conveying a picture of Rutherford and his times. Erwin N. Hiebert finds that physicists themselves around 1900 experienced a growing sense of unity and progress and spearheaded an expansion of physical principles into the world of the very small and very large and that such tendencies to speculate and collaborate had emerged more than a decade or so earlier; that they held firm to such anchor points as the first law of thermodynamics, the periodic table, and Maxwell's theory; and that their principal puzzles centered on the ether, electron theory, radioactivity, and the second law of thermodynamics. Neil Cameron provides another perspective by discussing the general intellectual and educational setting in England, at one point (p. 136) encapsulating the relative status of physics at Cambridge and Oxford in a telling comparison:

> In the 1870's at Cambridge you could find Maxwell, at Oxford, Clifton; in the 1880's at Cambridge, Rayleigh, at Oxford, Clifton; and from then on until the end of the First World War, at Cambridge, J. J. Thomson, at Oxford, Clifton.

Stephen G. Brush, in his essay, suggests that to understand the concept of a scientific revolution one should look at the broader canvas, which at the turn of the century reveals a veritable age of scientific genius and a general sense of crisis, in many disciplines—physics, mathematics, astronomy (the subject of Guglielmo Righini's essay here as well), geophysics, chemistry, biology, psychology, anthropology, technology. He selects for more detailed comment the revolutionary achievements of Einstein, Rutherford, T. C. Chamberlin, E. B. Wilson, Nettie M. Stevens, Alfred Binet, and Freud, finding that the single common element linking them was a deep change they wrought in our perception of time, from an essentially evolutionary world view to a stochastic one.

Focusing more particularly on Rutherford and McGill, Lawrence Badash somewhat iconoclastically finds the seeds of the transition from little science to big science in Rutherford's research at McGill—in his role as the leader of a vigorous and productive research group specializing in a restricted number of problems, in the generous financial support received from Macdonald, and in Rutherford's capacity to attract public attention and personal honors. John L. Heilbron provides a bird's-eye view of the full range of physics at McGill, displaying its institutional setting and showing how Rutherford's approach to physics, research, and influence on students and assistants contrasted with that of his predecessor, H. L. Callendar, and Callendar's student (subsequently Rutherford's colleague) H. T. Barnes. Thaddeus J. Trenn analyzes in detail how Rutherford, through brilliant experiments and compensating calculational errors, concluded in 1902 that alpha particles are corpuscular in nature. The story of the alpha particle is extended further in time by Feather in his Rutherford Memorial Lecture, which is reprinted from the *Proceedings of the Royal Society of London*. Finally, Stanley L. Jaki illustrates and discusses Rutherford's realistic world view.

The quality of the papers collected in this volume, in general, is high; the editorial work less so. The absence of a subject index, which greatly increases the utility of a volume of this type, is regrettable; the absence of a name index is inexcusable.

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A Successful Career

Gay-Lussac. Scientist and Bourgeois. MAURICE CROSLAND. Cambridge University Press, New York, 1978. xvi, 334 pp. $36.

What one misses in Gay-Lussac and in the French physical scientists of his generation is *passion*, the unwavering demand to *know*. Naturally there are few in any age who are passionate to a vivid purpose. Those who are, however, or who are fortunate enough to live in a time when it looks like passion might get somewhere, are the ones we remember—Michael Faraday the Sandemanian, the indefatigable Darwin, Einstein sure that Jehovah does not gamble, Rutherford willing to go on tinkering his whole life because at bottom things must be *simple*.

Perhaps this is a romantic view and utterly out of consonance with Gay-Lussac, who was at the opposite pole from romanticism, as is his biographer. Gay-Lussac emerges from these pages puritanical, utilitarian, ambitious, diligent, hardworking, henpecked, conservative, positivistic, cautious, colorless, and humorless. He may have sowed a few wild oats when he first arrived in Paris (from St. Léonard, near Limoges) in 1795, and he may, just after that, have been a draft-dodger, but for the rest of his life he was a virtual Boy Scout. This does not make his biographer's job easier, for there are no amusing anecdotes to tell, no surprises throughout Gay-Lussac's long life, no obvious tensions, and, therefore, no drama. The man had no dash and, apparently, no vision. If this is the case with most of us, it is also the reason most of us would not make interesting biographies.

Despite the author's intention "to place the man in his intellectual, social and national context" (p. x) and his assertion that Gay-Lussac "did not divide his life into two separate compartments: science and private life" (p. 226), his book treats the life and the work separately, in terms of distinct principles. The life is dedicated to the principle of the "career," and the work to that of the "contribution" to science. These two words recur throughout the text to tell us on the one hand how Gay-Lussac shaped the course of his life and on the other hand how he saw his place within science.

Gay-Lussac's "career" went largely from success to success. His and his father's plan for him to study law in Paris went awry as he got caught up in the excitement that infused the founding and early years of the Ecole Polytechnique. He decided to devote himself to science and came under the tutelage of Claude-Louis Berthollet. After working for several years as Berthollet's assistant he entered (1806) the Institut National (the successor to the Académie de Sciences), became professor at the Faculty of Science (1809) and at the Ecole Polytechnique (1810), then assumed the editorship (with Arago) of the *Annales de chimie et de physique* (1816). In middle and later life he held a high position at the Paris Mint and sat in the Chamber of Deputies (1831) and in the Chamber of Peers (1839). Along the way he invested wisely, capitalized on his knowledge of chemical processes with several inventions that he patented, and bought land. Honors, respect, and prestige followed. Gay-Lussac died well-off and established; his rise from provincial petit bourgeois to national figure took place without serious setback through the storms and uncertainties of Napoleonic, 1830-revolutionary, and bourgeois-monarchy France.

About all of this in Crosland's treatment I have no quarrel. It is a story told with firm command of detail and with imaginative documentation. I find his account of the other aspect of Gay-Lussac's life deficient, however. Now there is no doubt that this great chemist made "contributions" to our knowledge of both chemistry and physics, and also to

technology. If it had not been for Gay-Lussac's own acknowledgment of Charles's dubious priority, we should have "Gay-Lussac's law" of the constancy of gaseous expansion with temperature. We do unequivocally recognize "Gay-Lussac's law" of combining volumes of gases. Working alone and with Louis-Jacques Thenard, he isolated boron and helped to clarify the nature of the alkali metals and the halogens (his paper on iodine is a masterpiece of systematic and thorough chemical investigation). Here, incidentally, Crosland very sensibly and without partisanship balances the value of the French chemists' work against that of Humphry Davy of overinflated historical reputation. Alcoholometry, analytic technique, methods of assaying, the Gay-Lussac tower: all these and many more contributions are examined and placed within their respective lines of scientific and technical development.

The idea of a "contribution" to science, however, suggests a theory that regards scientific advance as analogous in the intellectual realm to the additive accumulation of capital in the economic. Crosland has always insisted (in this and in previous writings) that Gay-Lussac's primary purpose as a scientist was to discover "laws." Leaving aside the question whether this is or is not what every scientist would like to do, we may ask: is that all he wanted to do? His mentors, Berthollet and Laplace, hoped to reduce molecular phenomena to Newtonian physics. They thought they fully understood celestial dynamics, and in their view (and in Napoleon's view as well) it was time to understand the dynamics of small particles and the agencies—heat, light, electricity, magnetism, and capillarity—with which they interact. The task was to make the second Scientific Revolution, that is, not to add to our knowledge but to transform it. Did Gay-Lussac ever share these hopes and this program? If he did, when and why did he give them up? If he did not, how does one explain his "positivism," his humble satisfaction with enunciating laws rather than exploring mechanisms? Was there no sense of loss, no bitterness (as in Dulong's case), no conflict in this descent from the grand style of his teachers? Do we dare to suggest that perhaps the analogy between career, as accumulation of posts and property, and contribution, as cumulative advance of narrow knowledge, cuts deeper than we at first thought?

On these and related questions—those for example raised recently by J. W. Herivel, Eugene Frankel, and Robert Fox regarding the decline of scientific culture in France during precisely the years (1818–1830) when Gay-Lussac turned from chemical science to chemical technology—Crosland is silent. This patient and thoroughgoing biography—Crosland spent years negotiating with the Gay-Lussac family and various curators and archivists to get access to Gay-Lussac's papers—will likely remain the standard one. It is very informative. It is, however, not the last word.

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A Test of the Kuhnian Theory

Chemistry Transformed. The Paradigmatic Shift from Phlogiston to Oxygen. H. GILMAN MCCANN. Ablex, Norwood, N.J., 1978. x, 180 pp. $14.95. Modern Sociology.

Since its appearance in 1962, T. S. Kuhn's *The Structure of Scientific Revolutions* has been at the center of a vigorous and often vacuous debate. In this brief monograph McCann, a recent Princeton Ph.D. in sociology, seeks to pin down Kuhn's protean theory of scientific revolutions. First he "operationalizes" the theory; then he tests his version against Lavoisier's chemical revolution.

In specifying the theory of scientific revolutions, McCann makes two sorts of claims—some about the broad developments that are likely to accompany a scientific revolution and some about the scientists who are likely to be recruited to a revolutionary paradigm. During a scientific revolution, he proposes, the pertinent specialty community's size and productivity will increase faster than usual because new opportunities for recognition will stimulate immigration and publication. Likewise, so long as the revolution's success is in doubt, the community's output will be more theoretical than usual because the conflict is essentially over interpretative principles. Once the revolutionaries feel assured of victory, however, they will abandon polemics and resume the practice of normal science. Meanwhile, in sciences amenable to quantification, the community's standards of exactitude will rise in consequence of attempts by the contestants to use quantitative evidence to buttress their positions. Finally, as the revolution succeeds, its triumph will be mirrored in the growth of the revolutionaries' share of the community's publications and citations.

Regarding the recruits to the revolutionary faction, McCann postulates that the more theoretical, quantitative, and youthful members of the community will tend to embrace the new paradigm more readily than their colleagues. Those with theoretical propensities will tend to join the vanguard because their approach obliges them to consider any theory that promises to resolve alleged anomalies. Those with quantitative propensities will tend to join the vanguard because their penchant for precision makes them susceptible to any theory that challenges orthodoxy on quantitative grounds. And the youthful will tend to join the vanguard because, lacking a prolonged involvement with and investment in the prevailing paradigm, they are more likely to perceive scientific and personal advantages in rallying to the revolution.

As a test for his propositions, McCann chose the late-18th-century revolution in chemistry, partly because Kuhn made frequent reference to this case. Limiting himself to the periodical literature in Britain and France, McCann sought out and coded all the articles bearing on chemistry published by authors in these countries between 1760 and 1795. From this collection of 868 articles by 207 authors, he drew a "cited sample" consisting of the 717 articles written by the 129 authors whose work was of sufficient interest to garner them one or more references in the original collection. This sample serves as McCann's data base for most of his testing.

Dividing the sample along national lines, McCann finds impressive confirmation for long-surmised differences in the size and productivity of the British and French chemical communities of the late 18th century. While 27 British chemists published 101 articles between 1760 and 1795, 102 French chemists published 616 articles! Struck by this disparity, McCann draws upon the historical and biographical literature to argue that the comparative weakness of the chemical community in Britain was due to the relative lack of opportunities there both for learning chemistry and for making a career in the science. For all its interest, however, this argument is but a digression. Indeed, McCann's subsequent statistical analysis of the British case turns out to be another digression. As he admits, this analysis is inconclusive, partly because membership in the British chemical community never exceeded ten intermittently productive chemists and partly because Lavoisier's theory never made much headway in the British periodical literature prior to 1795.

Unlike the British case, the French