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When Western missionaries introduced modern chemistry to China in the 1860s, they called the discipline *hua-hsüeh*, literally “the study of change” – an appropriate name for the branch of science that studies the nature of pure substances and the processes by which they are transformed into something new.

In this first full-length study of science in modern China, James Reardon-Anderson describes the introduction and development of chemistry in China in the late nineteenth and early twentieth centuries, and examines the impact of these events on Chinese language, education, industry, research, culture, society, and politics.

In a broader sense, *The Study of Change* also explores the relationships among science, state, and society in the modernization process. Professor Reardon-Anderson shows that science in China fared best when a balance was struck between political authority and free social development. Chinese science and scientists had difficulty when a too-powerful state restricted the pursuit of knowledge, or, conversely, when political chaos precluded the order needed to give direction and purpose to dispersed scientific endeavors.

Throughout the book Professor Reardon-Anderson sets the development of chemistry in the broader context of the history of science in China and the social and political changes of this era. The narrative moves from detailed descriptions of particular chemical processes and innovations to more general discussions of intellectual and social history. It is based on an extensive study of Chinese and English sources.

Scholars and advanced students of Chinese studies and the history of science will find this a fascinating account of an important episode in the story of modern China. For a list of recent books in this series, turn to page 435.

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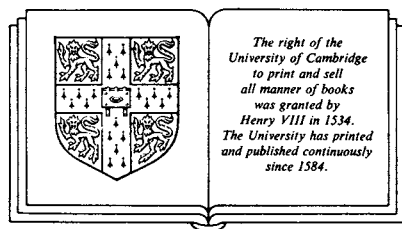
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# THE STUDY OF CHANGE

*Chemistry in China, 1840-1949*

JAMES REARDON-ANDERSON



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TO  
KATHLEEN,  
JANE, PETER, AND WILLIAM

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## Abbreviations

- CFJP *Chieh-fang jih-pao* [Liberation daily]. Yenan, 1941–7. Chinese.
- CHCYC *Chung-hua chiao-yü chieh* [Chung-hua educational review]. Chung-hua chiao-yü-chieh tsa-chih she [Chung-hua Educational Review Magazine Society]. Shanghai, 1912–37. Chinese.
- CJP *Chinese Journal of Physiology* [Chung-kuo sheng-li-hsüeh tsa-chih]. Chinese Society of Physiology [Chung-kuo sheng-li-hsüeh hui]. Peking, 1927–English.
- CKKCSL *Chung-kuo k'o-chi shih liao* [China historical materials of science and technology]. “Chung-kuo k'o-chi shih-liao” pien-chi-pu [Editorial Department of “China historical...”]. Peking, 1980–. Chinese.
- CMB The China Medical Board.
- CMJ *The China Medical Missionary Journal*, 1887–1909; *The China Medical Journal*, 1909–31. The China Medical Missionary Association. Peking, Shanghai. English.
- CRMJ *The Chinese Recorder and Missionary Journal*. Foochow, Shanghai, 1868–72, 1874–1941. English.
- CYNC *Chung-kuo chiao-yü nien-chien* [China education year book]. Ministry of Education. Shanghai, 1934, 1948. Chinese.
- CYTC *Chiao-yü tsa-chih* [Educational review]. Shanghai shang-wu yin-shu-kuan [Shanghai Commercial Press]. Shanghai, Changsha, Hongkong, 1909–48. Chinese.
- HCN *Hsin ch'ing-nien* [New youth]. Shanghai, Peking, Canton, 1915–22. Chinese.
- HHKC *Hua-hsüeh kung-ch'eng* [Journal of chemical engin-

- eering, China]. *Chung-kuo hua-hsüeh kung-ch'eng hsüeh-hui* [Chinese Institute of Chemical Engineers]. Tientsin, 1934-49. Chinese and English.
- HHKY** *Hua-hsüeh kung-yeh* [Chemical industry]. *Chung-hua hua-hsüeh kung-yeh hui* [Chinese Society of Chemical Industry]. Peking, Shanghai, Chungking, 1923-49. Title varies, vols. 1-3: *Chung-hua hua-hsüeh kung-yeh-hui hui-chih* [The journal and proceedings of the China Society of Chemical Industry]. Chinese.
- HHSC** *Hua-hsüeh shih-chieh* [Chemical world]. *Shang-hai shih hua-hsüeh kung-yeh chü* [Shanghai Chemical Industry Society]. Shanghai, 1946-66. Chinese.
- HHTP** *Hua-hsüeh t'ung-pao* [Chemistry]. *K'o-hsüeh ch'u-pan-she* [Science Publishers]. Peking, 1951- . Chinese.
- JACS** *Journal of the American Chemical Society*. The American Chemical Society. Washington, DC, 1979- . English.
- JBC** *Journal of Biological Chemistry*. Rockefeller Institute for Medical Research. Baltimore, 1905- . English.
- JCCS** *Journal of the Chinese Chemical Society* [Chung-kuo hua-hsüeh-hui hui-chih]. Chinese Chemical Society [Chung-kuo hua-hsüeh hui]. Nanking, Chungking, 1933-66. English.
- JCP** *Journal of Chemical Physics*. American Institute of Physics. Lancaster, PA, 1933- . English.
- JSHS** *Japanese Studies in the History of Science*. Nippon Kagakusi Gakkai [The history of science society of Japan]. Tokyo, 1962- . English.
- KCHP** *Ko-chih hui-pien* [The Chinese scientific magazine]. John Fryer. Shanghai, 1876-7, 1880-1, 1890-2. Chinese.
- KH** *K'o-hsüeh* [Science]. *Chung-kuo k'o-hsüeh-she* [Science Society of China]. Shanghai, 1915-58. Chinese.
- KHYJSK** *K'o-hsüeh yü jen-sheng-kuan* [Science and the philosophy of life]. Ed. Ch'en Tu-hsiu and Hu Shih. Shanghai: Ya-tung, 1923. Reprinted as *K'o-hsüeh yü jen-sheng-kuan chih lun-chan* [Debate on science

## ABBREVIATIONS

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- and the philosophy of life]. Ed. Wang Meng-tsou. Hong Kong: Chinese University of Hong Kong, 1973. Chinese.
- KJCC** *K'ang-jih chan-cheng shih-ch'i chieh-fang-ch'ü k'o-hsüeh chi-shu fa-chan shih tsu-liao* [Historical materials on the development of science and technology in the liberated areas during the War of Resistance]. 5 vols. Ed. Wu Heng. Peking: Chung-kuo hsüeh-shu ch'u-pan-she, 1983–5. Chinese.
- KYCH** *Kung-yeh chung-hsin* [Industrial center]. Chung-yang kung-yeh shih-yen-so [National Bureau for Industrial Research]. Nanking, Chungking, 1932–49. Chinese.
- NCUSR** *National Central University Science Reports, Series A, Physical Sciences* [Kuo-li chung-yang ta-hsüeh k'o-hsüeh yen-chiu-lu, chia tsu, wu-chih k'o-hsüeh]. National Central University [Kuo-li chung-yang ta-hsüeh]. Nanking, 1930–3. English.
- PCF** *Shen-Kan-Ning pien-ch'ü tzu-jan pien-cheng-fa yen-chiu tsu-liao* [Research materials on the dialectics of nature in the Shen-Kan-Ning Border Region]. Ed. Shen-hsi-sheng kao-teng yüan-hsiao tzu-jan pien-cheng-fa yen-chiu-hui, Yen-an ta-hsüeh fen-hui [Shensi Provincial Higher Schools Dialectics of Nature Research Society, Yen-an University Branch]. Sian: Shen-hsi jen-min ch'u-pan-she, 1984. Chinese.
- PSEBM** *Proceedings of the Society for Experimental Biology and Medicine*. Society for Experimental Biology and Medicine. New York, 1903– . English.
- RAC** Rockefeller Archive Center, Pocantico Hills, New York.
- SQNUP** *Science Quarterly of the National University of Peking* [Kuo-li Pei-ching ta-hsüeh, tzu-jan k'o-hsüeh chi-k'an]. National University of Peking, College of Science [Kuo-li Pei-ching ta-hsüeh li-hsüeh-yüan]. Peiping, 1929–35. English.
- SRNTU** *Science Reports of National Tsing Hua University, Series A: Mathematical and Physical Science* [Kuo-li Ch'ing-hua ta-hsüeh li-k'o pao-kao, ti-i-chung]. National Tsing Hua University [Kuo-li Ch'ing-hua ta-

- hsüeh]. Peiping, 1931-3. English.
- TFTC* *Tung-fang tsa-chih* [Eastern Miscellany]. Tung-fang tsa-chih she [Eastern Miscellany Society]. Shanghai, Changsha, Hongkong, Chungking, 1904-48. Chinese.
- TJKHSYC* *Tzu-jan k'o-hsüeh shih yen-chiu* [Studies in the history of natural sciences]. "Tzu-jan k'o-hsüeh shih yen-chiu" pien-chi wei-yüan-hui [Editorial Committee for the *TJKHSYC*]. Peking, 1981-. Chinese.
- TLPL* *Tu-li p'ing-lun* [Independent critic]. Tu-li p'ing-lun she [Independent Critic Society]. Peiping, 1932-7. Chinese.

## Preface

In the spring of 1840, Lin Tse-hsü, governor-general of Kwangtung and Kwangsi, arrived in Canton with orders from the emperor to eradicate the opium trade. Lin issued a decree that all opium must be surrendered immediately, and eight days later the British consul delivered nearly 20,000 chests of the substance. Now that he had it, what was Lin to do with this great mound of “foreign mud”? Shipping it north to Peking would be both expensive and risky. Mixing it with tung oil and burning it, the usual means of destroying opium, might leave as much as a quarter of the drug undamaged, inviting thieves and tempting corrupt officials. Boiling down the opium and soaking it in brine and lime, a method favored by some because it left a residue that could not be recovered, was time-consuming, expensive, and left open the possibility that as the procedure dragged on, some of the opium might be stolen. Finally, after seeking the advice of experts, Lin adopted a new process, which proved remarkably effective:

[Lin] ordered two pits to be dug at a high point along the shore outside the gates of Canton. Each pit was a square, more than 15 feet on a side, surrounded by a fence to keep out thieves and connected to the sea by two ditches, one in front and one behind. At high tide, the rear ditch was opened, allowing sea water to flow into the pit. Once full, blocks of opium were thrown in and left to soak in the salt water for half a day, after which lime was added. Workmen, standing around the edge of the pit, stirred the boiling mass with iron shovels, causing the opium to react with the salt water and lime, forming little beads. As the tide began to flow out, they opened the ditch in front, allowing the mixture to exit to the sea. Once emptied, the pit was washed clean with new water and the process repeated. In this way, they destroyed 800 to 900 chests of opium a day, and the whole job was completed in a matter of weeks.<sup>1</sup>

It was so like Lin Tse-hsü, the first Chinese official to recognize the superiority of Western “ships and guns” and alert his country-

<sup>1</sup> Li Ch'iao-p'ing, *Chung-kuo hua-hsüeh shih* [History of Chinese Chemistry], 2 vols. (Taipei: T'ai-wan shang-wu yin-shu-kuan, 1976), 727–9.

men to the potential of modern technology, to try a new method for disposing of opium, which, although Lin could not have known it, relied on chemical reactions. Throughout the next century, a growing number of Lin's countrymen responded in similar fashion to a succession of foreign threats by resorting to technological innovation. The problems were not always so simple, nor the solutions so apt, but the results were to invest chemistry and other branches of science deeply and broadly in the fabric of modern China.

This book is about the first century of Chinese chemistry, and at times I feared it might take me that long to write it. I began about ten years ago, more out of personal curiosity than scholarly purpose, to look for information on science in China and discovered one of the ironies of China studies and, as I later learned, modernization studies in general: namely, that whereas almost everyone agrees that science is an essential feature of modernity, almost no one has written about the development of science in so-called "modernizing" non-Western societies. China, despite the attention it has attracted, is no exception. In fact, this irony is easy to explain. Scholars who have spent years learning esoteric languages and the intricacies of strange cultures have no time or energy left for the equally forbidding world of science, and vice versa. Some people study China, some study science, but few have the stomach for both. An important, interesting subject with few busy-bodies looking over my shoulder was all the invitation I needed to attempt the book that sits before you.

Now, I want to begin with a tip for my fellow sinologists: Science is not that hard! I say this with some trepidation, because I am not a scientist, and even this book is more sociology than history of science in the narrow sense of the term. Still, my "research" took me back to college to study chemistry, an experience I found entertaining, illuminating, and no more humbling than a similar introduction to Chinese. I want to thank Ronald Breslow, Clark Still, Kris Wynne-Jones, and other members of the Columbia University chemistry department, who helped enlighten me to their dark craft. And I urge other area specialists to enrich their studies with knowledge of a technical sort. It's fun, and it offers insights hitherto lacking in our study of the non-Western world.

Several other parties who helped support my work along the



## PREFACE

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way also deserve a word of thanks. The East Asian Institute of Columbia University, then under director James Morley, gave me an office and a pat on the back in the fall of 1982, while I was writing the sections on industry and education. I am proud to appear again in the Studies of the East Asian Institute, a series ably edited by Carol Gluck with the assistance of Madge Huntington. Much of the research and writing was done between and around my chores as Columbia's East Asian librarian, causing a schizophrenia that was made tolerable only by the understanding and support of the university librarian, Patricia Battin, and the marvelous staff of the C. V. Starr Library. The book was completed during my tenure as Sun Yat-sen Research Professor of Chinese Studies at Georgetown University, where dean of the School of Foreign Service, Peter Krogh, director of Asian Studies, Matthew Gardner, and my other colleagues have given kind counsel and generous assistance. Grants from the Joint Committee on Contemporary China of the American Council of Learned Societies and the Social Science Research Council and from the Father Walsh Fund of Georgetown University relieved me from other duties at crucial points along the way.

Many people have read all or parts of the manuscript and offered helpful advice. They include Raymond Chien, Robert Dernberger, Albert Feuerwerker, Thomas Fingar, Steven Levine, Andrew Nathan, Mary Rankin, Thomas Rawski, Laurence Schneider, and Nathan Sivin. Several research assistants – Dan Brown, Scott Davidson, Christie Hong, Margaret Huang, Margot Rogers, Carrie Schmitt, Jeffrey Schultz, Sun Chung-hsing, Zhang Jiahui, and Zheng Xuecheng – have contributed to the project. Dr. Shen C. Y. Fu, Senior Curator of Chinese Art, Freer Gallery of Art and Arthur M. Sackler Gallery, provided the calligraphy that appears in Table 2.1. Others who helped in less direct ways or whom I have simply forgotten should remind me the next time we meet. Finally, I dedicate this book to my wife, Kathleen, and our children, Jane, Peter, and William, who put up with it all and remain my chief collaborators in life.

Bethesda, Maryland, 1989

J. R.-A.