Book Reviews

Energy: A Portrait of Lawrence

An American Genius. The Life of Ernest Orlando Lawrence. HERBERT CHILDS. Dutton, New York, 1968. 576 pp., illus. $12.95.

This book provides a detailed record of the life of an extraordinary man. A gifted experimental physicist, Ernest Lawrence won the Nobel prize for inventing and developing the cyclotron. In the process of attaining higher particle energies he created "Big Science." During a decade characterized by a great depression, when physics department expenditures for research were commonly a few thousand dollars, Lawrence moved up to the million-dollar class. Later his organizational talents and experience were crucial in the production of the atomic and hydrogen bombs. He participated in making the decisions to go ahead with them and in many technical aspects of their development.

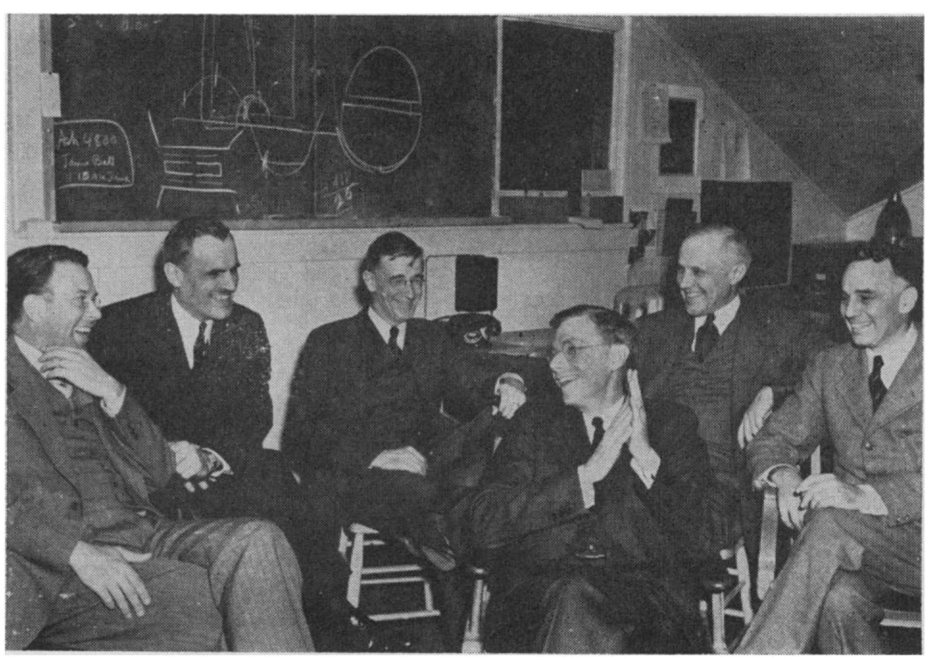
If one were to characterize Lawrence with one word, it would be *impact*. The man had an important influence on events; his influence on his associates was profound and unforgettable. One consequence of this impact is apparent in the book. The author was able to draw on vivid recollections of some 800 people who had known Lawrence and could provide what amounts to a series of detailed eyewitness accounts of important events in Lawrence's life as he progressed from boyhood in the obscurity of a small South Dakota town to association with the mighty. Moving in and out of the spotlight with Lawrence are many of the leading scientists of the times, such as Bohr, Fermi, Compton, and G. N. Lewis. A series of incidents involving Lawrence and Oppenheimer are described; they provide considerable information on the evolving relationship of the two men.

Lawrence's youth paralleled that of many young scientists. At an early age he began to interact with other boys of the neighborhood in imaginative enterprises. One of his playmates was a boy of the same age who lived across the street. He was Merle A. Tuve, now Home Secretary of the National Academy of Sciences. The two boys early experimented with wireless and later with radio. By 1917 they were listening to broadcasts from Europe and communicating with other amateurs over a wide area. To obtain funds for his experiments, Lawrence engaged in a number of money-making enterprises. While still in his teens he organized and directed a large group of boys in the selling of aluminum ware, and he profited handsomely.

After graduation from the University of South Dakota, he attended the University of Minnesota for a year and the University of Chicago for a year, before earning his Ph.D. in physics at Yale in 1925. As a graduate student and new Ph.D. Lawrence proved to be an imaginative, productive, and careful experimentalist. Lawrence soon became one of the nation's most sought-after young physicists. He used his bargaining position skillfully to advance up the academic ladder. He moved to Berkeley and in 1930 was made full professor.

On about 1 April 1929, Lawrence had the idea of how a cyclotron might function. Helping him develop the concept were two graduate students, first N. Edlefsen and later Stanley Livingston. On 2 January 1931, Lawrence and Livingston produced 80,000-volt protons with only 160 volts on the electrodes. The principle of the cyclotron had been firmly established.

Lawrence's performance in exploiting opportunities inherent in the cyclotron was magnificent. He was the star of the show. Though he surrounded himself with a cast of talented experimental physicists, he dominated the scene by reason of personal excellence. During the next decade a series of bigger and better machines were built and successfully operated. Lawrence had a gift for devising or selecting new designs for equipment and was quick to adopt the good ideas of others. He was extremely skillful, often intuitive in diagnosing operating difficulties and quick to find practical means of curing them. His qualities as a physicist alone would have won fame for him. However, Lawrence had other assets working for him. He was a great leader



On the top floor of the old Radiation Laboratory building, Berkeley, 29 March 1940. Left to right: Lawrence; Arthur H. Compton, chairman of physics and dean of physical science, University of Chicago; Vannevar Bush, president of the Carnegie Institution; James B. Conant, president of Harvard; Carl T. Compton, president of M.I.T.; Alfred L. Loomis, physicist, trustee of the Carnegie Institution and M.I.T. The visitors "had just agreed to support Lawrence's proposals for the giant (184-inch) cyclotron." [Photograph by Donald Cooksey. From *An American Genius*] of men. He was an imaginative creator of ideas. He was a supersalesman of the excitement of science. He was a talented scrounger who in the early stages of the development of the cyclotron was able to find an available 85-ton magnet.

As his successful development of the cyclotron became better known, Lawrence was able to obtain substantial financial support. Young men were eager to join him. His laboratory and its work commanded the attention and admiration of the world's leading physicists as well as that of many leaders from other branches of science and other walks of life. In 1939 he was awarded the Nobel Prize.

Following his meteoric rise during the '30's, it was inevitable that Lawrence should be an important figure during World War II and after. He was a Nobel laureate, a scientist with a reputation of being able to deliver on his promises even when he promised what might seem impossible. He was an experienced manager backed by a highly competent team. In the last half of this book the author portrays Lawrence's use of power. First, there are described Lawrence's wartime activities, including his efforts in bringing about the Manhattan Project, and his subsequent participation in that project. Then, his efforts of the following decade are recorded; during this period Berkeley was in the vanguard in developing machines for high energy physics and in exploiting them. The author also covers Lawrence's participation in the development of the hydrogen bomb and describes how an accumulation of tensions associated with this effort, including his estrangement from Oppenheimer, found Lawrence vulnerable. He suffered from an ulcerative colitis, and his worst bouts with the disease were clearly emotionally related. Ultimately the disease killed him.

In assembling his book the author worked under the handicap that he had never met Lawrence. Nevertheless, he has succeeded in presenting a unique and valuable biography. He has tapped many resources, including voluminous personal correspondence, official records, and personal recollections. He has avoided becoming a captive of his subject. Perhaps this cannot be said of all the hundreds of acquaintances who furnished material to the author. There is some evidence that time has softened their memories of some of the tougher aspects of Lawrence's character. For example, the author in two places mentions the possibility that Lawrence might have been a "slave driver." Then he quotes witnesses who deny the possibility. Perhaps they are correct, but my memory of graduate school at Berkeley is that any time I worked less than a hundred hours a week I was made to feel that I was a "weak sister."

The author does not attempt to analyze or interpret his subject; rather he has chosen to be a careful reporter. Nevertheless, the reader will find that Lawrence emerges in the book sharply etched. For example, the influence of his upbringing is there—his lack of profanity and his exemplary honesty. Throughout the book are many evidences of Lawrence's unusually deep loyalty and attachment to old friends and former colleagues. Also evident is Lawrence's consistent refusal to be petty either through gossip or through jealousy of the successes of others. For those who did not know Lawrence or the era in which he lived the author may present more details than they care to read. However, those who have some memory of the man will find this book fascinating, and historians will find it a rich source.

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Science

Techniques for Biology

Magnetic Resonance in Biological Systems. Proceedings of the 2nd international conference, Stockholm, June 1966. A. EHRENBERG, B. G. MALMSTRÖM, and T. VÄNNGÅRD, Eds. Pergamon, New York, 1967. viii + 431 pp., illus. $21.50. Wenner-Gren Center International Symposium Series, vol. 9.

This volume of proceedings of the Second International Conference on Magnetic Resonance in Biological Systems includes a wide range of contributions based on most of the principal magnetic resonance techniques—high-resolution nuclear resonance (NMR) and relaxation, electron spin resonance (ESR), electron-nuclear double resonance (ENDOR), and Mössbauer spectroscopy. The proceedings of the first conference (Boston, 1964, reported in *Science* **146**, 552) were not published, and there are no plans to publish the proceedings of the third, to be held this year. The book is therefore likely to remain a unique public record of an otherwise closed series of meetings. With the emphasis on scope—which is highly commendable if the reader is to assess the relative power and merits of the different techniques—one is not surprised to find that the volume faithfully reflects the unevenness of achievement in different areas. The contributions range from more or less definitive solutions of biochemical problems, to exploratory surveys, to discussions of basic theory without obvious applications, to purely instrumental developments. There is not much question that the standard of achievement in this field is set by the successful use of magnetic resonance to solve a biologically relevant problem—just as the determination of a protein structure today sets the standard in protein x-ray crystallography. Nor is there much question that magnetic resonance is not just another spectroscopic tool. In principle it is able to provide unique and very detailed information in at least two areas: (i) structure, conformation, and interactions of macromolecules in solution (largely NMR, but also ESR in problems of conformation) and (ii) structure of crystal fields surrounding metal ions and the nature of metal ion catalysis. But the record makes it plain that only in rare instances has this potential been exploited to the full extent.

Among the highlights of the volume are the pioneering studies of McDonald and Phillips with the 220-megacycle NMR spectrometer, clearly showing that at least partially interpretable NMR spectra of proteins can now be obtained, and the elegant experiments of McConnell illustrating the usefulness of labeling proteins with synthetic free radicals (spin labeling) in studies of protein conformation. It is of course true that these and several other important developments that have occurred since 1966 are recorded more completely in the more recent literature than in the collected volume—yet this is to be expected in a rapidly growing field.

The book is not for the novice. A fair degree of familiarity with at least the elementary theory of magnetic resonance is needed to read the text. Still, the erudite nonexpert can get from it an admirable bird's-eye view of the direction in which the field is moving. The thoughtful reader will also gather that a successful marriage of virtuosity in the theory and practice of physics with sound biological intuition is still a very rare thing.

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