on a higher moral plane than its members' fathers had been able to reach.

The Prince de Broglie turned his back not only on his father but upon ten generations of diplomats, courtiers, and generals in choosing a career in physics; his path was eased, however, by his brother Maurice, who had already defied the family by leaving the navy for science. Bohr gives Feuer trouble. It is not easy to find expression of the urge to parricide in his idyllic boyhood, or in the fruitful intellectual intercourse between him and his scientist father. Feuer's imagination locates the required generational conflict in the elder Bohr's love of Goethe, who did not like Newton's ideas about optics; the younger Bohr, as a physicist, necessarily preferred Newton to Goethe, and so agitated his Oedipal energies.

No doubt Feuer is right in affirming that creative young scientists strive to outdo their seniors, to reject or correct their practices, to invent new theories, to build more powerful machines. The makeshifts he uses to attach these strivings to received psychological theory ought not to be taken literally, but as fictions that may help one order the quantity of pertinent biographical and sociological data needed in the second phase of his analysis.

The guiding principle here is what Feuer calls an "isoemotional line," a class of theories or ideas which are expressions, reflections, outcomes, or projections of the same emotion. The notion has its uses even though Feuer does not say how he knows when he encounters "isomorphemes," or instances of the same emotion in different fields.

In the case of Einstein, the fullest Feuer develops, the operative line was that of the emigré socialist youth in Berne and Zurich at the turn of the century. Lenin, Trotsky, Weizmann, and Mussolini, to name but the best known, spent time there; so did squadrons of revolutionary Slavic coeds denied educational opportunities at home. Einstein can be connected to this group in two ways. First, he was a fellow student and friend, perhaps a close one, of Friedrich Adler, an idealistic reformer of international socialism and a trained physicist who strove to integrate Mach and Marx. Both Einstein and Adler chose wives from among the Slavic women students. Second, Einstein, like many of his socialist friends, lived on the margin of society for several years after finishing his degree: recall his difficulty finding a job, his occasional substitute teaching posts, his first secure position as an examiner, second class, in the Patent Office in Berne. During the astoundingly productive years 1902–1906 Einstein surrounded himself with fellow marginal types, who read Mach's philosophy and formed themselves into a lighthearted, serious-minded antiestablishmentarian society, the "Olympia Academy." According to Feuer all this set an isoemotional revolutionary line which, in physics, expressed itself in a rejection of the most basic concepts of time and space. In keeping with the Mach-Marx teaching that all concepts, however inevitable they may appear, are in fact cultural artifacts, Einstein's emotional line pushed him inexorably toward a theory of relativity.

For Bohr the line was philosophical, not social revolutionary, and developed not in marginal or emigré groups but in the Ekliptika Circle, an intellectual club of secure, talented, upper-middle-

class students at the University of Copenhagen. The Circle drew its inspiration from Kierkegaard and from Harald Høffding, the leading Danish philosopher and historian of philosophy, who admired William James. Bohr liked to point up their epistemology by quoting from a novel by Kierkegaard's teacher, P. M. Møller, called *Adventures of a Danish Student*. Feuer places great weight on these *Adventures*; and in truth the student's perplexity over the several meanings of "I" or the difficulty of unambiguous description compares strikingly (at least after the fact) with the perplexity of physicists confronted with the dualities of quantum mechanics. The isoemotional line whose trace in philosophy is Kierkegaard has complementarity as its trace in physics.

Heisenberg's emotional makeup derived from his youthful traumas during World War I, the last year of which he spent on a farm near Munich in order to be able to obtain food for himself and his parents. His sense of the failure of materialistic Wilhelmian society was reinforced by rusticity, which, however, did not bring him to cultivate his own garden, or to reject the past, or to join the socialists. He helped put down the Munich soviet in 1919. For an alternative to materialism he turned tentatively to Plato, whose mathematical conception of the constitution of the elementary substances, as set forth in the *Timaeus*, he found more to his taste than the rude schoolbook representations of atoms linked together by hooks and eyes. (Heisenberg's later emphasis on the disgust he felt for these harmless models seems out of proportion to the stimulus; Feuer explains them as "crude symbols of male sexuality," just the thing for materialist Bolsheviks but anathema to the fastidious admirer of Platonic spirituality.) Heisenberg's confusion and uncertainty, born of the war, only increased in the early 1920's, when he studied physics at the University of Munich: the anti-Semitism and clean living of his comrade Knights directed him to spurn his older fellow student, Wolfgang Pauli, whose abilities he could not help admiring (*2*). Heisenberg chose to accept Pauli. Then came Bohr, who was able to advance in atomic theory by employing models only slightly less crude than the detestable hooks and eyes. The isoemotional trace in physics of all this uncertainty is, not unexpectedly, the principle of uncertainty. Among other advantages the principle assured that no experiment could ever reveal that atoms have hooks and eyes after all.

The gap in this isoemotional (not to mention logical) line may be narrowed by reference to the discussions of causality which, as Forman has shown, were conspicuous in Weimer intellectual life. Many physicists inspired by the prevailing *Lebensphilosophie*—which esteemed the immediate, the subjective, and even the irrational above the reflective, objective, and controlled—questioned whether "strict causality" regulated the physical world. Many hoped that it did not, that instead a radical indeterminism reigned, the nature of which, however, they did not stop to specify. Note that this inclination toward an acausal physics antedated the recognition of the difficulties in quantum physics that it helped to resolve. Note also that it suited Heisenberg's emotional line.

The emotions of the solitary Louis de Broglie almost eluded Feuer. Fortunately de Broglie has from time to time expressed interest in the philosophy of Henri Bergson, whom Feuer therefore takes as de Broglie's "pilot wave": the philosopher's insistence that life is "an immense wave which, starting from a center, spreads outwards" guided the physicist to the discovery of the internal vibration of the electron. "The emotional-intellectual valence for the notion of a wave . . . was conveyed by Bergson's writings: wave theory became an isomorpheme for young French intellectuals at odds with bourgeois, republican atomism and materialism."

The fantasy of this last correspondence underscores the chief conceptual problem of Feuer's analysis. He intends his isoemotional line to be an explanation—or a necessary part of the explanation—of the origin of scientific theory. Einstein invented relativity (partly) *because*, consciously or not, he wished to bring physical theory into parallel with certain social, political, and philosophical views. But how does Feuer judge which theory is isoemotional with a particular extrascientific commitment? And how does he choose which bit of a theoretical system embodies the commitment? His answers, as implied by his several analyses, are often arbitrary and unhistorical, and sometimes silly.

What is the kernel of Einstein's paper "On the Electrodynamics of Moving Bodies?" Feuer makes it the revolutionary relativization of space and time. But from the genetic point of view, from the standpoint of the psychology of invention, the relativization should perhaps be regarded as the consequence, not as the guide, of Einstein's thought. Instead of "relativity" the operative isomorpheme might then be "symmetry" (as stressed in the opening paragraph of Einstein's paper) or "constancy" (as expressed in the restriction regarding the speed of light) or "impotence" (as reflected in the failure to engage the ether or to catch up to a light ray). These alternatives would be harder to square with Feuer's assessment of Einstein's emotions than revolution and relativity. Had Feuer justified his choice by reference to all of Einstein's innovative work of 1905, his conclusions might have been subtler and, perhaps, more credible (*3*).

Feuer locates the emotionally significant point of Bohr's first paper on the "Constitution of Atoms and Molecules" (1913) in the quantum jumps (an isomorpheme of Kierkegaard's doctrine of "either-or"). If this is meant genetically it can be dismissed immediately: Bohr's concern with spectra and excited states awakened only after he had conceived the general features of his atomic theory (*4*). Here Feuer's account fails from ignoring not only the full context of the work but also the pertinent recent literature on the history of science.

In general Feuer handles his sources with little regard for the order of evidence; he jumbles together contemporary evidence, conflicting retrospective accounts, and secondary sources of disparate value. For example, he harvests the notoriously unreliable Engelbert Broda (*5*), and derivative tales by physicists, to establish that Boltzmann was a victim of intergenerational scientific warfare: he took his life because his type of pictorial physics had been defeated by positivists, energeticists, and thermodynamicists. In fact Boltzmann had wiped the floor with these gentlemen at their only face-to-face confrontation, at the Naturforscherversammlung of 1895 (*6*). If Boltzmann did not recognize his victory, that should be interpreted as a result not of intergenerational conflict but of the mental illness that loosened his grip upon the world.

Feuer's genetic interpretations fail because he attempts to link the sociological factors of a discovery not to the contemporary state of science as perceived by the discoverers but to the general philosophical import of that discovery

as later recognized by nonscientists. One might, however, profitably regard the jabberwocky isomorphemes as strictly formal correspondences or analogies, useful—as the wide-ranging and unexpected sources consulted by Feuer indicate—for raising questions and suggesting where to look for answers. So understood, Feuer's book is valuable in itself and, one may hope, a harbinger of more refined studies in the sociology of scientific knowledge.

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References and Notes

1. P. Forman, "Weimar culture, causality, and quantum theory, 1918–1927: Adaptation by German physicists and mathematicians to a hostile intellectual environment," *Hist. Stud. Phys. Sci.* **3**, 1 (1971).
2. Compare the reviews of Heisenberg's *Physics and Beyond* by K. Hufbauer, *Isis* **62**, 558 (1971) and by P. Forman, *Science* **172**, 687 (1971).
3. Feuer makes much of Einstein's use of "relativity" in the paper of 1905; but nothing can be inferred from this since, as Feuer knows, Poincaré, whose conservatism and classicism rest on an anti-Einsteinian emotional line, had earlier used the same word in the same sense.
4. J. L. Heilbron and T. S. Kuhn, "The genesis of Bohr's atom," *Hist. Stud. Phys. Sci.* **1**, 211 (1969).
5. E. Broda, *Ludwig Boltzmann* (Deutscher Verlag der Wissenschaften, Berlin, 1957).
6. See the account of the meeting in *Verh. Ges. Dtsch. Naturforsch. Ärzte* **67**, 28, 32 (1895); W. Ostwald, *Lebenslinien: Eine Selbstbiographie* (three vols.) (Klasing, Berlin, 1926–1927), vol. 2, p. 197ff; A. Sommerfeld, "Das Werke Boltzmanns," *Wien. Chem. Ztg.* **47**, 25 (1944).

Surface Structures

Bacterial Membranes and Walls. LORETTA LEIVE, Ed. Dekker, New York, 1973. xx, 496 pp., illus. $38. Microbiology Series, vol. 1.

The investigation of bacterial surface structures has advanced through unintegrated attack on a multiplicity of limited objectives. Chemical analyses of structural polymers, investigation of the mechanism of their biosynthesis, and the inhibition of these mechanisms by antibiotics have naturally led to an interest in associated membrane functions, and the stated aim of this book is to juxtapose the available data so as to facilitate a concerted approach to some of the difficult problems that remain. These problems, mostly related to the control of biosynthesis and morphology, are easily stated, but it is hard to design experiments to deal with them. While the quality of the nine reviews making up this volume is generally high, few of the authors have provided guidelines for an interdisciplinary approach to such problems. For the most part, then, the book is simply a useful collection of reviews.

Leonard Mindich's chapter is concerned chiefly with the composition and assembly of protoplast membranes. It is a good review, but it does not provide a coherent treatment of the biochemical genetics of lipid biosynthesis in *Escherichia coli*, and there is no statement of conclusions or perspectives.

The chapter by Ghuysen and Shockman on biosynthesis of peptidoglycan starts with a routine review of peptidoglycan structure. It continues with a discussion of biosynthesis that emphasizes kinetic analyses of the few soluble enzymes available for study and places undue stress on the unproven identity of the soluble D,D-carboxypeptidases and physiologically functional transpeptidases of *Streptomyces*. The chapter ends with an excellent review of autolytic enzymes and their potential functions, much of it deriving from Shockman's own studies. In this and other chapters, the phenotypes of bacterial mutants with alterations in cell surface phenomena (wall synthesis or breakdown, cell shape and division, membrane and transport functions) are discussed. Usually such mutations have pleiotropic effects and interpretation is problematical even when the lesion is biochemically identified.

Hiroshi Nikaido's outstandingly clear discussion of lipopolysaccharides and the outer membrane layer of gram-negative cell wall is reasonably successful in fitting the data into a comprehensible pattern. Because lipopolysaccharides are components of the outer membrane of gram-negative bacterial cell walls, and are synthesized within the plasma membrane, the discussion leads into the membrane-associated phenomena of polymerization, transport, ligation, and assembly into functional supramolecular arrays.

The section on transport commences with an excellent discussion of binding proteins by Rosen and Heppel. This chapter gives careful consideration to functional and operational definitions of binding proteins, transport proteins, and periplasmic enzymes and to the significance of these with respect to active transport. The inclusion of data on yeast and fungi is useful, as is the discussion of approaches to unsolved problems.

Ronald Kaback's chapter on transport mechanisms is less successful because it attempts to cover too much material on the mechanism of direct coupling of active transport to energy production of respiration and does not discuss chemiosmotic coupling. The controversy over coupling remains very much alive, and the reader would benefit from a thorough discussion of the matter. This article is exemplary in its coverage of recent literature.

The excellent review of colicins by Salvador Luria places proper emphasis on problems that need reexamination and clarifies the function of colicin E3. The functions of E1, K, and (to a much greater extent) E2 remain a matter of confusion. There is no discussion of megacins and gonocins or of colicin factor DNA replication. This short chapter is otherwise comprehensive, and it raises provocative questions about structural, regulatory, and evolutionary aspects of colicins.

Alexander Tomasz's review of the mechanisms of transformation is an interesting account of the author's own work on competence. Other matters related to transformation, such as the molecular biology of the uptake of single-stranded DNA, are excluded. This review does, however, cover aspects of transformation that are clearly related to the biology of bacterial cell surfaces.

The section on morphogenesis and reproduction begins with a chapter by Pardee, Wu, and Zusman on cell division. They state that "the combination of facts and bold hypotheses have allowed a guess as to the general appearance of the picture of bacterial cell division, but much remains to be discovered before the puzzle can be sorted out and a complete picture emerges." This is not an overstatement. Hypotheses of a very general nature concerning the linkage between genome replication and cell division continue to outstrip experimental demonstration by a considerable margin. This review covers basic models of cell division, notably those of Helmstetter and Cooper, without attempting to present many of the hard data. As a result, it is somewhat superficial, and moreover little attempt has been made to update the information. There are some curious omissions: for example, in the discussion of the separation of replicating strands, no mention is made of Albert's work on bacterial and phage unwinding proteins. There are other oversimplifications of the data, and the review does little to clarify a very confusing field.