BOOK REVIEWS

Ladies in the Laboratory? American and British Women in Science, 1800-1900: A Survey of Their Contributions to Research, Mary R. S. Creese, with contributions by Thomas M. Creese, The Scarecrow Press, Inc. Lanham, MD and London, 1998, 452 pp. $98.50.

Where and who were the female scientific role models for the women of the late 20th Century? This question has been asked for the last twenty-five years, and it has not been an easy task to identify them. Additionally, while most can identify in general some of the hardships that the women scientists faced in the 1800s and early 1900s, the specific challenges and hurdles faced by these pioneering women and contributions to their chosen field of endeavor are harder to identify. Who where they? Where did they get their education? Who were the trailblazers? What were their lives like?

Mary Creese has put together a splendid survey of those pioneering scientific women that helps to match names and lives with those women who faced the challenges of society. The women who because of their drive, love of science, and love of learning faced the hardship of obtaining a scientific education, publishing, and making notable contributions to their chosen field of study. The survey focuses on American and British women who published between 1800 and 1900 – but does not stop there. As one might anticipate many of these women published in the later 1800s and, thus, continued to work through the first half of the 1900s and some beyond. Creese, following the careers, lives, and contributions of many of these women throughout their entire life, gives a wonderful picture of the scientific world from the perspective of these women during the later part of the 19th century and gives names and life to those women who paved the way for today's female scientific leaders.

The survey is based on a bibliography of scientific journal articles extracted from the London Royal Society's monumental *Catalogue of Scientific Papers*, 1800-1900. The preface provides a statistical breakdown of the number of female authors by country and discipline; and each chapter provides additional information on the number of papers presented by decade. This allows the reader to put the women into context, i.e., when and where. Thus, Creese provides a foundation for why she chose to focus on American and British women.

The survey itself is broken up into three parts: life sciences; mathematical, physical and earth sciences; and social sciences. Chapters are focused on particular disciplines such as "Largely Lepidopterists," "Ripple-Marks in the Sand, Images on the Screen, Unit Standardization," and "Geographers, Explorers, Travelers, and a Himalayan Climber." As one can see from the choice of titles, this is not a dry approach to the chronicling of these women's lives and contributions. Each chapter is a set of life stories—the struggle to be educated, to publish, and to continue the scientific enterprise. And each story provides a glimpse into the culture that shaped the road that each of these women had to travel. Thus, the reader also gets a tremendous sense of the strength of character that each of these women must have had in order to make the contributions listed here.

To get a flavor of how Creese brings these women to life while at the same time chronicling the publications and providing biographical and bibliographical information, here are two brief excerpts of stories that show this strength of science and character. The first is from the life of Florence Stoney, who became known for her X-ray work in army hospitals. The story recounts an episode during World War I:

By 8 November the unit was reestablished at Cherbourg, ... and Stoney and her staff of seven women doctors and twelve nurses served there until 24 March 1915. This time they were quartered in the sixteenth-century Chateau Tourlaville, picturesque but hardly ideal for their purposes. ... Sanitation was primitive, a bucket system being necessary and no running water except on the ground floor. Water for surgical use had to be carried up two flights and sterilized by boiling over oil stoves. Within a week of their arrival the French had filled the seventy-two beds with critically wounded men ... The less seriously ill were sent south directly. Most of Stoney's cases were compound fractures, and her X-ray work was invaluable in determining the precise locations of shell fragments in the exceptionally septic wounds. With constant practice she also became skilled at distinguishing dead bone from living and found that removal of the former speeded recovery. Of the 120 patents the women's team treated during their four and half months only ten died.

The second relates to the life of chemist Ellen Swallow Richards. She was recognized as a prominent chemist and was the first woman student at MIT and its first woman instructor:

However, as early as the 1880s Richards was well aware that, despite her extensive involvement in the Massachusetts water survey and other projects, her opportunities for professional development and advancement in chemistry were limited. So she gradually turned to other areas where she felt she had something to offer. Her public health work had made her increasingly conscious of the then barely recognized dangers from air and water pollution and adulterated foodstuffs in a society rapidly becoming more and more urban and overcrowded. Nutrition research and the setting up of dietary standards became special concerns, and from there she was drawn into the tasks organizing the field of home economics.

Both excerpts reflect how the times and the conditions had a tremendous effect on the women involved. The survey is filled with these stories—some tragic, some heroic, and some frustrating. The survey also includes the impact on these scientific women of mentors, the schools, and the trends in scientific institutions such as the Academy of Science and the formation of the American Association of University Women. Creese treats us to the nonscientific accomplishments of these women as well. Because of the drive and strength of character, many of these women were active in social endeavors as reflected in the excerpt on Ellen Richards.

The survey that Creese has put together is extremely comprehensive. It includes a wealth of biographical and bibliographic information that makes it an essential reference for anyone who is interested in the history of women in science. Mary Creese has achieved success in a most difficult task: bringing the lives and accomplishments of women scientists into the open while at the same time not rewriting history. She has put a face to the challenges and has described how the women coped within the confines of the social framework of the time. Thus, the role models and the change agents have come to life for all to see. These women truly were trailblazers in the world of science. *Frankie K. Wood-Black, Phillips Petroleum, Borger Refinery and NGL Center, Borger, TX 79008*

A Chemical History Tour: Picturing Chemistry from Alchemy to Modern Molecular Science Arthur Greenberg, John Wiley and Sons, New York, 2000. xx + 312 pp, 164 figures, index, ISBN 0-471-35408-2. $59.95.

Greenberg, who is Chair of the Chemistry Department at the University of North Carolina-Charlotte, provides what he calls a "light-hearted tour through selected highlights of chemical history." He is writing for chemists, chemistry teachers, and interested lay readers, not professional historians of chemistry. Although he has aimed at producing "light reading," filled with intriguing illustrations and richly peppered with humorous episodes, ironic anecdotes, and jokes, he also wished to create an effective adjunct for teachers and a book that might lead the general reader toward a greater appreciation for the chemical arts. He succeeded.

This is, indeed, a delightful book, filled with curious lore and wry observations. Greenberg states in the front matter that "I am not a chemical historian," and at times this is noticeable (a minor point in illustration: George Starkey and James R. Partington both acquire here the first name "John"). But Greenberg never intended to write a contribution to scholarship in history of chemistry. Instead, regarding alchemy, we read a section on "Ratso Rizzo and the Poet Virgil as Transmuting Agents;" regarding Van Helmont, "A Tree

Grows in Brussels;" regarding Starkey, "A Harvard-Trained Alchymist;" regarding Priestley, "Making Soda Pop;" regarding a famous Edinburgh professor, "Black's Magic;" and regarding Cannizzaro, "My Parents Went to Karlsruhe and All I Got Was This Lousy Tee-Shirt!"

It is a measure of Greenberg's success that even professional historians of chemistry will find this book filled with clever—and sometimes even profound—observations, and many arresting illustrations. "And if a few students are caught snickering over a page of Rabelaisian chemical lore or some bad puns," Greenberg remarks, "would that be such a bad thing?" This reader does not think so. *Alan J. Rocke, History of Technology & Science, Case Western Reserve University, Cleveland, OH 44106.*

The Chemical Industry in Europe, 1850-1914: Industrial Growth, Pollution, and Professionalization, E. Homburg, A. S. Travis, and H. G. Schröter, Ed., Kluwer Academic Publishers, Dordrecht, 1998. x + 344 pp, hardbound, ISBN 0-7923-4889-3. $154.

Determinants in the Evolution of the European Chemical Industry, 1900-1939: New Technologies, Political Frameworks, Markets and Companies, A. S. Travis, H. G. Schröter, E. Homburg, and P. J. T. Morris, Ed., Kluwer Academic Publishers, Dordrecht, 1998, xii + 393 pp, hardbound, ISBN 0-7923-4840-7. $195.

These books comprise volumes 17 and 16, respectively, of *Chemists and Chemistry*, a series by Kluwer Academic Publishers "devoted to the examination of the history and development of chemistry from its early emergence as a separate discipline to the present day." Previous topics in the series have been biography, chemical concepts, nomenclature, scientists' attitudes, polyolefins, lactic acid, rare earths, instruments, chemistry in America, and the development of chemical engineering.

The volumes reviewed here augment and expand on the meager amount of work published in book form in English on the history of chemical technology and manufacturing in Europe, particularly that of Haber (1, 2) and to some extent that of Hohenberg (3), Aftalion (4), and Arora, Landau, and Rosenberg (5). They grew out of two workshops sponsored by the European Science Foundation during 1995 and 1996 on the Evolution of Chemistry in Europe. Twenty-nine authors, mostly academics from fourteen countries, bring expertise and insight from such diverse fields of learning as history, chemistry, chemical engineering, economics, control engineering, general science, and technology. Longer than usual "Notes on Contributors," including their addresses, bolster the academic worth of the books.

All essays in both books are well researched, well documented, well indexed and will be of lasting value. Issues they raise will provide grist for the mills of future research. As might be expected of the output from a cadre of authors, some chapters are more interestingly written than others, and some contain more meat than others. Because the essays as collections tend to be disjointed, and fail to present a "big picture," namely, a coherent unified history, they are far more likely to be consulted for the important details, insights, and perspective they can bring to the standard works. I found less of an overarching commonality among the essays within a theme of Volume 16 than those of Volume 17. For that reason, I reviewed each essay of Volume 16 separately.

Obscure words and complex sentence structures in a few essays in both books often caused me to reread for meaning. The lack of thorough copy editing and proofreading is apparent in both. Missing punctuation, missing words, misspellings, and inconsistencies in format and layout, although stumbling blocks to the perfectionist, are not sufficient in number to mar the value of the contents. The print in Volume 16 was more difficult to read than that of Volume 17. Prices of both volumes, at about $0.45 per page, although steep for the average reader, are in keeping with those of other works of limited distribution.

The 17 chapters of Volume 17 are published in three themes: **Patterns of Industrialization, Pollution,** and **Chemists and Companies**.

In the first theme, **Patterns of Industrialization**, five chapters cover the formation and growth of chemical industries in Switzerland, Denmark, Italy, Poland, and Sweden; and one contrasts national approaches to developing chemical industries in Britain and Germany. The histories trace the rise of major chemical companies and their products with emphasis on the cultural, economic, and political climates that engendered them and hastened their growth: a need, know-how, access to capital, available factory sites and labor, supplies of raw materials, and, in time, expanding markets. Over time, the national industries moved from reliance on craft or "recipe based" knowledge to academic knowledge based on theory. Intertwined with the growth of national industries was the inevitable growth in chemical education, journal publication, and the formation of chemical societies. Decline of the industry in Britain and its corresponding ascendancy in Germany are attributed to matters of 1) vision both by the state (subsidized higher education) and within industry (innovation, diversification, managerial techniques, etc.) and 2) cooperation by the state, academia, and industry at all levels.

"How to Tell the Tale," the final section in the essay on Switzerland, is particularly noteworthy. It contends that in writing chemical industry history, it is no longer appropriate simply to chronicle those events, statistics, and bold strategies by principals, which culminate in success. The history must also grapple with the effects of social and cultural issues, such as labor disputes, catastrophes, and the life cycle of products. The history must also remember those companies that failed. I would add only that the shortcomings of an industry of 25, 50, or 100 years ago must be judged within its context, not by modern-day values.

The four chapters on **Pollution**, which to me are the most important in the book, contain far more material on the subject than all the histories cited above. Three chapters focus on rising public concern and governmental action in the latter half of the 19th century to curb pollution in Britain (HCl gas from alkali works), the Netherlands (acid wastes in streams from dye works), and Germany (arsenic wastes in streams from dye works). The presentation is objective. Pollution is treated as an issue to be dealt with rather than, as is often the case, a mere nuisance foisted on industry by malcontents. The historical material strongly reinforces the contention by some that industry, even today, when faced with environmental complaints, is likely to stonewall by pointing a finger at others or by contending that reducing pollution is not economically feasible. When, however, industry is forced to clean up its act, it often finds ways to make a profit. The essay on Robert Angus Smith (1817-1884), chief enforcer of Britain's Alkali Act of 1863, also provides a lesson for today. Once pollution laws are enacted and government has the upper hand, it can accomplish far more by working with industry than by arrogant penalization.

My only criticism of this section is that so much of pollution's toll is documented in economic terms: for example, the effect of HCl gas on crops and landscape, which were important to the landed gentry, while so little is said about its toll on humanity. In fairness, though, the authors reflect their sources. It was the gentry who complained and whose records were preserved. Chemists and physicians were of little help. Chemists tended to be tools of industry. Blinded by mindset and lack of knowledge, physicians often dismissed the poor health of workers as a result of intangible miasmas. Desperate to put bread on his table, the affected worker had little choice but to tolerate even the vilest working conditions. Towns and cities whose economic viability depended on the giant industries could easily look the other way.

Of the seven chapters in **Chemists and Companies**, six deal directly with the work of chemists and one is an outlier. Using Britain's alkali trade as a model, one chapter examines the general processes that led to the employment of trained chemists in laboratories and shows how the functions of laboratories evolved from simple control tools to include research and innovation. Another chapter contrasts how three companies—Hoechst, Bayer, and Schering—organized for innovation and discovery in the pharmaceutical industry.

Four chapters deal specifically with the work of four chemists. Principal among them is Heinrich Caro (1834-1910) in his role as head of the Central Research Laboratory at BASF and as an outstanding mediator between academia and industry. Another chapter explores Caro's close friendship with Ivan Levinstein (1845-1916), owner of a family dye works in Britain, and their collaboration in business. The other two chapters are devoted to Paul Schützenberger (1829–1897) and Daniel-August Rosenstiehl (1839–1916), obscure Alsatian dye chemists who, like Caro, fostered close collaboration between academia and industry. The outlier chapter in this section shows the impact of the development of measuring instruments and process control on the chemical industry, its products and labor force, a subject not covered at all that I can find in any of the standard histories.

Volume 16 covering the period 1900-1939 contains 15 unnumbered essays distributed among five numbered parts: **A New Technology for the 20th Century, The Impact and Burden of World War I, Science and Industry, Different Routes to Competitive Advantage,** and **State Intervention and Industrial Autarky**.

Part 1, **A New Technology for the 20th Century**, consists of a single masterfully written, concise, fact-filled chapter, "High Pressure Industrial Chemistry: The First Steps, 1909-1913." It hails high pressure industrial chemistry as "nothing less than the paradigm shift that thrust the chemical industry into the 20th century." This thrust was initiated in 1903 with the pioneering academic work of Fritz Haber (1868-1934), later sponsored by BASF, who by 1907 had synthesized ammonia directly from nitrogen and hydrogen in a catalyzed system, operating continuously at 250 atm. and 600° C. In 1909, Carl Bosch (1874-1940) of BASF took on the task of scaling up Haber's bench-top process. It required mostly new technology from start to finish. Problems of scale abounded, such as finding a cheaper catalyst, hydrogen enbrittlement of steel reaction vessels, catalyst poisoning, and inefficient gas compressors. Yet, by 1912, a commercial plant had been brought on-line, and by 1915, converters 12 meters high and weighing 75 tons had begun to supply ammonia for conversion to nitric acid for German munitions during World War I.

The chapter then outlines the postwar development of competitive ammonia processes necessitated by BASF's reluctance to license the Haber-Bosch process to others. The momentum created provided worldwide incentive for academic and industrial research of the reactions of all types of gases under high pressure. By the mid 1920s high-pressure chemistry had become the fastest growing sector of the industry. Notable industrial outcomes were coal-to-oil processes, polyethylene, and the remarkable acetylene chemistry developed by BASF's J. Walter Reppe (1892-1969) to make a variety of organic chemicals.

Part 2, **The Impact and Burden of World War I**, in two closely related chapters, lays bare both the human and economic tolls of war.

"Chemistry for Kaiser and King: Revisiting Chemical Enterprise and the European War" fully catches the war mentality to win at any cost, which led to the use of poisonous gasses. After failing German tactics bogged down what both sides thought would be a short war, and after a British blockade reduced by half Germany's suupply of nitrates, German forces were soon faced with a shortage of munitions. To stall for time until nitric acid production could be increased, Germany, in April 1915, resorted to the most dreaded of weapons—toxic gases. The Allies retaliated, and as the attacks escalated, the talents of the chemical community were increasingly enlisted to develop new gases (lachrymotors, skin blisterents, lung injurants), gas delivery systems (portable generators, exlosive shells), and personal defenses (impervious masks, clothing). By 1916 evenly matched armies of the chemically trained numbering in the thousands were serving on both sides. By the end of the war in 1918, it is estimated that Germany had delivered 66,400 tons of toxic gases and the Allies, mostly Britain, 57,800 tons. Perhaps the most constructive outcome of this particular type of carnage was the forced engagement and cooperation among the chemical interests—government, academia, and industry—in Britain, France, and the United States.

"Productive Collateral or Economic Sense: BASF Under French Occupation, 1919-1923" examines the war's aftermath which vindictive victors wrought on Germany's chemical industry. Although the war left Germany's chemical plants largely intact, its toll on the industry was very heavy. What happened to BASF at the hands of the French is typical. After the fighting stopped in November 1918, French forces occupied BASF plants in December, and over the next year assigned teams, including an array of chemists, to search out systematically BASF secrets. Under the Versailles treaty BASF was required to hand over 50 percent of its stockpiles of dyes, chemicals and pharmaceuticals, to supply 30,000 tons of ammonia per year and, for the next three years, allocate 25 percent of its total production for export at pre-war prices. Furthermore, BASF, in exchange for France not destroying its giant Oppau chemical plant, consented to give France know-how for the Haber-Bosch ammonia process. Other countries that had been at war with Germany were also free to exploit BASF patents and trademarks. When, by May 1923, reparations had fallen behind schedule, French troops once again occupied BASF plants and between then and October confiscated 500 railway cars of dyes and 60,000 tons of fertilizer, goods valued at 49 million RM. France also tried and sentenced the entire board of directors to at least eight years in prison for lack of cooperation. The long-term result of the war on the hobbled German chemical industry was that, in order to survive, eight of the largest companies came together in 1925 to form IG Farbenindustrie AG, the largest chemical company in the world.

Part 3, **Science in Industry**, consists of four essays that provide excellent insight into today's ongoing debates over the relative merits of theoretical vs. practical work and how resources should be allocated to each.

"Basic Research in Industry: Two Case Studies at I. G. Farben AG in the 1920s and 1930s" starts at the right place with an evaluation of definitions of research related terms. Basic science, basic research, pure research, fundamental research, and pioneering research can all be taken to mean acquisition of knowledge for knowledge's sake. A science-based industry is one that is reliant on basic research supplied primarily by academia. By contrast, applied science, applied research, and industrial research are the practical application of basic research to manufacturing and production. Technology and development are not applied research but disciplines in their own right.

Then, in the economic and political context of the 1920s-1930s the chapter examines research at BASF's Central Research Laboratory in Ludwigshaven and at its Ammonia Laboratory in Oppau as to types of projects undertaken, number of personnel, and management outlook. In doing so, the author builds a case for the presupposition, "It is difficult and in many cases even pointless to distinguish between applied and basic research." He then redefines basic research as "work toward deeper understanding of corporate-related science and technology…." As I interpret the findings, the types of projects undertaken depend on at least three factors: the corporate definition of research, the research director's personal philosophy of research, and the funds available to do research.

Although this essay is enlightening, in my opinion, there is still enough confusion over the use of research-related terms to warrant some authoritative body such as the IUPAC to build a consensus of meanings within academia and industry through the use of well established terminological principles and procedures.

"Ambros, Reppe and the Emergence of Heavy Organic Chemicals in Germany, 1925-1945" delineates the intertwined careers of two Munich trained organic chemists: Otto Ambros (1901-1990) and J. Walter Reppe (1892-1969). Ambros, a highly personable, persuasive authority on synthetic rubber manufacture, rose quickly through I. G. Farben ranks to become, at age 40, the youngest member of its board of directors. Reppe was the brilliant innovator in acetylene chemistry who provided the scientific breakthrough that led to the synthesis of butadiene and the I. G.'s commercial process for making synthetic rubber. Unlike Ambros, Reppe was hot tempered, easily provoked, and lacking in social skills. Although his one ambition was to be recognized through his work as the chemical leader of Germany, he advanced slowly in the company and became bitter over this failure. When BASF was revived after the war, Reppe was made research director and served until his retirement in 1957.

After World War II, Ambros was tried as a war criminal and sentenced to eight years in prison. Though not mentioned in this essay, the charges against Ambros related to his use of forced labor in building the synthetic rubber plant at Auschwitz. He was convicted of slavery and mass murder.

This story is very readable. It is jargon-free and has lots of contextual material, interesting pictures, and explanatory charts of research organizations and chemical reactions. It concludes that the joint R&D efforts of Ambros and Reppe paved the way for the West German chemical industry to switch from coal-based to petroleum-based chemicals in the 1950s and early 1960s.

"The Development of Chemical Industries in Sweden and the Contribution of Academic Chemistry after 1900" primarily examines the role of laboratory research in three industries: superphosphate fertilizer, pulp and paper, and sodium perchlorate made by the electrolysis of sodium chlorate. It shows that although the pulp and paper industries maintained laboratories, the labs were small, poorly equipped, staffed by nonchemists, and used primarily for control purposes. What the industries needed primarily was practical knowledge and adequate financing. However, because the labs presented an image of science to outsiders, they were useful in advertising. Industry in general saw science as unprofitable, and government was reluctant to support applied science except in industries critical to the economy. Academic chemists had little interest in fertilizer and paper from which research results and patents were likely retained by the companies. However, science-based chlorate electrolysis attracted a large number of dedicated researchers.

Though slow in arriving, science and applied research came to Swedish chemical industry by two avenues: 1) professional consultants who brought an outlook to the plant totally different from that of the practitioner; 2) contacts with technical and scientific institutions in which industrial work was part of the responsibility of the professional chair holder. These people, however, were troubleshooters who improved existing processes rather than develop new ones. Applied research and its attendant laboratories came ultimately with the hiring of chemically trained staff.

"Selling Science: Dutch Debates on the Industrial Significance of University Chemistry, 1903-1932" shifts the emphasis from the consumers of research to the producers of research by focusing on the efforts of university chemists to create jobs for their graduates. In 1876, the Dutch Parliament had overhauled the nation's university system and, in doing so, had turned Utrecht University into a research based institution where a degree required seven or more years for completion. At the same time, the Polytechnic Institute at Delft was turning out chemical technologists in four years. Because industry gave Polytechnic graduates a decided edge in hiring, the University had to convince industry of the value of its graduates and the kind of work they were trained to do.

A government proposal in 1903 to raise the status of the Polytechnic to that of the University sparked a two-decade-long debate over the type of education best suited to industry and the compatibility of academic knowledge with practical experience. Opinions ranged from an "unbridgeable gap" to "closely related activities." As proposed terms and definitions were revised and repeatedly modified, a compromise slowly emerged: pure research was driven by curiosity, and applied scientific research was necessary for plant and production problems.

During World War I the need to reduce imports of food, fertilizer, and all kinds of chemicals forced industries into research. For example, Phillips Electrical had to build its own plant to make argon for filling light bulbs. Capitalizing on this turn of events, university chemists began to emphasize the social aspects of being a researcher and of building a strong nonelitist sense of the chemist's functions *in* society not *above* society.

Part 4, **Different Routes to Competitive Advantage**, contains five essays which describe how the chemical industries in Britain, Norway, and Switzerland used science, technology, education, advertising, shrewd marketing, and astute management to gain market footholds.

"Modernizing Industrial Organic Chemistry: Great Britain Between Two World Wars" begins with the struggles of the British chemical industry during World War I to recover know-how for making products it had once mastered but then lost to German competition. When the war brought explosives, drugs, dyes, and toxic gases under government strategic planning, it also forced interaction and cooperation within the chemical industry. The postwar result was an industrial reassessment of available raw materials, new technology, particularly high-pressure processes, and new products, such as plastics, resins, and adhesives. To position itself in world markets and to offset foreign competition, industry sought new directions. The government brokered mergers of small companies and created new ones. Among new industrial and governmental organizations growing out of this forced cooperation were The Association of British Chemical Manufacturers, The Department of Scientific and Industrial Research, and the National Research Laboratory.

The story is told with particular emphasis on ICI, formed in 1926 to compete with DuPont, Dow, and I. G. Farben, and the development of its processes for synthetic fibers, phthalocyanine dyes, polyvinyl chloride, methyl methacrylate, polyethylene, sulphonamides, and coal-to-oil fuels.

"Scaling Up: The Evolution of Intellectual Apparatus Associated with the Manufacture of Heavy Chemicals in Britain, 1900-1939" would have been better titled "Scaling Up: Britain's Role in the Early Development of Chemical Engineering." Although the term "chemical engineering" seems to have been coined in Britain in the 1880s; and without doubt, George Davis (1850-1906) of Manchester Technical School published the first book on the subject in 1901, the concept of unit operations, as proposed by Arthur D. Little in the US in 1915, is generally recognized as the intellectual basis of the profession of chemical engineering.

This essay compares the development of the profession in the United States and in Britain. John W. Henchley (1871-1931), who followed George Davis at Manchester, introduced the concepts of material and energy balances to arrive at the most economical way to produce a given chemical, namely through "process design." Likewise, he was the first to draw on students' training in civil, electrical, and mechanical engineering to educate them in "plant design."

Much of the history of chemical engineering hinges on how terms have been defined. Britain's Institute of Chemical Engineers (I Chem E) made the "capacity to design manufacturing plants on a commercial basis" central to its definition, as distinct from the American concept of unit operations. While it is stated here that the I Chem E, as early as 1925, "pioneered reaction treatments of materials" or what would become known as unit processes, I was unable to find supporting data. The concept of unit processes is usually attributed to a paper in 1928 by P. H. Groggins (b. 1888), of the United States Department of Agriculture, followed by his text, *Unit Processes in Organic Synthesis*, published in 1935.

"The Use of Measuring and Controlling Instruments in the Chemical Industry in Great Britain and the USA during the Period 1900-1939" is an attempt to show that instruments were introduced into the chemical industry to reduce waste and labor costs and to improve product quality. It is based on limited data mainly from three sources: trade literature, instrument sales data for the US and Britain, and technical articles published in the 1920s and 1930s. Three reasons are given for the more rapid acceptance of instruments in the US than in Britain: development of mass production processes, standardization of products, and acceptance of the principles of scientific management with "one best way" for doing everything. In Britain, by contrast, the chemical industry was based on small production units, a flexible approach to production, and greater reliance on the skills of craft based labor.

In my opinion, this essay overly emphasizes the role of instruments in labor cost reduction at the expense of their role in product quality improvements. I also question the validity of comparative data on worker productivity in the US and Britain without such knowledge as respective union and/or governmental work rules, hourly lengths of work weeks, and the contributions of labor saving machinery.

"Norwegian Capitalists and the Fertilizer Business: The Case of Hafslund and the Odda Process" tells a fascinating, almost mystery-like tale of the development in 1928 of the now virtually unknown Odda process for making a highly concentrated, nonmixed, three-component (N, K, Ca) fertilizer to compete with I. G. Farben's Nitrophoska. The chemistry given for the process is very sketchy but appears to have consisted of treating phosphate rock with excess nitric acid and then neutralizing with ammonia; but the chemistry involved is not the point of the story. Rather, it is about why the company Odda Smelteverk came to develop the Odda process and why neither it nor its parent company, the Hafslund group, ever used the process, but licensed it to I. G. Farben. In particular, the essay provides a close-up of the inner workings of the companies, the personalities of their principals, their dealings with banks, their gamble on the research and development of innovative products, and how the company's desire for short term profits governed its policies. In short, it is the story of an industry's intricate strategies to survive during the difficult period between the wars.

"The Swiss Pharmaceutical Industry: The Impact of Industrial Property Rights and Trust in the Laboratory, 1907-1939" is true in content to its well worded title. The modern pharmaceutical industry based on laboratory research dates from the 1880s, when Swiss firms began to concentrate on name-brand specialized products of high profitability. They also brought the principles of scientific management to production and established effective international marketing and advertising for prescription drugs supplied through physicians. Although well established companies such as CIBA and Sandoz took the lead, a number of smaller companies manufactured patent medicines. In the 19th century, Swiss firms had not recognized foreign patents so specialized in imitation rather than innovation. After a trade agreement against such "piracy" became fully effective in 1907, the number of Swiss patents doubled over the next six years.

Diversification of product lines resulted in specialized research in pharmacology, bacteriology, and physiology; and advertising aimed at convincing the public of the effectiveness and supremacy of name-brand remedies. The result was that by the 1930s the large corporations based in Basel represented 90% of the Swiss pharmaceutical business, and Swiss drug exports increased from 4.6% in 1911 to 19.7% in 1939. This growth was also due in part to a worldwide decline in patent medicines after they came under increasing governmental regulation starting in the 1920s.

Part 5, **State Intervention and Industrial Autarky**, in four essays considers the role of government regulation in the development, or lack thereof, of the chemical industry in Italy, Spain, Denmark, and Finland.

"Technical Change in the Italian Chemical Industry: Markets, Firms, and State Intervention" is crammed with facts on firms, patents, products, markets, and sales that are bolstered by examples from Montecatini, Italy's leading chemical firm. Prior to 1930, chemical production in Italy was based on the needs of agriculture and traditional manufacturing. However, government efforts in the 1930s to accelerate R&D and to buy foreign technology advanced the industry by providing the technical skills, scientific know-how, and practical experience needed for extraordinary growth after World War II. The impact is summarized for five industries: aluminum, dyes, pharmaceuticals, oil refining, and polymers.

Governmental autarky policies instituted in 1934, namely those designed to establish a self-sufficient national economy, generally worked well; and there was a high degree of convergence between the strategic purposes of the chemical industry, the ideas of the technocrat managers of state-owned industries, and Mussolini's fascist ministers. The balance of power was such that no one segment could dominate, and conflicts such as the allocation of scarce resources required compromise. The working rationale, still valid, was this: to improve long-term economic prospects and to gain status in world markets, a nation must not slavishly adhere to competitive costs and short term advantages, but must invest in those industries, technologies, and human resources which improve overall productivity.

"The Frustrated Rise of Spanish Chemical Industry Between the Wars," starts with the premise that World War I was beneficial to the chemical industry in Spain. As a neutral country, it could readily attract investment capital to enlarge existing facilities such as explosives, sulfuric acid, and alcohol. When, after the war, it faced strong competition from recovering nations in Northern Europe, the industry declined in spite of protectionist laws and tariffs. The reasons cited for Spain's industrial backwardness, which lasted until the 1960s, include: lack of vital resources (raw materials, cheap power, investment capital, modern transportation, and scientific and commercial know-how), stagnant markets, and a short-sighted management that lacked self-confidence. Added to these were the lack of theory-oriented technical schools and research institutions, lack of industrial R&D, and the perverse effects of over regulation by government.

Between World Wars I and II, progress in addressing these conditions within and among competing interests resulted in modest gains on all fronts. The underlying factors leading to growth in five industries — sulfuric acid and soda, explosives, dyes, fertilizers, and alcohol—are examined in detail.

"The Take-Off Phase of Danish Chemical Industry, ca 1910-1940" gives an overview of those events that gave the industry its impetus to grow. Denmark, a largely agricultural country, had few of those natural resources—minerals, oil, coal, forests—needed to establish a heavy chemical industry. What chemical industry it had at the turn of the century was dominated by small, geographically isolated, technically backward firms that mainly produced goods associated with agriculture. At the outbreak of World War I, 60% of the industry's gross income derived from sugar refineries, margarine factories, breweries, distilleries, and oil mills. Some highly successful ventures developed between the wars included cryolite mining for aluminum smelting, beet sugar refining, hydrogenated coconut oil for margarine, and the production of insulin. Contributing to the take-off was a tradition dating from 1832 at the Polytechnical College in Copenhagen of training engineers highly qualified in chemical process technologies. Although a modern patent law was passed in 1894, few Danish companies filed patent applications; and few of those were developed. Two prime examples were the quinhydrone electrode [1920] for measuring pH and discovery of the element hafnium [1923], which became important in the Dutch electrical industry.

Plans in 1918 to build a Haber-Bosch ammonia plant failed to materialize as did one based on an electric arc process in 1933. One reason was that the government was eager to maintain friendly trade relations with Norway, to which it sold agricultural products and from which it bought fertilizer.

"Neglected Potential? The Emergence of the Finnish Chemical Industry, 1900-1939" focuses on the question of "why Finland's chemical industry developed so slowly and so late and achieved so little considering its potential." The answer in short is that, before World War II, industries of all types competed for the same resources: waterpower, timber, funding, technical expertise, and management skills. The government did not attempt to attract large transnational companies by offering economic incentives. Efforts to buy foreign know-how could easily get mired in bureaucracy. Although higher education could offer a few outstanding chemists, it was not organized to do research that would foster industry. Furthermore, Finland's industries hired few chemists and did little or no research on their own. Through the mid-19th century, Finland had exported pine tar, pitch, potash, and saltpeter; but as technology changed, shipbuilding in particular, the markets for these craft-based industries slowly collapsed. A new beginning came in the 1890s-1900s, with the building of plants for carbide, dynamite, potassium chlorate, and consumer rubber goods; but by the time of World War I, these had largely withered and died.

After the nation gained its independence from Russia in 1917, it began to develop its mineral and copper resources, further develop its hydroelectric power, establish fertilizer works, and manufacture caustic soda, sodium sulfite, Glauber's salt, and calcium hypochlorite for its flourishing pulp and paper industry. One very bright spot was government-built plants (17 in all) to convert spent sulfite pulp waste to fuel alcohol. During 1941, the peak production year, these plants produced 31,000 tons of alcohol. *Herbert T. Pratt, 23 Colesbery Dr., New Castle, DE 19720-3201.*

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SIXTH HISTORY OF CHEMISTRY SYMPOSIUM

at

SACRED HEART UNIVERSITY

Fairfield, CT

on

Saturday, November 11, 2000

8:45 A.M. – 4:15 P.M.

Speaker	Topic
Dr. William B. Jensen University of Cincinnati, OH	The Reichenback Affair: The Pseudo Science in the 19th Century
Dr. Derek Davenport Purdue University, IN	The Royal Institution of Great Britain from 1800-2000
Dr. Peter Childs University of Limerick, Ireland	History of Chemicals from Seaweed: from Alkali to Iodine to Alginates
Dr. Kathryn Steen Drexel University, Philadelphia, PA	U.S. Synthetic Organic Chemicals Industry in World War 1 and the 1920's
Dr. John Smith Lehigh University, PA	History of Catalysis

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