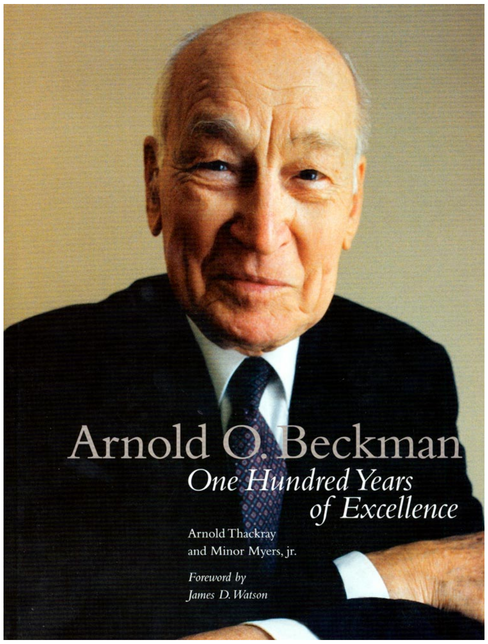
Media Reviews

Arnold O. Beckman: One Hundred Years of Excellence. By Arnold Thackray and Minor Myers, Jr. Special folio volume in the Chemical Heritage Foundation Series in Innovation and Entrepreneurship. Includes CD-ROM video. Chemical Heritage Foundation: Philadelphia, PA, 2000. Illustrations. xvii + 379 pp, 23.8 × 28.8 cm. $65.00, hardcover. ISBN 0-941901-23-8.

On April 7–8, 2000 the California Institute of Technology commemorated the 10th anniversary of the Beckman Institute on the Pasadena campus with a two-day, four-session symposium dubbed the "Beckmanfest," featuring a dozen speakers, including a Nobel chemistry laureate (Thomas R. Cech), discussing cutting-edge research and developments at the point where chemistry and biology interact. Each session featured two well-known researchers, whose presentations were separated by that of a Beckman Young Investigator (Since its founding in 1991, the Beckman Young Investigator program has supported the work of 150 fledgling scientists). Also, a gala dinner was held on April 10 to celebrate the 100th birthday of the chemist–inventor–entrepreneur–philanthropist whose gifts to Caltech have shaped the campus in profound ways. Beckman's centennial birthday was also commemorated by the publication of a profusely illustrated, luxurious, oversized volume that documents the life and achievements of a man who has literally become a legend in his own time.

Arnold Orville Beckman was born on April 10, 1900 in the small farming community of Cullom, Illinois, the son of blacksmith George W. Beckman and Elizabeth Ellen Beckman (née Jewkes). His mother inculcated in him the importance of disciplined effort in achieving success, a trait that became a characteristic of his life and career, and chores were a regular part of home life. At the age of nine Arnold, nicknamed "Hoot" by his friends, found a copy of Joel Dorman Steele's *Fourteen Weeks in Chemistry,* and he became hooked on "the central science." For his tenth birthday, his father built him a small "shop" behind the house for his chemistry experiments. At the age of twelve, Arnold became a grocery clerk and "resident chemist" in a general store, where he was the "official cream tester." In 1912 Arnold's mother died, and in 1914 his father moved the family to Normal, Illinois so that the children (Arnold, his older half-brother Fred, and younger sister Wilma) could acquire a better education. A year later they moved to nearby Bloomington, Illinois. While attending University High School in Normal, where he took a number of college-level chemistry courses, Arnold earned money as a consulting analytical chemist at Bloomington's Union Gas & Electric Company (he had business cards printed, and his home laboratory became "Bloomington Research Laboratories," of which he was "Chief Scientist"). He also had a regular job as movie-house pianist for silent films, and he had his own dance band. In 1918 he graduated as valedictorian with the highest average ever attained by a University High student.

The United States had entered World War I, and in August 1918 Beckman joined the U.S. Marines and spent three months in boot camp at Parris Island, South Carolina before reporting to the Brooklyn Navy Yard, a major embarkation point for troops headed for Europe. His train arrived late, another contingent had sailed in place of his unit, and the Armistice was signed on November 11, 1918. After eating a Thanksgiving Day dinner, his unit was ordered to attend a second dinner arranged by the Red Cross to honor Marines returning from France; because of the high casualty rate, not enough men had returned to fill the tables. Here he met and fell in love at first sight with 17-year-old Mabel S. Meinzer of Brooklyn, who was helping her mother serve food. As Beckman later said, "Luck has played a big role in my life—finding a chemistry textbook and meeting my wife through lucky circumstance." The two lovers did not become engaged until four and a half years later or marry until six and a half years later when Beckman had established himself financially, but their romance continued by frequent correspondence.


Arnold O. Beckman
One Hundred Years of Excellence
Arnold Thackray and Minor Myers, jr.
Foreword by James D. Watson

Beckman was discharged from the service in January 1919. That summer he hopped a freight train and earned money in Ashton, Idaho, where he played the piano in a theater. In the fall he enrolled in the University of Illinois intending to become an organic chemist, but he developed an extreme sensitivity to organic mercury compounds, a project assigned to him by Carl Shipp ("Speed") Marvel, so he switched his major. He received his B.S. degree in chemical engineering in 1922 and his M.S. degree in physical chemistry in 1923.

Attracted to the West and determined not to get all his training at one school, Beckman decided to pursue his doctorate at the California Institute of Technology, then a very new and very small institution. However, he longed for Mabel, whom he had seen only once since they first met. In 1924 he abandoned his graduate studies to find a well-paying job in New York and to be near Mabel. After a single interview he received an offer of a job as a chemist at Standard Oil of New Jersey's Bayonne, New Jersey refinery.

However, fate again intervened (Beckman described his life as a mixture of "pluck and luck"). He arranged to meet and "chew the fat" in New York with Todd Nies, a former Caltech student who was employed at Western Electric's Engineering Department, later to become the most famous of all industrial research laboratories—Bell Laboratories. Nies introduced him

The Beckmans' wedding portrait, 1925 (Courtesy, Beckman family).

The Beckmans in later life (photograph by Antony di Gesù,Courtesy, Beckman family).

to a colleague, Walter Andrew Stewhart, later known as the father of statistical quality control. One of Beckman's special gifts has been his uncanny ability to sense the "sweet spot" where excellence and opportunity come together. He became Stewhart's first technical employee in the new Inspection Engineering Department of Bell Laboratories, where he spent two years (1924–1926) learning about electronic technology, the vacuum tube, and statistical quality control in manufacturing (considered by some to be "a third wave of the Industrial Revolution") and the structure of research and development as practiced in the most renowned of industrial research centers. Less than a decade later, he would make the "marriage of chemistry and electronics" a reality. In Beckman's words, "If I'd never gone to Bell Labs, I might not have developed any interest in electronics."

On June 10, 1925 Beckman married Mabel in Bayside, Long Island, and in the fall of 1926 he returned to Caltech. During their cross-country trip he improved his Model T Ford by placing a bicycle valve through the gas cap to solve a problem encountered when climbing hills. In 1928 he received his Ph.D. degree for research on the photochemical decomposition of hydrazine, supervised by Roscoe Gilkey Dickinson. In the course of related work on hydrogen azide he invented a quartz-fiber manometer, resulting in his first scientific publication (*J. Optical Soc. Amer.* **1928**, *16*, 276–277). On September 18, 1928 he received his first patent (U.S. 1,684,659)—for a "signaling device" that could be attached to a car's speedometer that would buzz when a preset speed had been reached.

Almost immediately after earning his doctorate, Beckman was appointed an instructor at Caltech, and a year later, assistant professor. Although he continued his photochemical research and was becoming known as a master of experimental apparatus and instrumentation, his primary interest lay in teaching. Still he found time to act as a scientific and technical consultant and expert scientific witness. In 1934 he began to advise the National Postal Meter Company of Los Angeles, which on November 26, 1934 established a subsidiary company called the National Inking Appliance Company, with Beckman as vice president. He received his second (Inking Reel, U.S. Patent 2,038,706, April 28, 1936) and third (Inking Device, U. S. Patent 2,041,740, May 26, 1936) patents.Because Mabel was unable to have children, the Beckmans adopted Gloria Patricia ("Patty") and Arnold Stone ("Arnie") in 1936 and 1937, respectively.

Beckman's next invention not only revolutionized chemistry in a number of ways but also changed the course of his life**.** Glen Joseph, a chemist at the California Fruit Growers Exchange laboratory who had been a former business manager of *The Illinois Chemist*, the University of Illinois magazine that Beckman had edited during his senior year, turned to Beckman for help in getting consistent measurements of the acidity of lemon juice as part of his research on by-product processes. The sulfur dioxide used as a preservative bleached litmus paper and "poisoned" the hydrogen electrode, and the sensitive galvanometer used to measure the current produced by the glass electrode often failed. Beckman substituted a rugged vacuum tube for the galvanometer to amplify the current so that a sturdier, glass electrode could be used. Beckman had again illustrated his dictum, "When you're faced with the necessity to do something, that's a stimulus to invention." In his words, "If Dr. Joseph hadn't come in with his lemon-juice problem, chances are I never in the world would have thought about making a pH meter."

Beckman's "acidimeter" (U.S. Patent 2,058,761, filed June 8, 1934, issued October 27, 1936), later called the pH meter, was revolutionary in two ways: the highly sensitive amplifier was an electronic innovation, and his idea of building an integrated chemistry instrument around it was also new. For the first time scientists could buy a portable, precision instrument and immediately make quick, simple, and reliable measurements that required no expertise in chemistry or electronics, leaving them free to focus on discoveries instead of tinkering with wires and meters. Its advent marked the "opening commercial move" in the 20th century's instrumentation revolution that has "made the research frontier ever more accessible to ever greater numbers of investigators and that has made possible the exponential growth of scientific knowledge."

On April 8, 1935 National Inking Appliance Company became National Technical Laboratories (NTL) to signify its change from reliance on one product to a program resulting in novel commercial products. In 1939 Beckman resigned his Caltech professorship and began his career as a full-time instrument maker and entrepreneur, and instrument after instrument flowed from his creative, problem-solving imagination. During World War II he responded to the war effort by providing vital parts for radar and the Manhattan Project and by producing many critical innovations, most of them involving light. The Beckman DU spectrophotometer, which appeared in 1942, was "the first ready-to-use tool for determining the makeup of a given substance by analyzing the appearance of its absorption spectrum. It was a key ingredient in what historians have called the "second chemical revolution" (the first originating in 1789 with Lavoisier's antiphlogiston chemistry) by making available powerful analytical techniques to increasing numbers of scientists so that complex, delicate measurements that had once required hours or days to perform could now be made in minutes with one instrument. It found application in the wartime projects producing penicillin, TNT, and synthetic rubber. Nobel chemistry laureate R. Bruce Merrifield called the DU "probably the most important instrument ever developed toward the advancement of bioscience."

The DU was focused on the ultraviolet region of the spectrum, and at the request of the Office of Rubber Reserve, Beckman built infrared spectrophotometers (IR-1 to IR-4) for the synthetic rubber program. MIT's Radiation Laboratory needed potentiometers for its radar systems, and Beckman obliged with the "Helipot" (a contraction of helical potentiometer), and he established the Helipot Corporation as a separate, subsidiary company. Wartime Beckman inventions for the Manhattan Project were the micro-microammeter (an outgrowth of the pH meter amplifier) and a quartz fiber dosimeter. He also formed a new corporation, Arnold O. Beckman, Inc. to market his oxygen analyzer, modified from Linus Pauling's earlier instrument, for submarines and high-flying aircraft, which found postwar application for monitoring oxygen levels in incubators for premature infants—a harbinger of the use of instruments in clinical and biomedical applications.

By the end of the war Beckman had created new instruments and companies, fulfilled government contracts and expectations, entered the electronics market, and greatly expanded the production of his inventions. He now diversified and opened new and larger plants producing additional cutting-edge instruments and accessories such as mass spectrometers, mobile air quality laboratories, and automobile exhaust gas analyzers. On April 27, 1950 he renamed his main company Beckman Instruments Inc., which led the American instrumentation industry in experiencing the phenomena of spin-offs, job-hopping (several of his most important employees left to found their own firms), and entrepreneurship that characterize today's new industries.

Beckman became a civic spokesman on science- and technology-related public issues. In 1954 he was appointed chairman of the Los Angeles Chamber of Commerce's Air Pollution Committee. In 1955 he became vice president of the Chamber, and on January 25, 1956 he became president of the Chamber, where he focused his attention on air pollution, especially smog, and the "scientific-technical-industrial-educational nexus emerging in the region." In 1967 he became president of the California Chamber of Commerce, and in 1970 President Richard M. Nixon appointed him to a 4-year membership on the Federal Air Quality Board, which brought Beckman national visibility.

Always on the cutting edge of economic and technological developments, Beckman became a global leader in instrumentation by opening an international subsidiary in Germany in 1953, followed by ones in Scotland, France, Austria, the Netherlands, Sweden, South Africa, Mexico, and Puerto Rico. Not all Beckman's endeavors were successful. (He always said, "If you're not taking risks, you're probably not doing very much.") Together with Caltech graduate and 1956 Nobel physics laureate William B. Shockley, Beckman formed the Shockley Semiconductor Laboratories, a subsidiary of Beckman Instruments, to manufacture silicon semiconductors. The venture was unsuccessful (Beckman always insisted, "I'm a teacher, not a businessman"), but by locating the firm alongside Hewlett-Packard in the Stanford Industrial Park, it initiated the chain of events leading to the birth of Silicon Valley and the U.S. semiconductor, computer, and Internet industry. The Beckman Systems Division, formed in 1957, long before computers were common, manufactured computer systems to deal with the vast amounts of data telemetered back to Earth from satellites and unmanned spacecraft. Other new Beckman instruments were the gas chromatograph and his Spinco Division's analytical centrifuge.

In 1964 Beckman became chairman of the Caltech Board of Trustees, and in 1965 he resigned his presidency of Beckman Instruments but remained as chairman of its board of directors. For the next quarter century he developed inventions of excellence in science, public service, and philanthropy. In 1953 he had become the first Caltech alumnus to serve on its board of trustees, and in 1964 he became chairman of the board. In the latter year, the inaugural concert of the Beckman Auditorium, constructed through his and Mabel's gift of one million dollars, was held, and in 1974, the year in which Beckman became a Caltech life trustee, the Beckmans donated six million dollars for the construction of the Mabel and Arnold Beckman Laboratories of Behavioral Biology.

In 1981 Beckman retired from Beckman Instruments to devote himself full-time to philanthropy as head of the Arnold and Mabel Beckman Foundation, which had been incorporated in September 1977 to "support basic scientific research, with an emphasis on the forward looking in chemistry, biochemistry, medicine, and instrumentation." The foundation's goal was to donate not only income from, but the entire capital base of, the Beckmans' fortune during their lifetimes. Beginning in 1983 they made five "megagifts," resulting in (1) the Beckman Research Institute, City of Hope National Medical Center, Duarte, CA (1983); (2) the Beckman Laser Institute, University of California, Irvine, CA (1986); (3) the Beckman Institute for Advanced Science & Technology, University of Illinois, Urbana-Champaign (1989); (4) the Arnold and Mabel Beckman Center for Molecular and Genetic Medicine, Stanford University (1989); and (5) the Beckman Institute, California Institute of Technology (1989). According to Harry B. Gray, director of the Caltech Beckman Institute since its inception, "The Institute is a fitting monument to Arnold. We are not only committed to excellent research…, but also to the invention of methods and instruments to enhance research at the interface of chemistry and biology."

An additional institute was the Beckman Center of the Academies of Sciences and Engineering, a conference center at Irvine, California that brings together industrialists and academics to encourage the application of science and technology and that also houses the Beckman Foundation.

On June 1, 1989 Mabel Beckman, Arnold's companion for 64 years who had always served as his advisor and sounding board, died of cancer, a painful blow for him. After recovering from a broken hip and his grief over Mabel's death, he decided that the foundation should be "recast as a foundation in perpetuity, spending only its income." In 1993, because of declining health and the burden of administering the foundation (He once quipped, "It is more difficult to give money away than it was to make it"), he retired, but he continues as chairman emeritus of the foundation, which now has an expanded board of directors. The centenarian's daughter Pat currently lives with him at Mabel's and his home in Corona Del Mar.

In addition to the major gifts mentioned above, the foundation made many smaller bequests, too numerous to mention, that totaled millions. However, the Arnold and Mabel Beckman Center for the History of Chemistry at what is now the Chemical Heritage Foundation (CHF) in Philadelphia, Pennsylvania and the Frederick P. Beckman Lecture Room at Illinois Wesleyan University, Bloomington, Illinois deserve to be cited here, for Arnold Thackray and Minor Myers, Jr., the authors of the book under review, are president of the CHF and Illinois Wesleyan, respectively. The authors have chronicled in fantastic detail the fascinating Horatio Alger story of Beckman's life—a tale that we have only had space to sketch briefly above. They record the life of a poor Midwestern youth, whose integrity, discipline, and drive combined with his natural talent and remarkable instinct for opportunity enabled him to become "a creative solver of direct scientific and technological challenges," as 1962 Nobel laureate in physiology or medicine James D. Watson terms him in the foreword to this handsome volume. Most of our generation have grown up with Beckman's ingenious products, and we can nod in recognition with Watson's statement, "Measurements with pH meter and spectrophotometer soon became integral to my life. My first two purchases for my Harvard lab were Beckman instruments, whose accuracy and reliability I never had to question."

Thackray and Myers have drawn on a wide range of source materials—scientific articles, the historical literature, corporate documents, unpublished papers and letters, oral histories, interviews, and photographs, and they have left no stone unturned in their effort to produce a complete and balanced portrait of the public and private figure who, more than anyone else, played a central role in the 20th century's instrumentation revolution, in California life, and in science-oriented philanthropy. In example after example they successfully capture Beckman's humorous, knowledgeable, and fundamentally modest personality. Intended for the general nonscientific reader, the book includes dozens of separate sections, highlighted in light green, that provide background material on persons, theories, techniques, instruments, institutions, companies, and other topics as they arise in the text. This profusely illustrated volume contains no fewer than 355 pictures—formal portraits and informal snapshots, maps, patents, buildings, laboratories, apparatus and equipment, instruments, newspaper clippings, magazine and book covers, documents, letters, architectural designs, automobiles, advertisements, announcements, bulletins, computer systems, posters, groundbreaking and award ceremonies, offices, and a host of other items to complement and supplement the text. Lists of selections of Beckman's honors and awards, patents, and scientific publications, a note on sources and suggestions for further reading, and a 6-page (3 columns per page) index conclude this inspiring and informative volume. Considering its length, contents, and range, its relatively modest price makes it a real bargain.

The book is accompanied by a 14-minute movie narrated by his grandson Arne W. Beckman, which adds an audio dimension to the text and pictures, a vivid video portrait of Beckman in CD-ROM format for both Mac and PC. Produced by Jeffrey I. Seeman, editor of the critically acclaimed 22-volume American Chemical Society "Profiles, Pathways, and Dreams" series of biographies of organic chemists, it features the voice of Beckman himself speaking about his early life, his long partnership with Mabel, and his philosophies of research, inventorship, education, and philanthropy. To the best of our knowledge, this is the first time that a CD-ROM video has been included with a book-length biography. Because Beckman was the conceptual source of and financial support for the development of numerous new technologies, useful in so many disciplines of human endeavor, it is fitting that such state-of-the-art technology be part of his saga.

In many ways this book is similar to another recent Chemical Heritage Foundation volume, also coauthored by Arnold Thackray, *Donald Frederick and Mildred Topp Othmer: A Commemorative of Their Lives and Legacies*, but on a grander and more detailed scale. Thus, with a few alterations, our general evaluation of the earlier book (Kauffman, G. B.; Kauffman, L. M. *The Chemical Educator* **2000**, *5* (4), 82–83) applies to the present volume: As the book vividly documents, Arnold O. Beckman was a prolific educator, inventor, entrepreneur, and philanthropist. His numerous scientific and technological achievements ushered in the instrumentation revolution, and his legacy lives on through his instruments, the companies that he founded, the achievements of his students, and the institutes that he and his wife so generously endowed. Together, the Beckmans were an extremely devoted couple—devoted to each other, to their work, to their community, and to the advancement of humanity. Although Mabel did not live to see the book's publication, it is indeed fortunate that Arnold has lived to witness the appearance of this unique 100th birthday present. It truly illustrates Beckman's dictum that "There is no satisfactory substitute for excellence." We highly recommend it to chemists and chemical engineers, historians of chemistry, chemical educators, entrepreneurs, and anyone concerned with the American and international chemical, scientific, and technological communities.

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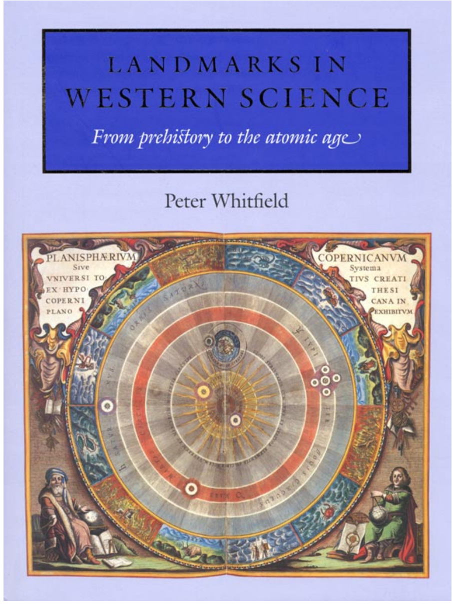
S1430-4171(01)02472-9, 10.1007/s00897010472a

Landmarks in Western Science: From Prehistory to the Atomic Age. By Peter Whitfield, 1999. Illustrations. 256 pp, 26.1 × 20.5 cm. In North America, Routledge, 29 W. 35th St., New York, NY 10001-2299, ISBN 0415925339. http://www.routledge.com. USA, $35.00; Canada, $50.00. In the UK, British Library, 76 Euston Road, London NW1 2DB, blpublications@bl.uk, http://www.bl.uk; order from Turpin Distribution, Blackhorse Road, Letchworth, Herts SG6 1HN, UK, turpin@rsc.org, £25.00, hardcover. ISBN 0-7123-4640-6.



According to Peter Whitfield, author of several books on maps and mapmakers such as *The Image of the World: 20 Centuries of World Maps* (1994), *The Mapping of the Heavens* (1995), and *New Found Lands: Maps in the History of Exploration* (1998), our “understanding of nature—as a succession of forms assumed by eternal elements—emerged during the hundred years between 1840 and 1940, when theories of thermodynamics, atomic structure, and the equivalence of matter and energy all took shape, and it stands as arguably the greatest single achievement of human thought.” In this beautiful, coffee-table-sized book he describes the long and complex process of discovery lying behind that achievement, and demonstrates “how man has tried for centuries to build bridges between nature and eternity” (a paraphrase of the King’s advice to Hamlet—Act I, Sc. 2, line 72).

Because this sweeping panorama of the development of science from prehistoric times to the middle of the 20th century deals with so many topics and persons, the coverage of each must necessarily be brief, as Whitfield readily admits. However, a much more detailed treatment would have resulted in a quite different and less accessible book than the one that he had in mind and that he has successfully produced. Although there are numerous comprehensive histories of individual sciences and technologies, general histories of science presupposing no specialized knowledge on the part of the reader are extremely rare or nonexistent. In Whitfield’s words, “My only excuse for writing so briefly is that I had searched for years for a book like this—for an outline of scientific history—and could never find one.”

During the last two centuries, science has become defined by its methodology (the widely acclaimed “scientific method”); its critical examination of the material world; its language of quantitative measurement, experiment, and deduction; and its formulation of general laws from specific cases. However, during earlier millennia, in different countries and cultures, it was defined not by its method but by its content—it sought to construct a set of beliefs about nature and its workings—what came to be known as “natural philosophy.” Thus Whitfield regards the history of science as an inclusive discipline that is central to man’s entire intellectual history. He proceeds not by searching the past for anticipations of modern scientific ideas (the so-called “whiggish” approach to history) but by adopting the model of science as answering questions about the world and man’s place in it, and trying to find out how these questions were answered in the past. Although the way many of these questions were answered in the past would now be seen as religious, mythical, or poetic, these answers are nevertheless part of the history of science, and Whitfield does not neglect them. Accordingly, he discusses philosophy and religion as often as what we would strictly consider science, because knowledge has never existed in a vacuum and because past scientists have frequently sought to place their work in a philosophical framework. He also cogently argues, with many well-chosen examples, that “the history of science, like that of art, is not a simple progression from lower to higher, but a sequence of responses to the world, conditioned by historical circumstances.”

Each of the book’s eight chapters is prefaced by a pertinent quotation. Some idea of its scope and breadth can be gleaned from the chapter titles: (1) “The Origins of Recorded Science” (20 pp, the shortest chapter); (2) “The Classical Achievement” (22 pp); (3) “Science in Religious Cultures: Part 1. “The Islamic Masters” (17 pp), Part 2. “Christian Pupils” (23 pp); (4) “The Problem of the Renaissance” (30 pp); (5) “Science Reborn” (40 pp); (6) “Eighteenth-Century Interlude” (22 pp); (7) “The Machine Age” (43 pp, the longest chapter); and (8) “Twentieth-Century Science: the New Labyrinth” (21 pp). A section of Chapter 7, titled “The Chemical Revolution” (pp 184–191), deals briefly with the contributions of Black, Cavendish, Priestley, Lavoisier, Dalton, Proust, Davy, Volta, Gay-Lussac, Avogadro, Berzelius, Cannizzaro, Bunsen, Kirchhoff, and Mendeleev, but chemistry is treated in other parts of the book as well.

A fascinating array of illustrations, both familiar and unfamiliar, from a variety of sources, but most from The British Library (the book’s publisher), complement the text. Of the 181 unnumbered figures, 25 are in full color and 26 are full page. Among these are portraits of scientific luminaries, their handwritten manuscripts, maps, woodcuts, paintings, title pages, cartoons, instruments, diagrams, and photographs of objects as small as microorganisms and as large as galaxies.

A select 3-page bibliography, divided into eight sections and concentrating on classical science, cites 74 books from 1935 to 1997, and a 6-page (2 columns per page) index facilitates location of material. This relatively inexpensive but well-researched volume, as much a work of art as of impressive scholarship, clearly and succinctly presents the experiments, inventions, speculations, and theories of the great thinkers of each age with a wide range of relevant illustrations from ancient, medieval, renaissance, and modern sources. It makes an ideal gift for the general reader interested in a short but authoritative and lavishly illustrated introduction to science, its most significant achievements, its most important practitioners, and its evolution through the ages.

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S1430-4171(01)02473-8, 10.1007/s00897010473a

Laboratory Inquiry in Chemistry. By R. C. Bauer, J. P. Birk and D. J. Sawyer. Brooks/Cole, 2001, 229 pp. ISBN 0-534-37694-0.

One of the best things about this book is the fact that it has been written at all. This laboratory manual is presented in a fashion devoid of the recipes common in the traditional expository style of books for the laboratory course. It is good inspirational stuff, and even if you choose not to use it as the manual for your class, it is well worth the read to see how methods can be changed. Perhaps beforehand one might read an article by Daniel Domin on the changing style of laboratory manuals (Domin, D. S. *J. Chem. Educ.,* **1999,** *76,* 543–547).

The introductory paragraphs set the style. The roles of the individual, the group in which the students work, and the instructor are all defined. There is a lovely analogy asking if your college basketball team has one ten-hour practice a week, or several shorter ones. This drew a wry smile from the senior high school teenagers that we know!

Forty-two "investigations" of varying difficulty follow; the first one is the usual sort of safety discussion. Unfortunately it was clearly the weakest section. It did not really maintain the style promised by the opening pages, and perhaps some creativity could make this necessary topic rather less dull. Don't be put off! The next investigation (yuk, what a horrible word; why can't we still call them experiments? Is it politically incorrect these days?!) is much better. The scenario is described in a couple of sentences, followed by a short and informative section, "Getting Started." Many of the scenarios are very well posed, giving the group of students the best chance to buy into the problem at hand. A fine example is included in no. 36, where the students are asked to prepare a bill for the client along with the report.

Reading part of the way into the manual, it was obvious that instructors could use some supplementary information. There was no reference to an instructor's version of the manual within the book. The Brooks/Cole website (www.brookscole.com) does have a list of contents, but getting there is probably Investigation no. 43 of the book! There are some additional "Preface Notes to the Instructor" on the web page and the promise of instructor's guides (1–16 as of January 26, 2001) hidden behind a password that was not immediately obtainable. Three sample guides were accessible, which contain the specific details (recipes and content notes) needed to teach that experiment.

Even though we are familiar with working with groups of students in the laboratory and with experiments sans recipe, more supportive tips on teaching in this style would help. For example, there is a page devoted to every experiment for the students to identify the percent contribution of each member of the group. There are several ways to use this type of grading system—perhaps a suggestion or reference to literature sources would be helpful. Probably, many instructors would like some encouraging ideas to prevent groups degenerating into an exercise during which one person performs the experiment while three watch. It would be easy to see that some of the experiments might encourage this tendency, as all of them have an analytical or physical measurement flavor. There are no syntheses, and organic chemistry is not introduced.

One might be forgiven for believing that the authors are writing themselves out of business by generating a manual with less information in it than most. On the contrary , by buying this book, one is paying for creativity and new ideas, not words. In fact, the number of pages could be pruned further to save a few trees. The book is designed with tear out pages, which really are not necessary. The rest of the format is fine and the layout is quite functional for a laboratory setting. By contrast, the quality of the photography is very disappointing, both in subject and reproduction. For a book of inspiration in the year 2001, it is sad to see triple beam balances and ancient visible spectrometers featured. We all still use these workhorses, but we like to dream of better times!

So to sum up, this book is thoroughly recommended for all laboratory instructors, teaching at all levels, to peruse. If you are used to using a commercial manual, then this one has a bundle of creative ideas for the introductory college/university level.

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S1430-4171(01)02474-7, 10.1007/s00897010474a

Nationalizing Science. Adolph Wurtz and the Battle for French Chemistry. By Alan J. Rocke. 442 pp + xi. The MIT Press: Cambridge, Mass. and London, England. £29.50 clothbound. ISBN 0-262-18204-1.

In the earliest years of the nineteenth century, chemistry was very clearly a minority interest. The small amount of chemistry research that was carried out was focused in Germany, France, and, to a lesser extent, England. Chemistry was the study of still largely mysterious and unpredictable events, and progress was hampered by a number of intractable problems.

A theoretical understanding of how and why chemical change occurred was almost completely absent. Proposals that matter might exist as "atoms" or "molecules" had little support, and indeed there was no persuasive evidence to suggest that such a theory might be of value.

Scientific equipment was naive and often fragile; it was difficult to use, and inaccurate. Consequently, the composition of chemicals could be determined only approximately. As an inevitable result, it was not only hard to distinguish one compound from another, but also to make meaningful comparison of data generated in different laboratories.

External funding for scientific research was almost unheard of, and the costs of most work were met by the researchers themselves. Finally, communication between scientists in different countries, and even within a single country, was poor, so discoveries made in one laboratory remained largely unrecognized outside it, and so could do little to fertilize and encourage work elsewhere.

This unpromising environment was, in the space of a few decades, transformed by a series of technical developments, and by the rise of a number of outstanding chemists. Liebig, Gay-Lussac, Dumas, Wurtz, Berzelius, and many others suddenly found the world of chemistry opening up before them. By the middle of the nineteenth century, the precision of chemical analyses had improved beyond recognition; this was the key step in the development both of modern organic synthesis and the atomic theory.

The principle advance in chemical technique was the development by Liebig of his *Kaliapparat*, which allowed the analysis of organic compounds to be carried out with unprecedented precision, even by workers with quite modest training. Widespread use of this new equipment lead to a rapid expansion of chemistry in centers across Europe, but particularly in Paris, London, and several cities in what is now Germany. Adolph Wurtz was not the key figure in these developments, but had a special position in French chemistry, linking together in an almost unique way the evolution of the subject in France and Germany.

As Alan Rocke writes, *Nationalizing Science* seeks to "integrate personal biography, development of scientific thought, scientific work and the scientific world in which the scientist operates," and this wide-reaching aim is entirely appropriate for a book about Wurtz. In it, the author describes the chemist not merely as a researcher, but also as a participant in the social, cultural, and political world of nineteenth-century France. The focal point is thus what Rocke describes as the "socio-politico-scientific network" in which Wurtz lived.

Two initial chapters describe the scientific culture which existed before Wurtz's arrival in Paris. French chemistry was dominated by Gay-Lussac, Thenard, and DuLong, but progress, even for such notable scientists as these, was hampered both by a lack of funds, and by the *cumul*. Under this system, many university professors held simultaneous appointments at several Parisian universities. While these multiple appointments helped to provide a living wage, little time remained for research, since most professors were required to teach every day at every university at which they held an appointment. Such research as was possible was usually carried out in ill-lit, poorly-ventilated rooms, hardly an ideal situation for studies which must often have produced toxic or unpleasant fumes.

In spite of the primitive conditions and poorly developed state of the subject, chemistry instruction was in considerable demand in Paris. Dumas regularly lectured to audiences of a thousand, and applause was common during lectures.

Into this world came Wurtz. He was one of a small number of scientists who not only recognized that progress in chemistry was heavily dependent upon the sharing of knowledge between workers in different countries, but who had the linguistic skills and—eventually—the contacts to play a central role in this sharing.

These contacts were vital. Parisian university life appears to have been deeply inbred, at least in chemistry. When a professor chose to take up a chair at a different university, a sequence of moves might be triggered which would shift professors from one chair to another down the line. Although appointments were, in principle, based upon merit, movement up the pecking order was facilitated if one knew the right people; the development by Wurtz of suitable contacts, so crucial for advancement, is described in some detail by Rocke.

Indeed, the complex way in which Wurtz's academic and personal lives were necessarily entwined forms perhaps the most fascinating aspect of this engrossing book. By developing the picture of Wurtz as a Parisian, rather than presenting a one-dimensional picture of him as a scientist, Rocke does far more than just catalogue Wurtz's scientific achievements. Instead, this book provides an intriguing insight into life in Europe during the middle of the nineteenth century, and shows the way in which this environment strongly influenced the development of chemistry.

Nationalizing Science is at its heart a scientific biography. Although as biography the book has much to recommend it, the chemical background and achievements of the main characters are described in some detail. This is essential in order to appreciate fully the significance of, for example, the developments made by Liebig, or the difficulties faced by those trying to construct scientific theory at the time. However, the level of chemical terminology, while adding to the authority of the book, will probably restrict the readership to those with a chemical background.

Nationalizing Science is heavily researched, much of the background material gathered by the author while on extended visits to Paris There are footnotes on almost every page, and about one thousand footnotes in total. An extensive bibliography and index are included, together with a number of plates consisting mainly of images of scientists, or the buildings in which they worked.

In his introduction the author writes, "This book has, among its other goals, a biographical intent." Indeed these are the words with which the book begins. *Nationalizing Science* is very much a biography, rather than a description of scientific research with a few personal details added as an afterthought; it is all the stronger as a result. This is a fascinating, challenging and engrossing book. Not only does it deserve to find its way onto the bookshelves of many chemists, once there it will surely be referred to over and over again.

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S1430-4171(01)02475-6, 10.1007/s00897010475a

Organic Laboratory Techniques, 3rd ed.; by Ralph J. Fessenden, (the late) Joan S. Fessenden, and Patty Feist. Softcover. 229 pp, US $38.95. Brooks/Cole: 2001. ISBN 0-534-37981-8.

It is unusual to find a laboratory textbook that does not contain specific experimental procedures, but *Organic Laboratory Techniques* is just such a book. It is written as a *companion* text for students in a beginning organic laboratory, not as a laboratory manual, and therein lies its strength.

The text consists of an introduction to the organic laboratory, seventeen technique sections, and three appendices. The introduction discusses laboratory safety, notebooks, and equipment. The subtopics on safety are particularly well written, and examine personal safety, procedures for dealing with and avoiding accidents, and the handling of chemicals. A summary of the safety rules has been simplified to: "In the case of a spill, WASH!" and "In the case of a fire, GET OUT!"; good advice for the beginning student!

The remaining sections thoroughly examine the basic techniques required in an organic laboratory. The sections can be categorized into procedures for carrying out reactions (reaction setup, extraction of mixtures, and solution drying), compound purification (crystallization, sublimation, distillation, and column chromatography), and analyses (melting point, refractive index, thin-layer chromatography, gas chromatography, IR spectroscopy, and NMR spectroscopy). There is also a section on the use of the chemical literature. The only basic technique not covered is polarimetry. The order of the sections is not as noted above, but follows a sequence seen in many university laboratories, where the techniques are practiced as exercises before reactions are attempted.

Each section is laid out in the same style. The technique and its purpose are introduced, and the expected results are described. The physical chemistry behind the technique is discussed. General procedures are given for doing the technique in both macroscale and microscale procedures. Any additional related or supplementary techniques are also discussed. Finally, each section ends with several problems related to the technique.

These sections are very well written. The writing style is very general, and thus easy to read and understand. The discussion of each technique builds clearly from an introduction to a conclusion. The descriptions of relevant physical chemistry are written for students who have not had (or may never have) a course in physical chemistry, and can be understood by the nonspecialist. The combination of both microscale and macroscale procedures allows the student (and the instructor!) to compare and contrast the differences in the techniques. Safety notes are also included with the procedures. The supplementary techniques might not be seen by the students in a beginning course, but may become useful later in their careers.

The three appendices complete the text with background information on commonly used calculations, elemental analyses, and the health hazards of organic chemicals.

A reference is given to the publisher's website (http://www.brookscole.com), which allows access to *WebWorks*. *WebWorks* is an online resource center dedicated to the text. The instructions given in the textbook for finding the website were inaccurate; the exact address of the website is: http://www.brookscole.com/chemistry/fessenden/olt3/OCOL.HTM. *WebWorks* consists of five main areas: instructor resources (requires a password), chapter by chapter resources to links on the web, two sections relating to spectroscopy, and a compound gallery.

The spectroscopy sections include review material, and a series of problems. The problems either involve one technique at a time (IR, ^{1}H and ^{13}C NMR, and MS) or are integrated, and all are at a suitable level for the beginning student. The gallery is a virtual museum of more than 400 compounds, including simple molecules, natural products, and a variety of synthetic molecules. For each molecule, there are basic physical data, an interactive 3D picture of the molecule in MDL mol file format, and links to other references on the web. The interactive MDL files are treats for beginning and new chemists alike!

Though I may have a few (very few!) personal quibbles about how the material is presented, the book is well done from start to finish. In the preface, the authors state "It is also our hope that Organic Laboratory Techniques, Third Edition, finds its way into the professional library of every science student." I must agree with the authors, as this text is a valuable resource for the practicing chemist.

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S1430-4171(01)02476-5, 10.1007/s00897010476a