Specifically, Boussingault discovered, with his rival George Ville, that plants grow best when supplied with a mixture of nitrates and phosphates. His researches into photosynthesis established that plants give off one volume of oxygen for every volume of atmospheric carbon dioxide fixed into carbohydrates. A major find in animal nutrition was Boussingault's realization that the fat in grass-eating animals derives from the carbohydrates they ingest.

Actually, these and other researches into agricultural chemistry account for only half of the 350 papers published during Boussingault's long life, 1802–1887. Son of a Paris tobacconist and his Bavarian wife, Boussingault was a school dropout who regained intellectual momentum by attending free public lectures by eminent scientists and then enrolling in the mining academy of Saint-Etienne. Two years after his graduation in 1820, Boussingault, with strong encouragement from Alexander von Humboldt, accepted a professorship at the National School of Mines in Bogotà, just then being established by Colombia's liberator, Simón Bolívar. There followed a ten-year stay in South America, in the course of which Boussingault did little teaching but much exploration and research on a wide variety of problems, among them malaria and goiter (for which he recommended dietary iodine or the drinking of non-local water). He climbed seven volcanoes, identified new minerals, and studied the mining and separation of precious metals and the composition of tribal body paints. After returning to France in 1832, he continued to publish to the end of his long life a stream of papers on South America—quite reminiscent of Charles Darwin, who for many years produced works based on his experience on the voyage of the *Beagle* from 1831 to 1836.

There are other parallels with Darwin. Boussingault too married a rich wife—Adel LeBel, whose family farm in Alsace could be made available for Boussingault's experiments because it lay over coal and oil fields, from which the LeBels drew their fortune. During much of Boussingault's life he spent the summer and fall on this farm, and in winter and spring he lived in Paris, where he became professor of agricultural chemistry at the Conservatoire des Arts et Métiers, a non–degree-granting institution offering public lectures and modest research facilities. Also in Paris Boussingault could work toward his doctorate at the Sorbonne and later, after election to the Institut de France (as the Academy of Sciences was then called), could attend its sessions and those of other scientific commissions on which he served from time to time.

But, unlike Darwin, Boussingault never made it into the most influential circles of his nation's science. A major reason for this was his lack of interest in the fundamental questions of 19th-century chemistry and his reluctance to compete with Liebig in providing an overview and structure to agricultural chemistry. His contributions consist mainly of skillful chemical analyses brought to bear on problems of immediate practicality. Boussingault's personality also kept him from easy interaction with the scientific élite. He was a "loner," self-centered and self-sufficient, inclined to approach others with caution, ungenerous in sharing credit, unable to inspire students to follow in his footsteps. His strength lay in his versatility, independence of judgment, experimental inventiveness, and above all capacity for work.

This altogether well-researched biography is enriched by the author's strong interest in the diverse scientific questions addressed by Boussingault. The origins and context of each investigation are admirably sketched. This is not so true of the experiments themselves. But we are always treated to a judiciously restrained appraisal of our hero's contributions relative to those of other investigators, and we are shown both the immediate and long-range consequences of his findings.

Readers who enjoy mystery stories will appreciate having to wait till the last chapter to learn the important things they wanted to know about Boussingault's personality and standing in the history of science. My own preference in biographies is to be informed adequately about what I want to know at the point where the subject is raised. Until I read the last chapter I wondered whether the author was capable of articulating a coherent psychological and social portrait of his subject. Eventually he does and ties up other loose ends. But questions regarding Boussingault's family life, finances, working and reading habits, politics, and values remain, perhaps because of a paucity of sources. Writing an exciting biography about a private, colorless scientist is not easy. Overall, McCosh has done his job capably and taught us much about the history of 19th-century agricultural science and chemistry.

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Themes Beyond Chemistry

The Periodic Table. PRIMO LEVI. Schocken, New York, 1984. vi, 233 pp. $16.95. Translated from the Italian edition (Turin, 1975) by Raymond Rosenthal.

The author of this book—a series of essays each named after a chemical element—is an organic chemist. The book, however, is not about chemistry but about the personal and emotional development of the author. Levi is a Jew and a famous Italian writer, best known for two books entitled *Survival in Auschwitz* and *The Re-awakening* in English translation. Both are expressions of human survival by dignity and of Jewish humor without pathos—a combination rare among American Jewish writers.

The present book is again a terse, low-key, but intensely serious document of life under stress—either the stress of a youth curbed by fascism or the stress of a chemist struggling with stubbornly defective reagents. The names of chemical elements are used sometimes as metaphors, sometimes more literally to provide occasions for sharp vignettes of the author's early life. As a Jewish student in a fascist society that made Jews openly pariahs; as a climber who found relief in fighting mountain slopes instead of the unapproachable fascist rulers; as a partisan facing the Nazi enemy in those same mountains; and finally as a young chemist learning to deal with the incompetence or worse of the industrial world—Levi sustains an evenness of mood through which shines the consciousness of a hard personal integrity.

Among the essays the first, "Argon," depicts the little-known society of Piedmontese Jews, in which both Levi and this reviewer were raised, a culture that for a long time hardly interacted with the surrounding Christian world (hence behaving like the noble gas argon in air) yet made some outstanding contributions to Italian intellectual life. Anthropologists may be interested in this essay, which reveals a hitherto neglected facet of Italian society.

The essay called "Gold" is both personal and symbolic. In prison as a partisan, his life in immediate danger, Levi found relief in consorting with a professional smuggler who had at some time eked a living by collecting a few flakes of gold from a mountain river. The implied message: there is some gold to be found in a human being, or in a river, or in prison if you are alert to it.

Other essays are closer to natural science. "Potassium"—set in 1941—tells of

a brief courtship the author had with physics as a possible vocation. The immediate impetus was apparently the willingness of a young physics teacher of philosophical bent to take seriously the intellectual eagerness of a student whom chemistry teachers had, not surprisingly, left unstimulated. This reviewer, who a few years earlier had found among Italian physicists the intellectual stimulus liberating him from a humdrum medical education, can vouch almost to the last comma for the authenticity of the experience described by Levi.

"Arsenic" is a vignette that could easily have been turned into a crime investigation in the hands of a less sensitive author. One of his first clients brings to Levi a pound of sugar which he suspects of having been doctored. Levi analyzes it and finds plenty of arsenic. For the rest of the day he goes on with other work. Next day the client returns, hears the verdict, explains calmly that a competitor—a cobbler like himself—has been making his life hard and now has apparently attempted to poison him. No fuss, no police; the cobbler, a quiet Piedmontese, will return the sugar to his enemy and "explain two or three things" to him. Levi's philosophy of constructive faith in reasoning reminds me, here and elsewhere in the book, of Diderot's trust in human common sense.

"Vanadium" is the story of a more recent event. While dealing with a German firm concerning a batch of imported resin (which misbehaved because of a vanadium salt impurity) Levi discovered that his German correspondent was the same man who had been his boss in the Auschwitz camp. The exchanges that ensue illustrate the conflicts of an honest man divided between the forgiveness demanded by personal self-respect and the contempt felt for a Nazi colleague—truly an impurity in the scientific milieu.

In all 18 essays the writing has an immediacy achieved without sacrifice of sophisticated literary skill. The English translation manages to keep the freshness of the original Italian best seller. Primo Levi succeeds in transforming chemical concepts and processes into metaphorical comments on life. He also achieves the more difficult feat of writing autobiographical stories without either self-effacement or self-congratulation. These essays are in fact, as the author calls them in the essay called "Nickel," "tales of militant chemistry."

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Visual Neurobiology

Development of Visual Pathways in Mammals. JONATHAN STONE, BOGDAN DREHER, and DAVID H. RAPAPORT, Eds. Liss, New York, 1984. xvi, 489 pp., illus. $68. Neurology and Neurobiology, vol. 9. From a symposium, Sydney, Aug. 1983.

Until a few years ago, a good deal of what was known about the development of the brain came from studies of lower vertebrates, where it has been methodologically feasible to examine the events associated with the initial outgrowth of neural pathways and with regeneration of pathways following damage. Recently, however, a remarkable amount of new information about brain development in mammals has become available. Not surprisingly, a good deal of this information is concerned with the development of the mammalian visual system, a favorite subject for developmental neurobiologists because of the relative wealth of knowledge concerning the details of visual system organization in adult animals.

Development of Visual Pathways in Mammals is a collection of 30 or so contributed papers written by some of the participants at a meeting. Although its title conveys the impression that it is largely about visual system development, the book is divided into four sections, of which only the first two, on the mammalian retina (section 1) and central visual pathways (section 2), are specifically concerned with development. An equal portion of the book is devoted to the modification and recovery of the visual system from the effects of damage or surgical manipulations (section 3) and to abnormal visual experience (section 4).

Several themes recur throughout the book and play upon each other. One is that the adult pattern of visual system organization is not established during development but emerges following an extended period in which an immature pattern is progressively reorganized by a combination of regression and addition. This is true of the mammalian retina, where the adult central-to-peripheral variation in ganglion cell density is sculpted out of an initially uniform distribution by a process of selective cell death, as is discussed in papers by Stone *et al.*, Dreher *et al.*, Perry, and others. It is also true of the development of connections within the central visual pathways, in which the adult pattern of restricted and segregated inputs only emerges following a period during which excessive connections are made and then refined by collateral retraction or cell death (retinofugal connections are discussed by Chalupa and Williams, Sanderson, Godement, and Friedlander, and connections of visual cortex are discussed by Tsumoto *et al.*, Rhoades *et al.*, and Innocenti). A related theme is that the mammalian visual system at birth is actually surprisingly immature both anatomically and functionally, presumably because the events described above are not yet complete. Cat retinal ganglion cells (Ikeda and Robbins), lateral geniculate nucleus neurons (Friedlander), neurons of the superior colliculus (Stein), and corticotectal neurons (Tsumoto *et al.*) all undergo considerable postnatal development to attain their adult properties. The immaturity present during early postnatal life is also likely to contribute to the ability of the visual system to recover from surgical manipulations performed early but not later on in life (Kalil, Spear, Weller and Kaas) and from transplantation experiments (Harvey and Lund, Cunningham and Haun) and to the susceptibility of the visual system to the effects of abnormal visual experience on neurons (Wilson *et al.*, Leventhal, Crewther and Crewther, Timney, Hirsch, Murphy, Blakemore and Vital-Durand) and the consequent ability of the visual system to recover visual behavior and cortical function (Mitchell and Murphy, Van Sluyters and Malach).

Although a direct link must exist between the postnatal period during which visual connections develop to maturity and the period during which connections can be modified by various circumstances, the papers discussed above provide disappointingly little specific information on this point. Indeed, the sections on development are dissociated from the sections on the modifiability of the visual system by a conceptual and informational gap, which presumably was bridged during the meeting itself. In this regard it is worth noting that the contents of the book by no means cover all that is known about the development of visual pathways in mammals. Conspicuously absent is the entire subject of the role of neuronal activity (including synapse formation and neurotransmission) in the development and modifiability of visual system connections—a subject that has generated much interest and excitement in recent years and is of considerable relevance to all of the studies discussed above. In addition, a good deal is now known about early developmental events such as those associated